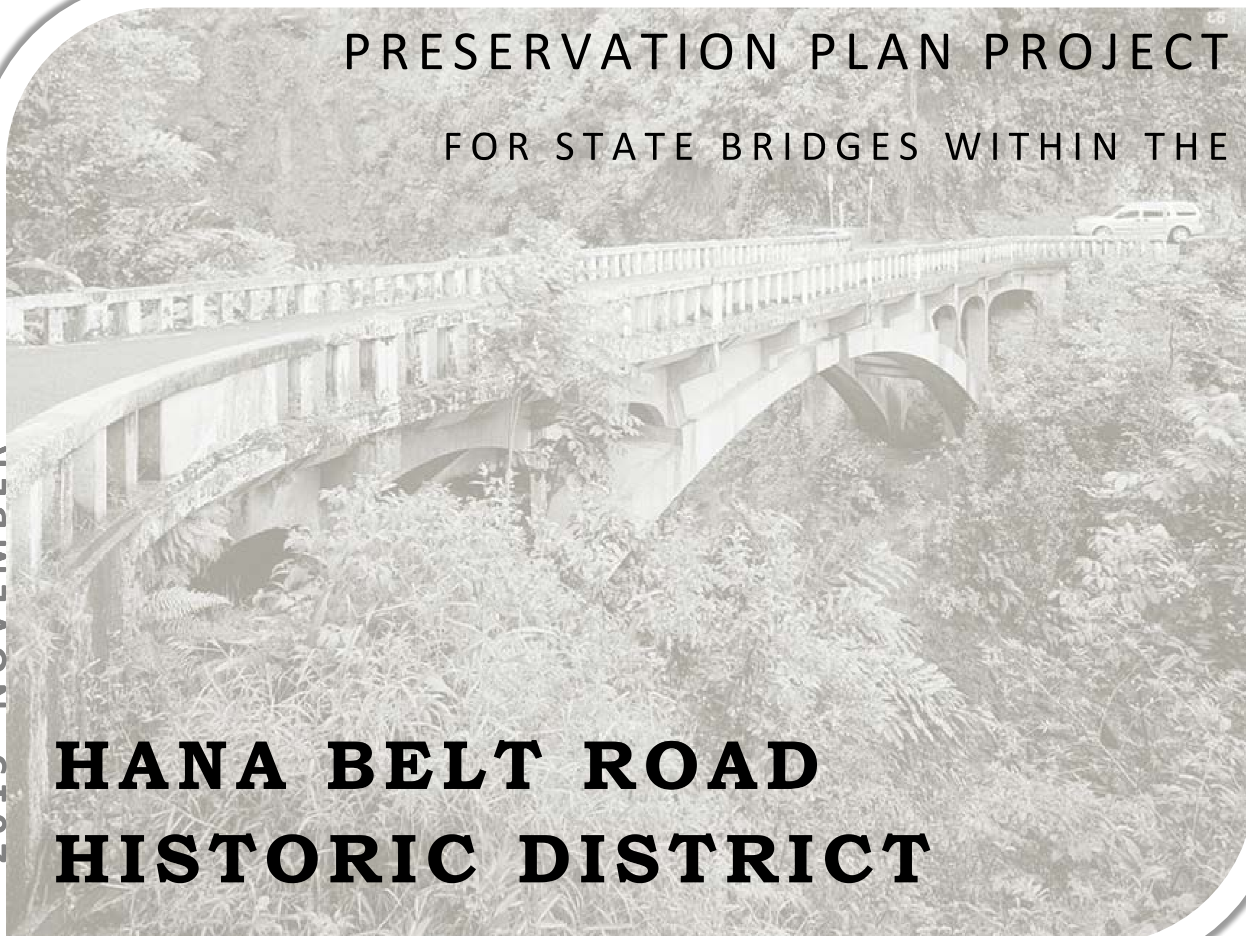
2015 NOVEMBER



PRESERVATION PLAN PROJECT

FOR STATE BRIDGES WITHIN THE

HANA BELT ROAD HISTORIC DISTRICT

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

HANA HIGHWAY, ROUTE 360
BRIDGE PRESERVATION PLAN

Prepared for

STATE OF HAWAII

Department of Transportation

Highways Division

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FINAL

November 2015

D I S C L A I M E R

This report pertains to the bridges and culverts between mile posts 5.0 and 34.0 along Hana Highway, Route 360, on Maui, Hawaii. The contents of this report were prepared using present day codes and standards. Information should be verified in the field and with local government agencies when future design projects are issued. Recommendations are not absolute and are not limited to those noted in this report. Future design teams shall use their knowledge, information, and judgment to determine what recommendations are feasible to address the needs of the project. If other methods to accomplish bridge recommendations are available to the future design team and pursued, then re-evaluation of those methods will need to be considered by all parties before implementation. These parties include, but shall not be limited to, HDOT, FHWA, SHPD, and the local communities.

ACRONYMS & ABBREVIATIONS

AASHTO
American Association of State Highway and Transportation Officials

AC
Asphalt Cement

ACHP
Advisory Council on Historic Preservation

ADT
Average Daily Traffic

AIS
Archaeological Intensive Survey

APE
Area of Potential Effect

BIRM
Bridge Inspector's Reference Manual

CFR
Code of Federal Regulations

CMP
Corrugated Metal Pipe

CRC
Cultural Resources Commission

CRM
Concrete Rubble Masonry

DLNR
Department of Land and Natural Resources

DOT
Department of Transportation (Federal)

DPW
Department of Public Works

EA
Environmental Assessment

EIS
Environmental Impact Statement

EMI
East Maui Irrigation

FHWA
Federal Highways Administration

FRP
Fiber-Reinforced Polymer

HAC
Hana Advisory Committee

HAER
Historic American Engineering Record

HBL
Hawaii Bicycling League

HBP
Highway Bridge Program

HBRRP
Highway Bridge Replacement and Rehabilitation Program
(superseded by HBP, 2008)

HDOT
State of Hawaii, Department of Transportation, Highways Division

HHF
Historic Hawaii Foundation

HRS
Hawaii Revised Statutes

LCA
Land Commission Awards

LFC
Loan Fund Commission

LRFD
Load and Resistance Factor Design

LRFR
Load and Resistance Factor Rating

MAP-21
Moving Ahead for Progress in the 21st Century Act

MBL
Maui Bicycling League

MECO
Maui Electric Company

MOA
Memorandum of Agreement

MP
Mile Point

MUTCD
Manual on Uniform Traffic Control Devices

NBI
National Bridge Inventory

NBIS
National Bridge Inspection Standards (Program)

NCHRP
National Cooperative Highway Research Program

NEPA
National Environmental Policy Act

NHO
Native Hawaiian Organization

NHPA
National Historic Preservation Act

NPDES
National Pollutant Discharge Elimination System

NRHP
National Register of Historic Places

OM3-L
Object Marker Type 3 – Left

OM3-R
Object Marker Type 3 – Right

PA
Programmatic Agreement

POA
Plan of Action

RCP
Reinforced Concrete Pipe

ROW
Right-of-Way (Maps)

SAFETEA-LU
Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

SHPD
State Historic Preservation Division

SHPO
State Historic Preservation Office

SI&A
Structural Inventory and Appraisal

SIHP
State Inventory of Historic Places

SOI
Secretary of the Interior

SPW
Superintendent of Public Works

STURAA
Surface Transportation & Uniform Relocation Association Act

THPO
Tribal Historic Preservation Officer

TIFIA
Transportation Infrastructure Finance & Innovation Program

TL-2
Test Level 2 Based on NCHRP Report 350

TMP
Transportation Management Plan

USC
United States Codes and Statutes

Table of Contents

EXECUTIVE SUMMARY

The Hana Belt Road is a designated historic distrct. This *Hana Highway Bridge Preservation Plan* (2015) presents preservation treatment recommendations for the 43 historic bridges and 12 selected historic culverts found within the state-owned portion of the Hana Belt Road Historic District. The intent of this report is to provide guidance for the State of Hawaii Department of Transportation (HDOT) regarding future rehabilitation projects along this highway. This report represents an early step in the overall planning process, and it should be noted that this preservation plan is not a construction project. Recommended designs are conceptual.

The project team identified four specific objectives for the Hana Highway, Route 360 historic bridges and culverts, as noted below:

1. Identify the historic features of each bridge and culvert,
2. Evaluate each structure's compliance with current acceptable safety standards,
3. Conduct community and agency consultation to ensure that input is received regarding the evaluation and preservation process, and
4. Prepare recommendations for the treatment of each bridge and culvert, considering historic qualities, public safety, funding options, and community and agency input.

Due to the age of original construction, many of the historic structures are not compliant with current HDOT, American Association of State Highway and Transportation Officials (AASHTO), and Federal Highways Administration (FHWA) codes. Since this is a designated historic district, application of the Secretary of the Interior's (SOI) Standards for the treatment of historic properties was a critical factor. Through the team's structural evaluation and context sensitive design, most of the historic bridges and culverts are to be treated as rehabilitation or preservation projects. Only one bridge is recommended for replacement due to structurally indeterminate conditions

The community whole-heartedly supports maintaining the historic and rural character of the bridges, as well as retaining the existing road configuration, which is characteristically winding and narrow, and is often one lane at bridge and culvert locations. This plan provides context sensitive design options to assist with HDOT's goal to upgrade these structures to meet a load-carrying capacity of 40 tons and to provide crash-tested railings for vehicular safety, while protecting the state's historic resources.

COMMUNITY OUTREACH

In order to accomplish these long-term goals, the team gathered public input throughout the course of developing the *Hana Highway Bridge Preservation Plan* (2015), which represents an early stage of the planning process. With a holistic approach, the team developed recommendations within the historic district.

Through extensive community outreach, which was completed in several phases, team members were able to compile knowledge gathered from multiple sources, which enabled the team to better understand the unique issues and concerns involved along the Hana Highway, Route 360, and to apply this knowledge to the comprehensive development of this preservation plan. This allowed the team to effectively develop context sensitive recommendations in harmony with the community's perspective, their quality of life, and the surrounding environment.

Efforts to engage identified community groups, stakeholders, and the East Maui public were a critical part of this project. Through several public and individual meetings, the team consulted with many East Maui residents, and various organizations and stakeholders listed below:

- Hana Community Association
- Nahiku Community Association

- Kaupo Community Association
- Kipahulu Community Association
- Hana Cultural Center & Museum Board
- State Historic Preservation Division
- Maui County Cultural Resources Commission
- Hana Advisory Committee
- Historic Hawaii Foundation
- Outdoor Circle Hawaii
- Aha Moku Representatives (Hana, Koolau, Hamakualoa, and Hamakuapoko)
- East Maui Irrigation
- Maui Bicycling League
- Individuals with special knowledge on the Hana bridges and Hawaiian names
- Elected County and State Officials
- Federal Highways Administration

County general plans, community plans, and transportation master plans were consulted for further guidance to ensure recommendations are consistent with the applicable policies outlined in these plans.

TRAFFIC

A Transportation Management Plan (TMP) was prepared in accordance with AASHTO, FHWA and HDOT guidelines that identify various construction constraints resulting from the proposed construction activities for the preservation and rehabilitation of bridges and culverts along Hana Highway, Route 360. The TMP provides general recommendations to reduce and minimize the traffic impacts from these construction activities, including a proposed location for a temporary by-pass bridge at each bridge and culvert location.

CIVIL

Site observations were conducted to assess traffic visibility, signage and striping, and drainage at each of the historic bridge and culvert locations. Data pertaining to drainage issues at bridges was gathered from various sources such as interviews, governmental agencies, and informational meetings, and then compiled in alignment with the team's analysis and recommendations. General recommendations were provided based upon AASHTO guidelines and the current version of the *Manual on Uniform Traffic Control Devices* (MUTCD).

ELECTRICAL

Existing overhead electrical utilities typically run parallel to the highway and bridges in several locations. These utilities consist of Maui Electric Company (MECO) high voltage and secondary circuits, Hawaiian Telcom telephone lines, and Oceanic Time Warner Cable CATV lines. Most of the existing overhead installations are located far enough away or high enough over identified project sites such that the installations will not conflict with proposed work to provide the necessary recommended bridge repairs. For those installations that may be in conflict with the bridge or culvert repair and rehabilitation work, the existing installations that will need to be re-routed clear of the work area were identified in anticipation of future projects. Scheduled outages to adjacent areas are expected to be minimal.

STRUCTURAL

Structural assessment data was compiled for each historic bridge and culvert along the highway. The 40-ton design load requirement per HDOT criteria can be addressed by adding beams to the underside of the decks of the bridges and culverts. Abutments will also need strengthening; different treatments are specified depending on existing conditions. Some abutment rehabilitation can be completed by replacing existing, typical concrete rubble masonry abutments with new concrete abutments that have a rock veneer, or simply new concrete if similar to existing conditions, while others may be documented and re-constructed at a higher level of detail to maintain the historic craftsmanship.

Existing historic bridge and culvert railings/parapets, which are one of the most visible and character-defining elements of these structures, generally do not meet current crash-testing requirements. It was determined that to meet contemporary safety requirements, a crash-tested railing can be placed on the interior side of the bridge parapets/railings when the bridge is wide enough to accommodate adding a crash-tested rail. In other cases, the bridge or culvert may be widened to allow construction of a crash-tested railing inside the existing historic bridge railing/parapet. Alternatively, if the existing bridge parapets/railings are not deemed "exceptional," it was determined that select parapets/railings may be replaced with a new, compatible crash-tested railing in order to avoid widening the road at bridge locations, therefore retaining the existing road alignment and character of the historic district.

HISTORIC ARCHITECTURE

While studying the historic features of each bridge, the team of architectural historians and historic architects noted numerous bridges with individually interesting and/or artistic architectural features. Following field investigation and analysis, the team created a system of identification for exceptional bridges and features, which informed the team's recommendations and also allowed for discussion of a few exemptions from the minimum criteria for crash-tested railings and bridge/culvert width.

ARCHAEOLOGY

Lastly, the archaeological literature review provides a summary of the cultural historical background and information on existing archaeological conditions, as well as the potential for encountering sensitive sites. The examination of previous archaeological studies and historic accounts suggests that habitation and intensive agriculture were widespread across the lands traversed by Hana Highway, Route 360. Thus, the proposed project poses a possible adverse impact to previously recorded historic properties, as well as potential historic properties that have yet to be formally documented. An archaeological inventory survey is strongly recommended for the proposed uses of this project as construction projects are conducted.

FUTURE CONSIDERATIONS

Because preservation is a key component in this *Hana Highway Bridge Preservation Plan* (2015), maintenance of existing historic structures is also highly recommended. This follows the current trend of FHWA support for preventive maintenance programs.

New bridge guidelines and context sensitive design policies developed over the last 20 years has allowed for greater flexibility of maintaining bridges with preservation in mind. FHWA recognizes that the development of new preservation technology and crash-test safety standards may occur in the future. In using this preservation plan, future design teams for bridge construction projects shall recognize new technological developments and shall take them into account, thus allowing for the possibility of modifying the design recommendations where appropriate and in accordance with HDOT, FHWA, AASHTO, and code standards. Future trends and technological developments that may occur in the years since this plan was developed may serve to further enhance the preservation treatment of these historic bridges and culverts.

INTRODUCTION

Historic bridges are a key component of the Hana Highway, Route 360 landscape and an important part of East Maui's development and transportation history. Along the state-owned portion of the highway that defines the scope of this preservation plan project, the Hana Belt Road Historic District nomination recognizes 43 historic bridges and 12 historic culverts between Huelo and the town of Hana.

Information on how to use the *Hana Highway Bridge Preservation Plan* (2015) can be found within Section A, Chapter 1. i. *Overview*. Due to the amount of detailed information contained in this report, this introduction section is intended to provide a brief, quick-reference synopsis of the most readily identifiable bridge characteristics and proposed treatment actions. Further detailed information on each bridge or culvert structure can be found in Section B. *Bridges* and Section C. *Culverts* of this report.

i. BRIDGE DESIGNATIONS

Since many of these bridges along Hana Highway, Route 360 were originally designed and constructed in small groups by the island of Maui's County Engineer's Office during the early 20th century, many of them also exhibit similar character-defining features that are easily identifiable and recognizable. However, through research, site visits, and evaluation, the team also identified variations in design, integrity, and condition. Thus, it became evident that a "one-size-fits-all" approach to treatment would not be possible.

Within *Hana Highway Bridge Preservation Plan* (2015), bridges are first designated according to preservation priority, detailed below:

1. *Preservation Priority*
    a) Exceptional Bridges:
        a. Exhibit unique character-defining features,
        b. Have an exceptionally-pleasing aesthetic feature or significant setting,
        c. Have an exceptional history to be noted and/or physically preserved,
        d. Have a high degree of historic integrity, and/or
        e. Remain in intact condition.
    b) Contributing Bridges:
        a. May be one of several examples of the same bridge type,
        b. May exhibit compromised condition/integrity, and
        c. May appear to have been heavily altered from the historic design.

a. Exceptional Bridges

The team identified 17 bridges and one culvert with exceptional characteristics that would merit special consideration in the treatment recommendations. The following categories encompass the range of "Exceptional Bridges" with the name of each specific structure designated as "Exceptional" noted below:

Curved Bridges
- #03 Nailiilihaele Stream Bridge
- #04 Oopuola Stream Bridge
- #14 Palauhulu Stream Bridge
- #17 West Wailuaiki Stream Bridge

Arched Bridges
- #16 Waikani Stream Bridge
- #26 Hanawi Stream Bridge
- #29 Kuhiwa Stream Bridge

Bridges with Distinctive Piers

- #21 Waiohue Stream Bridge
- #25 Kapaula Stream Bridge
- #42 Honomaele Stream Bridge

Bridges and Culverts with Distinctive Parapets/Railings

- #07 Waikamoi Stream Bridge
- #10 Kolea (Punalau Stream) Bridge
- #08 Puohokamoa Stream Bridge
- #15 Waiokamilo Stream Bridge
- #25C Waiokamilo Culvert

Unique, One-of-a-Kind Type Bridges: The East Maui Irrigation (EMI) Bridge

- #19 Kopiliula Stream Bridge

Unique, One-of-a-Kind Type Bridges: The Oldest Bridge

- #40 Mokulehua Stream Bridge

Unique, One-of-a-Kind Type Bridges: The Post-World-War-II Bridge

- #43 Kawaipapa Stream Bridge

b. Contributing Bridges

The remaining 26 bridges and 11 culverts are designated "Contributing Bridges." These bridges and culverts are considered historic due to their age and they retain the integrity of their original setting; however, they exhibit to a much lesser extent the aesthetic integrity, quality of original craftsmanship, character-defining features, and intact condition necessary to be considered an "Exceptional Bridge."

In order to compare the historic integrity of each "Contributing Bridge," bridges identified as "Contributing" to the historic district were grouped together, using railing type as the primary and most publicly-visible character-defining feature.

2. *Railing Type*
    a) Open picket railing, or
    b) Solid parapet.

Contributing Open Picket Railing Bridges

Twenty bridges have been designated as "Contributing Open Picket Railing Bridges," which are the most typical bridge type seen on Hana Highway, Route 360. While these bridges are generally not considered exceptional, each bridge has a unique combination of setting, substructure, integrity, and condition.

Typically, these railings are bookended by larger square posts with recessed panels at each end of the bridge. The design of some bridges also utilize intermediate square posts, depending on the length of the bridge and number of spans. A number of these posts have suffered damage and have been inappropriately repaired.

Contributing Solid Parapet Bridges

The six bridges designated as "Contributing Solid Parapet" historic structures fall into three sub-categories for evaluation. Designed and built during the earliest construction phases of the Hana Highway, Route 360 when the road was originally a wagon trail, these solid parapet bridges are too narrow to meet highway safety standards of a 16-foot-minimum curb-to-curb width. The "Contributing Solid Parapet Bridges" are noted as follows:

Typical Solid Parapet Bridges

- #09 Haipuaena Stream Bridge
- #22 Unnamed Stream No. 1 (Waiohuolua)
- #23 Unnamed Stream No. 2
- #24 Unnamed Stream No. 3

Hybrid Parapet Bridge

- #12 Nuaailua Stream Bridge

Bridge with Unknown Deck Structure

- #11 Honomanu Bridge
  Note: This is the only bridge on the Hana Highway, Route 360 portion of the Historic District that is recommended for replacement.

c. Contributing Culverts

Finally, there are 11 contributing culverts — seven culverts exhibit solid parapets and four culverts exhibit open picket railings.

Solid Parapet Culverts

- Like the bridges, a few of these culverts were designed with recessed panels on the outward face, while others exhibit a simple, flat elevation. Only one solid parapet culvert has an original date inscription.

Open Picket Railing Culverts

- The few culverts along the Hana Highway, Route 360 with open picket railings are similar to, but slightly shorter than, the typical Open Picket Railing Bridges along this route. Thus, they have also been categorized as typical and "Contributing" historic structures.

ii. BRIDGE RECOMMENDATION SUMMARY

The pages that follow are an overview of the detailed evaluation and recommendations included in the individual chapters in Section B. *Bridges* and Section C. *Culverts* and are intended as a quick reference, arranged by category.

- Exceptional Bridges
- Contributing Open Picket Railing Bridges
- Contributing Solid Parapet Bridges
- Contributing Culverts

Parapet / Railing Description

Open baluster, square post caps, 3-segment railing, curved

Bridge Components

Exemplary CRM abutments

03 Nailiilihaele Stream Bridge

Year Built	1930
Lanes	2 (currently used as 1)
Span	3
In/In Width (ft.)	19.66
Length (ft.)	63.98

Recommendation

- Reinforce deck to support new railings
- The bridge is currently being utilized as a one-lane bridge; therefore, it is recommended to change the number of lanes on the bridge from two to one for NBI Item 28A and to not widen the bridge
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings, patch and repair where necessary
- Add detached crash-tested rail across interior face of historic railings
- Retain existing appearance of concrete pier wall and CRM abutments on Hana side, which show evidence of exemplary historic craftsmanship
- Document existing rock configuration of CRM Hana abutment, and carefully remove rocks; rebuild abutment abutments with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Remove and replace CRM concrete abutments on Kahului side with reinforced concrete wall
- Remove and replace CRM wingwalls with reinforced concrete with new natural rock façade
- Investigate if piers and foundations meet current seismic codes; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Description

- Width exceeds the HDOT requirement of 16’ for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Exceptional example of CRM abutment (Hana)
- Good intact example of CRM wingwalls
- Exceptional example of concrete pier walls

exceptional bridges

04 Oopuola Stream Bridge

Year Built	1925
Lanes	2 (currently used as 1)
Span	1
In/In Width (ft.)	20.34
Length (ft.)	29.86

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Very short single-span bridge
- Railings are in satisfactory condition
- Scour critical bridge
- One of five historic Hana bridges that is adjacent to the man-made EMI system
- Exceptional example of CRM abutments
- Exceptional example of CRM wingwalls

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing, slightly curved

Bridge Components

Exemplary CRM abutments

Recommendation

- Reinforce deck to support new railings
- The bridge is currently being utilized as a one-lane bridge. Therefore, it is recommended to change the number of lanes on the bridge from two to one for NBI Item 28A and to not widen the bridge
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace upstream Hana approach metal guardrail with a TL-2 reinforced concrete wall with a CRM rock façade
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Retain existing appearance of CRM abutments and CRM wingwalls, which show evidence of exemplary historic craftsmanship
- Document existing rock configuration of CRM abutments and wingwalls, rebuild with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Investigate if foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Bridge is scour critical; HDOT Plan of Action (POA) should be followed
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

14 Palauhulu Stream Bridge

Year Built	1916
Lanes	2
Span	1
In/In Width (ft.)	20.34
Length (ft.)	30.84

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Natural Rock Foundation

Recommendation

- Provide appropriate roadway signs notifying drivers of the one-lane bridge condition
- Reinforce deck to support new railings
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Preserve exemplary natural rock formation
- Investigate if abutments and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge; bridge is currently striped as a two-lane roadway
- Existing railings do not meet TL-2 crash requirements
- Spans a distinctive streambed with visible evidence of an old abutment from an earlier bridge
- Good intact example of concrete abutments
- Good intact example of CRM wingwalls
- Exemplary example of natural rock formations

17 West Wailuaiki Stream Bridge

Year Built	1926
Lanes	1
Span	3
In/In Width (ft.)	20.01
Length (ft.)	70.87

Parapet / Railing Description

Open baluster, square post caps, multiple-segment railing

Bridge Components

Upstream view of Piers

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Curved triple-span arc
- Scenic setting with pool above and waterfall below
- Good intact example of CRM abutments
- Good intact example of concrete piers
- Good intact example of CRM wingwalls

Recommendation

- Reinforce deck to support new railings
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Replace concrete covered CRM abutments with concrete abutments
- Investigate if abutments, piers, and foundations meet current seismic codes and 40 ton load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Parapet / Railing Description

Open baluster, square post caps,curved end section with round starter post multiple-segment railing

Bridge Components

Underside view of arch ribs

16 Waikani Stream Bridge

Year Built	1926
Lanes	1
Span	1
In/In Width (ft.)	17.10
Length (ft.)	107.94

Recommendation

- Exemption on HDOT 16 feet width criteria
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Investigate if substructure and foundations meet current seismic codes; rehab may be necessary if they are found to be non-compliant without altering the open spandrel arch
- Future design team to consider additional stresses on the superstructure and substructure caused by construction for the deck replacement; additional strengthening may be necessary
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs
- Alternatives: Add a new 24 feet wide (curb-to-curb) two-lane bridge downstream of this location and repurpose the existing bridge for the pedestrian walkway; or, add new 16 foot wide (curb-to-curb) one-lane bridge downstream of this location and utilize both bridges; TBD following discussion with community and subject to approval by FHWA

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge, but is not sufficient to allow addition of detached crash-tested rail across interior face of historic railings
- Existing railings do not meet TL-2 crash requirements
- Open spandrel arch bridge, unique example of this arch design on Maui and in the State
- Exceptional example of concrete open spandrel arch bridge
- Good intact example of concrete abutments

26 Hanawi Stream Bridge

Year Built	1926*
Lanes	1
Span	1
In/In Width (ft.)	20.30
Length (ft.)	60.04

*According to SPW reports, Hanawi was built in 1929

Parapet / Railing Description

Open baluster, square post caps, 5-segment railing, downstream railing and adjacent utility building

Bridge Components

Base of spandrel arch at Hana end of Bridge

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Picturesque setting with pond and waterfalls
- Unique example of arched bridge and only one of two arch bridge in Maui
- Good intact example of closed spandrel arch bridge
- Good intact example of concrete arch ring

Recommendation

- Remove excessive asphalt overlay
- Reinforce deck to support new railings
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Investigate if arch ring and foundations meet current seismic codes; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Parapet / Railing Description

Open baluster, square post caps, 5-segment parapet

Bridge Components

Base of spandrel arch - exemplary foundation

29 Kuhiwa Stream Bridge

Year Built	1926*
Lanes	1
Span	1
In/In Width (ft.)	16.40
Length (ft.)	60.04

The Maui News reports a completion date of 1927

Recommendation

- Remove excessive asphalt overlay
- Reinforce deck to support new railings
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace deck and railings with best match TL-2 crash-tested railings
- Preserve exemplary natural rock formation
- Investigate if arch ring and foundations meet current seismic codes and are able to support the increase in load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge, but is not sufficient to allow addition of detached crash-tested rail across interior face of historic railings
- Existing railings do not meet TL-2 crash requirements
- Unique example of arched bridge and only one of two arch bridge in Maui
- Good example of closed spandrel arch bridge
- Good intact example of concrete arch ring
- Good intact example of boulder concrete wingwalls
- Exemplary example of natural rock formation with CRM in-fill cavity at foundation

21 Waiohue Stream Bridge

Year Built	1926
Lanes	1
Span	2
In/In Width (ft.)	13.00
Length (ft.)	40.03

Parapet / Railing Description

Solid with formed panels on face

Bridge Components

CRM Pier bearing on Natural Rock with cutwater profile

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing parapets do not meet TL2 crash requirements
- Upstream parapet is original and matched panel detail of extant original drawings
- Only bridge on Hana Belt Road with CRM pier wall with cutwater profile bearing on natural rock formation
- Exemplary example of CRM pier (only example of CRM pier)
- Good intact example of CRM abutments

Recommendation

- Reinforce deck to support new railings
- Widen downstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain historic upstream parapet
- Add detached crash-tested rail across interior face of historic upstream parapet
- Replace downstream side parapet with new best match TL-2 solid crash-tested railing
- Retain existing appearance of CRM pier wall, which shows evidence of historic craftsmanship
- Document existing rock configuration of CRM abutments and pier wall, rebuild with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

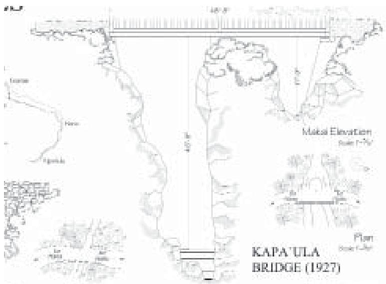
Parapet / Railing Description

Open baluster, square post caps,
2-segment parapet

25 Kapaula Stream Bridge

Year Built	1926
Lanes	1
Span	2
In/In Width (ft.)	16.40
Length (ft.)	48.88

Bridge Components



Recommendation

- Remove excessive asphalt overlay
- Retain existing width
- Reinforce deck to support new railings
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match TL-2 crash-tested railings
- Preserve exemplary natural rock formation
- Abutments, pier, and foundations are to be investigated are to be investigated as to whether they meet current seismic codes and are able to support the increase load carrying capacity; rehab/replacement may be necessary if they are found to be non-compliant preferably without altering the façade of the natural rock foundation
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of concrete abutments
- Good intact example of CRM wingwalls
- Exemplary example of concrete pier on natural rock formation

42 Honomaele Stream Bridge

Year Built	1924
Lanes	1
Span	2
In/In Width (ft.)	16.40
Length (ft.)	38.06

Parapet / Railing Description

Open baluster, square post caps, 1-segment parapet

Bridge Components

Hana side of pier wall with exemplary natural rock formation

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Oldest solid concrete pier wall on Hana Highway (built for 1906 wooden truss bridge and predates concrete bridge)
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls
- Good intact example of concrete pier wall
- Exemplary natural rock formation

Recommendation

- Retain existing width
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match TL-2 crash-tested railings
- Preserve exemplary natural rock formation
- Remove and replace CRM abutments with reinforced concrete walls with new natural rock façades
- Investigate if pier and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab/replace in kind may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Parapet / Railing Description

Solid with formed panels on face and 1912 date inscription on downstream side

Bridge Components

Distinctive concrete pier columns

07 Waikamoi Stream Bridge

Year Built	1912
Lanes	1
Span	2
In/In Width (ft.)	12.60
Length (ft.)	41.01

Recommendation

- Remove excessive asphalt overlay
- Reinforce deck to support new railing
- Widen upstream side of bridge to obtain a minimum clear curb-to-curb distance of 16’-0”
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain historic downstream parapet
- Add detached crash-tested rail across interior face of historic downstream parapet
- Replace upstream side parapet with best match TL-2 crash-tested railings
- Retain existing appearance of concrete pier wall, which shows evidence of historic craftsmanship
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Investigate if abutments, pier, and foundations meet current seismic codes; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing parapets do not meet TL-2 crash requirements
- Downstream parapet is original and contains inscribed date panel matching detail of extant original 1911 drawings
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls
- Exceptional example of concrete pier

exceptional bridges

08 Puohokamoa Stream Bridge

Year Built	1912
Lanes	1
Span	2
In/In Width (ft.)	15.09
Length (ft.)	56.10

Parapet / Railing Description

Solid parapets with formed panels on face and 1912 date inscription on downstream side

Bridge Components

Distinctive concrete pier wall

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Scour critical bridge
- Downstream parapet is original and contains inscribed date panel matching detail of extant original 1911 drawings

Significance

- Good intact example of concrete abutments
- Good intact example of concrete pier wall

Recommendation

- Remove excessive asphalt overlay
- Reinforce deck to support new railing
- Widen upstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Bridge deck is structurally deficient; rehab bridge deck
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain historic downstream parapet
- Add detached crash-rail across interior face of historic downstream parapet
- Replace upstream side parapet with best match TL-2 crash-tested railings
- Bridge is scour critical; HDOT Plan of Action (POA) should be followed
- Retain existing appearance of concrete pier wall, which shows evidence of historic craftsmanship
- Investigate if abutments, pier, and foundations meet current seismic codes; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Parapet / Railing Description

Solid parapets with raised 1911 date inscription on downstream side

Bridge Components

10 Kolea (Punalau Stream) Bridge

Year Built	1911
Lanes	1
Span	1
In/In Width (ft.)	12.80
Length (ft.)	34.12

Recommendation

- Widen upstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Bridge deck and superstructure are structurally deficient; rehab deck and girders
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain historic downstream parapet
- Add detached crash-tested rail across interior face of historic downstream parapet
- Replace upstream side parapet with best match TL-2 crash-tested railing
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Investigate if abutments and foundations meet current seismic codes; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing parapets do not meet TL-2 crash requirements
- Downstream parapet is original and contains raised 1911 date
- Good intact example of concrete abutments

15 Waiokamilo Stream Bridge

Year Built	1921
Lanes	2
Span	1
In/In Width (ft.)	22.75
Length (ft.)	23.95

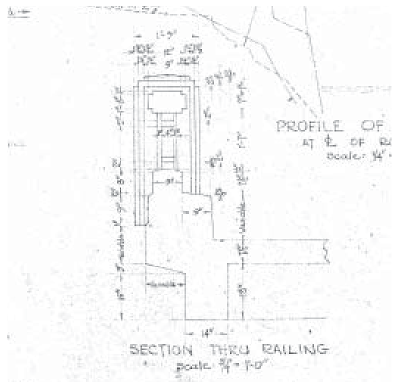
Description

- Width does not meet the HDOT requirement of 24 feet for a two-lane bridge
- Existing railings do not meet TL-2 crash requirements
- One of the two open Greek cross parapets on the Hana Highway, Route 360
- Good intact example of concrete abutments
- Good intact example of CRM wingwalls
- Good intact example of natural rock formation

Parapet / Railing Description

Open picket with Greek cross inset

Bridge Components



Recommendation

- Re-classify the number of lanes from two to one
- Reinforce deck to support new railings
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings (wide enough)
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Investigate if abutments and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation

exceptional bridges

25C Waiokamilo Culvert

Year Built	1921
Lanes	2 lane and part of Y-intersection
Span	1
Clear Span (ft.)*	13.67
Curb-to-Curb (ft.)	42.50
Culvert Length (ft.)*	44.50

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Parapet / Railing Description

Open picket with Greek cross inset

Bridge Components

2-lane road rather than 4 lanes

Description

- Culvert located near Y-intersection and supports two lanes of traffic
- Concrete abutments
- Reinforced concrete top slab
- Unlined bottom channel
- Concrete wingwalls
- Existing railings do not meet TL-2 crash requirements
- One of the two open Greek cross parapets on the Hana Highway, Route 360

Recommendation

- Investigate deck for ability to support new railings
- Install new CRM approach wall and metal approach guardrail at the Kahului and upstream Hana approaches, which meets TL-2 criteria
- Install new CRM approach wall which meet TL-2 criteria at upstream Hana side
- Add concrete bridge name panel on the CRM approach wall
- Retain historic railings
- Add detached crash-tested rail across interior face of historic railings
- Investigate if abutments and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further analysis of drainage
- Replace/add roadway signs

exceptional bridges

19 Kopiliula Stream Bridge

Year Built	1926*
Lanes	1
Span	2
In/In Width (ft.)	13.91
Length (ft.)	77.10

* Possibly 1914

Parapet / Railing Description

Concrete through beam/parapet with peaked top

Bridge Components

View from below (looking toward Kahului)

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Deck and superstructure are structurally deficient
- Existing railings do not meet TL-2 crash requirements
- Kopiliula Stream Bridge is one of five historic Hana bridges adjacent to the man-made EMI system
- Only bridge with EMI equipment attached (pulley for sluice gate); the dam below is integrated into the foundation of the bridge support system
- Good intact example of concrete abutments
- Good intact example of concrete pier columns
- Good intact example of CRM wingwalls
- Good intact example of natural rock formation

Recommendation

- Exemption on HDOT 16 feet width criteria
- Rehab deck, girders, and floor beams
- Remove and retain CRM rocks from approach walls to the bridge; rebuild approach walls with a TL-2 reinforced concrete wall; re-install CRM rocks and use as façade for approach walls
- Add concrete bridge name panel on the CRM approach wall
- Retain historic parapets
- Exemption on crash-testing to meet TL-1 criteria
- Investigate abutments, CRM wingwalls, pier columns, and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs
- Dam and sluice gate equipment is an integral part of the EMI aqueduct system and must remain in place

Parapet / Railing Description

Solid concrete wall, no cap

Bridge Components

Kahului side of Kahului & Hana Piers

40 Mokulehua Stream Bridge

Year Built	1908
Lanes	1
Span	3
In/In Width (ft.)	13.78
Length (ft.)	47.90

exceptional bridges

Recommendation

- Prefer to be widen on downstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain historic upstream parapet
- Add detached crash-tested rail across interior face of historic downstream parapet
- Replace downstream side parapet with new best match TL-2 solid crash-tested railing
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Investigate if pier and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Oldest concrete bridge on Maui and the 3rd oldest concrete bridge in Hawaii
- First reinforced concrete bridge built on the Hana Highway
- Replaced a wooden bridge and was constructed on top of the original bridge piers
- Only triple-span, solid parapet bridge on the Hana Highway
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls
- Good intact example of concrete pier walls
- Good intact example of natural rock formation

oldest bridge

exceptional bridges

43 Kawaipapa Stream Bridge

Year Built	1947
Lanes	2
Span	2
In/In Width (ft.)	26.50 (over bridge) 28.50 (over culvert)
Length (ft.)	79.07

Parapet / Railing Description

Bridge Components

Bridge pier rests on natural rock foundation

Description

- Width exceeds the HDOT requirement of 24 feet for a two-lane bridge
- Culvert added in 1991
- Existing railings do not meet TL-2 crash requirements
- Only Post-WWII bridge on Hana Highway
- Good intact example of concrete abutments
- Good intact example of concrete wingwalls
- Good intact example of concrete pier wall

Recommendation

- Install new CRM approach wall
- Add concrete bridge name panel on the CRM approach wall
- Retain railings
- Add detached crash-tested rail across interior face of both historic railings
- Remove and replace concrete covered CRM wingwalls with reinforced concrete wingwalls
- Investigate if concrete abutments, pier, culvert, and foundations meet current seismic codes and are able to support the increase load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Parapet / Railing Description

Open baluster, square post caps, 3-segment railing

Bridge Components

Hana abutment

01 Hoalua Stream Bridge

Year Built	1929
Lanes	1
Span	1
In/In Width (ft.)	16.73
Length (ft.)	48.88

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Investigate if abutments and foundations meet current seismic codes; rehab may be necessary if found to be non-compliant
- Remove and replace concrete/ CRM abutments with reinforced concrete walls
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

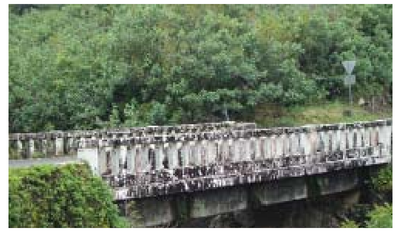
Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of concrete/ CRM concrete abutment

02 Kailua Stream Bridge

Year Built	1929
Lanes	2 (currently used as 1)
Span	1
In/In Width (ft.)	20.34
Length (ft.)	40.03

Parapet / Railing Description



Open baluster, square post caps, 3-segment railing

Bridge Components

Kahului CRM abutment bearing on natural rock

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Note: SI&A sheet describes bridge as having two lanes, existing bridge is currently used as a one-lane bridge
- Exceptional example of CRM abutments
- Exceptional example of CRM wingwalls
- Exemplary example of natural rock formations

Recommendation

- Remove excessive asphalt overlay
- The bridge is currently being utilized as a one-lane bridge. Therefore, it is recommended to change the number of lanes on the bridge from two to for NBI Item 28A and to not widen the bridge
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Preserve exemplary natural rock formation
- Retain existing appearance of CRM abutments and CRM wingwalls, which show evidence of exemplary historic craftsmanship
- Document existing rock configuration of CRM abutments and CRM wingwalls, and carefully remove rocks; rebuild with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 tons load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

CRM abutment and adjacent EMI structures

05 Makanali Stream Bridge

Year Built	1928
Lanes	1
Span	1
In/In Width (ft.)	16.40
Length (ft.)	18.04

Recommendation

- Exemption on HDOT 16 feet width criteria
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Description

- Current width exceeds HDOT requirement of 16 feet for one-lane bridge but will not exceeds after railing installation, see recommendation
- Existing railings do not meet TL-2 crash requirements
- One of five historic Hana bridges that is adjacent to the man-made East Maui Irrigation (EMI) system (Note: EMI system is a National Historic Civil Engineering Landmark)
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls

06 Kaaiea Stream Bridge West

Year Built	1928
Lanes	1
Span	1
In/In Width (ft.)	16.00
Length (ft.)	21.98

Description

- Width equals HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- One of five historic Hana bridges that is adjacent to the man-made EMI system
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

CRM abutment and adjacent EMI structures

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Parapet / Railing Description

Open baluster, square post caps, 1- segment railing

Bridge Components

Underside view of arch ribs

13 Piinaau Stream Bridge

Year Built	1916
Lanes	2
Span	1
In/In Width (ft.)	19.36
Length (ft.)	27.89

Recommendation

- Remove excessive asphalt overlay
- Due to the decreased curb-to-curb width resulting from the installation of interior crash-tested rails, two cars can no longer safely pass by each other on the bridge; therefore it is recommended to change the number of lanes on the bridge from two to one, in which case, widening the bridge to meet the 24 feet requirement for a two-lane bridge would no longer be necessary
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Abutments and foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased loading capacity; rehab may be necessary if found to be non-compliant
- Preserve exemplary natural rock foundation
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation

Description

- Width does not exceeds HDOT requirement of 24 feet for two-lane bridge but will exceeds HDOT requirements of 16 feet for one-lane bridge, see recommendation
- Existing railings do not meet TL-2 crash requirements
- Good intact example of concrete abutments
- Good intact example of CRM wingwalls
- Good intact example of natural rock formations

18 East Wailuaiki Stream Bridge

Year Built	1926
Lanes	1
Span	1
In/In Width (ft.)	18.40
Length (ft.)	34.12

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

CRM abutment

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Scour critical bridge
- Exemplary example of CRM abutments
- Good intact example of CRM wingwalls

Recommendation

- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open vertical TL-2 railings
- Bridge is scour critical; HDOT POA should be followed
- Retain existing appearance of CRM abutments which show evidence of historic craftsmanship
- Document existing rock configuration of CRM abutments, and carefully remove rocks; rebuild abutments with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Remove and replace CRM wingwalls with reinforced concrete walls with natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

20 Puaakaa Stream Bridge

Year Built	1926
Lanes	2
Span	1
In/In Width (ft.)	22.31
Length (ft.)	20.01

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Concrete abutment bearing on natural rock formation

Recommendation

- Due to the decreased curb-to-curb width resulting from the installation of interior crash-tested rails, two cars can no longer safely pass by each other on the bridge; therefore it is recommended to change the number of lanes on the bridge from two to one, in which case, widening the bridge to meet the 24 feet requirement for a two-lane bridge would no longer be necessary
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain existing historic railings
- Add detached crash-tested rail across interior face of historic railings
- Investigate if abutments and foundations meet current seismic codes; rehab may be necessary if found to be non-compliant
- Remove and replace CRM wingwalls with reinforced concrete walls with natural rock façades
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Description

- Width does not exceeds HDOT requirement of 24 feet for two-lane bridge but will exceeds HDOT requirement of 16 feet for one-lane bridge, see recommendation
- Existing railings do not meet TL-2 crash requirements
- Currently designated two lanes
- Good intact example of concrete abutments
- Good intact example of CRM wingwalls

27 East Hanawi Stream Bridge

Year Built	1926
Lanes	1
Span	1
In/In Width (ft.)	16.10
Length (ft.)	22.97

Parapet / Railing Description

Open baluster, square post caps,
1-segment railing

Bridge Components

CRM abutment

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Painted bridge name on top downstream railing
- Good intact example of CRM abutment

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load capacity; rehab may be necessary if found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation

28 Makapipi Stream Bridge

Year Built	1926
Lanes	1
Span	2
In/In Width (ft.)	16.40
Length (ft.)	40.03

Parapet / Railing Description

Open baluster, square post caps, 2-segment railing

Bridge Components

Concrete Pier with abutment beyond

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Concrete pier and foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load capacity; rehab may be necessary if found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs
- Remove or relocate utility lines if possible

Description

- Width exceeds the HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good example of CRM abutments
- Good example of concrete pier cap and columns on concrete pier wall
- Good example of CRM wingwalls

30 Kupukoi Stream Bridge

Year Built	1926
Lanes	1
Span	1
In/In Width (ft.)	16.40
Length (ft.)	23.95

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Kahului CRM abutment

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Superstructure is structurally deficient
- Good intact example of CRM abutments and CRM wingwalls

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Parapet / Railing Description

Open baluster, square post caps,
1-segment railing

Bridge Components

Kahului CRM abutment

31 Kahalaowaka Stream Bridge

Year Built	1926
Lanes	1
Span	1
In/In Width (ft.)	16.00
Length (ft.)	23.95

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Description

- Width equals to meet HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of CRM abutments

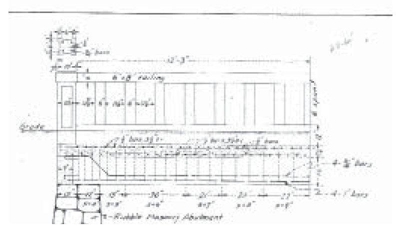
32 Pupape-Manawaikeae Stream Bridge

Year Built	1926
Lanes	1
Span	1
In/In Width (ft.)	16.40
Length (ft.)	23.95

Description

- Width exceeds HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of CRM wingwalls
- Good intact example of natural rock formations

Parapet / Railing Description



Open baluster, square post caps, 1-segment railing

Bridge Components

Hana CRM abutment on natural rock formation

Kahului CRM abutment on natural rock formation

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutment on Hana side and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Remove and replace concrete abutment on Kahului side with reinforced concrete wall
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

33 Kahawaihapapa Stream Bridge

Year Built	1922
Lanes	1
Span	3
In/In Width (ft.)	16.40
Length (ft.)	60.04

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Superstructure is structurally deficient
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls
- Good intact examples of pier walls
- Good intact example of natural rock formations

Parapet / Railing Description

Open baluster, square post caps, 3-segment railing

Bridge Components

Hana CRM abutment on natural rock formation

Kahului CRM abutment on natural rock formation

Recommendation

- Repair superstructure
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Retain existing appearance of CRM abutments, CRM wingwalls, and pier walls which show evidence of historic craftsmanship
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Piers and foundations are to be investigated as to whether they meet current seismic codes and are able to support the increase load carrying capacity; rehab/replacement may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

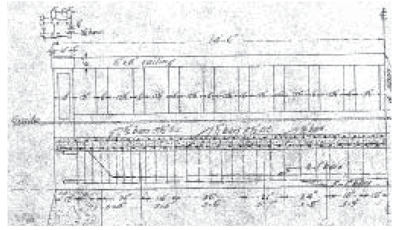
34 Keaaiki Stream Bridge

Year Built	1921
Lanes	1
Span	1
In/In Width (ft.)	16.40
Length (ft.)	21.98

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of CRM abutment

Parapet / Railing Description



Open baluster, square post caps, 1-segment railing

Bridge Components

Hana CRM abutment bearing on natural rock

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight

35 West Waioni Stream Bridge

Year Built	1920
Lanes	1
Span	1
In/In Width (ft.)	16.73
Length (ft.)	28.87

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Hana CRM abutment bearing on natural rock

Recommendation

- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Investigate unconnected concrete remnant; preserve the remnant if found to be historic
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Unconnected concrete remnant in stream
- Good intact example of CRM abutments

36 Waioni Stream Bridge

Year Built	1920
Lanes	2 (currently used as 1)
Span	1
In/In Width (ft.)	16.10
Length (ft.)	23.95

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Kahului CRM abutment bearing on natural rock

Description

- Width exceeds HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements

Recommendation

- The bridge is currently being utilized as a one-lane bridge; therefore, it is recommended to change the number of lanes on the bridge from two to one for NBI Item 28A and to not widen the bridge
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments with TL-2 reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

37 Lanikele Stream Bridge

Year Built	1925
Lanes	1
Span	2
In/In Width (ft.)	16.10
Length (ft.)	50.85

Description

- Width exceeds HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls
- Good intact example of concrete pier wall

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

CRM abutment bearing on natural rock formation

Pier wall

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Piers and foundations are to be investigated as to whether they meet current seismic codes and are able to support the increase load carrying capacity; rehab/replacement may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation

38 Heleleikeoha Stream Bridge

Year Built	1917
Lanes	1
Span	1
In/In Width (ft.)	16.10
Length (ft.)	27.89

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Hana CRM abutment bearing on natural rock

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Superstructure is structurally deficient
- Unconnected concrete remnant in stream

Recommendation

- Repair superstructure
- Remove and retain CRM rocks from approach walls to the bridge; rebuild approach walls with a TL-2 reinforced concrete wall; re-install CRM rocks and use as façade for approach walls
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Investigate unconnected concrete remnant; preserve the remnant if found to be historic
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

39 Ulaino Stream Bridge

Year Built	1914
Lanes	1
Span	2
In/In Width (ft.)	16.40
Length (ft.)	39.04

Parapet / Railing Description

Open baluster, square post caps, 2-segment railing

Bridge Components

Pier with Hana CRM abutment beyond, both bearing on natural rock formation

Recommendation

- Remove and retain CRM rocks from approach walls to the bridge; rebuild approach walls with a TL-2 reinforced concrete wall; re-install CRM rocks and use as façade for approach walls
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and wingwalls with reinforced concrete walls with new natural rock façades
- Pier and foundations are to be investigated as to whether they meet current seismic codes; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Adjacent residence and driveway near Hana upstream approach
- Good intact example of CRM abutments
- Good intact example of pier wall
- Good intact example of natural rock formations

41 Oilowai Stream Bridge

Year Built	1914
Lanes	1
Span	1
In/In Width (ft.)	16.40
Length (ft.)	21.98

Parapet / Railing Description

Open baluster, square post caps, 1-segment railing

Bridge Components

Kahului CRM abutment bearing on natural rock formation

Description

- Width exceeds HDOT requirement of 16 feet for one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls

Recommendation

- Remove excessive asphalt overlay on upstream side
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match open picket TL-2 crash-tested railings
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

contributing solid parapet bridges

Parapet / Railing Description

Solid wall with peaked rail cap; inscription with on downstream elevation

Bridge Components

09 Haipuaena Stream Bridge

Year Built	1912
Lanes	1
Span	2
In/In Width (ft.)	12.80
Length (ft.)	34.12

Recommendation

- Remove excessive asphalt overlay
- Widen upstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace railings with best match TL-2 crash-tested railings
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Abutments, pier, and foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load capacity; rehab may be necessary if found to be non-compliant
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

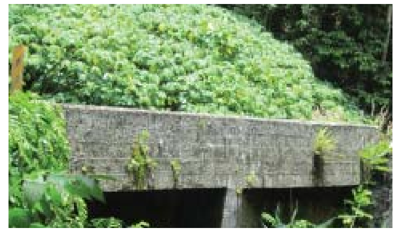
Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Original downstream parapet contains inscribed date panel matching detail of extant original 1911 drawings (Note: parapet heavily damaged unlike bridges #7, 8, and 10)
- Good intact example of concrete pier wall

11 Honomanu Stream Bridge

Year Built	1911
Lanes	1
Span	2
In/In Width (ft.)	12.47
Length (ft.)	47.90

Parapet / Railing Description



Solid wall with integral scuppers

Bridge Components

Concrete pier wall

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Deck and superstructure are structurally deficient
- Existing railings do not meet TL-2 crash requirements
- Good intact example of concrete pier wall

Recommendation

- Remove excessive asphalt overlay
- Replace deck, solid parapets, and superstructure to match original tee girder bridge with upgrades for increased load carrying capacity
- Increase bridge width along downstream side to obtain a minimum clear curb-to-curb distance of 16 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Abutments, foundations, and pier wall are to be investigated as to whether they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab substructure to support 40 ton load carrying capacity and current seismic codes
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

12 Nuaailua Stream Bridge

Year Built	1911
Lanes	2
Span	1
In/In Width (ft.)	21.00 min - 35.80 max (varies)
Length (ft.)	35.10

Parapet / Railing Description

Original solid parapet (left) and widened open picket railing (right)

Bridge Components

Hana concrete abutment

Recommendation

- Remove excessive asphalt overlay
- Bridge shall be widened at least 3 feet on upstream side
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace both parapets with best match, curved open picket TL-2 crash-tested railings
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Abutments and foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Prune vegetation to enhance line of sight
- Replace/add roadway signs

Description

- Width does not meet HDOT requirement of 24 feet for a two-lane bridge
- Existing parapets do not meet TL-2 crash requirements
- Good intact example of concrete abutments

22 Unnamed Stream Bridge No. 1 (Waiohuolua)

Year Built	1920
Lanes	1
Span	1
In/In Width (ft.)	12.50
Length (ft.)	19.03

Parapet / Railing Description

Solid parapet with cap

Bridge Components

Hana CRM abutment with shotcrete

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing railings do not meet TL-2 crash requirements
- Good intact example of CRM abutments

Recommendation

- Widen downstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Replace approach metal guardrails with to install new TL-2 reinforced concrete approach walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace solid parapets with best match TL-2 solid crash-tested parapets following documented original designs
- Remove and replace CRM abutments with reinforced concrete with new natural rock façades
- Foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Rehab superstructure to support 40 ton load carrying capacity
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

23 Unnamed Stream Bridge No. 2

Year Built	1920
Lanes	1
Span	1
In/In Width (ft.)	12.50
Length (ft.)	20.01

Parapet / Railing Description

Solid parapet with cap

Bridge Components

Kahului CRM abutment

Recommendation

- Widen downstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace solid parapets with best match TL-2 solid crash-tested parapets following documented original designs
- Remove and replace CRM abutments and CRM wingwalls with reinforced concrete with new natural rock façades
- Foundations are to be investigated as to whether they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they are found to be non-compliant
- Recalculate load rating after rehabilitation
- Replace/add new roadway signs

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing parapets do not meet TL-2 crash requirements
- Good intact example of CRM abutments
- Good intact example of CRM wingwalls

24 Unnamed Stream Bridge No. 3 (Paakea)

Year Built	1920
Lanes	1
Span	1
In/In Width (ft.)	12.66
Length (ft.)	19.03

Parapet / Railing Description

Solid with no cap

Bridge Components

Kahului CRM abutment

Description

- Superstructure is structurally deficient
- Width does not meet HDOT requirement of 16 feet for a one-lane bridge
- Existing parapets do not meet TL-2 crash requirements
- Good intact example of CRM abutments

Recommendation

- Widen downstream side of bridge to obtain a minimum clear curb-to-curb distance of 16 feet
- Repair superstructure
- Remove CRM approach walls; rebuild approach walls with a TL-2 reinforced concrete wall with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Replace solid parapets with best match TL-2 solid crash-tested parapets following documented original designs
- Remove abandoned parapet on upstream side (recover and photo document)
- Remove and replace CRM abutments with reinforced concrete walls with new natural rock façades
- Foundations are to be investigated as to weather they meet current seismic codes and are able to support the increased load carrying capacity; rehab may be necessary if they found to be non-complaint
- Recalculate load rating after rehabilitation
- Replace/add roadway signs

Parapet / Railing Description

Solid concrete parapets

2C Culvert #01

Year Built	Unknown
Lanes	1
Span	1
Clear Span (ft.)*	8.00
Curb-to-Curb (ft.)	17.75
Culvert Length (ft.)*	19.75

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Recommendation

- Remove excessive asphalt overlay
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Replace railing with best match solid TL-2 parapet
- Deck and foundations to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Replace CRM culvert walls and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

Description

- Width exceeds HDOT requirement of 16 feet for a one-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Reinforced concrete top slab
- Unlined bottom channel

19C Culvert #02

Year Built	Circa 1937-1940
Lanes	2
Span	1
Clear Span (ft.)*	15.00
Curb-to-Curb (ft.)	20.75
Culvert Length (ft.)*	23.00

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Parapet / Railing Description

Upstream CRM parapet (not shown) and downstream solid concrete parapet (above)

Description

- Width does not meet HDOT requirement of 24 feet for a two-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Upstream CRM abutments and downstream concrete abutments
- Reinforced concrete top slab
- Unlined bottom channel
- Load carrying capacity is assumed 10 tons

Recommendation

- Remove excessive asphalt overlay
- Widen on downstream side to obtain a minimum clear curb-to-curb distance of 24 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Replace upstream parapet with stone masonry guardwall
- Replace downstream parapet with best match TL-2 solid parapet
- Deck, abutments, and foundation are to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

20C Culvert #03

Year Built	Circa 1937-1940
Lanes	2
Span	1
Clear Span (ft.)*	16.00 (upstream) 20.5 (downstream)
Curb-to-Curb (ft.)	22.16
Culvert Length (ft.)*	25.00

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Parapet / Railing Description

Upstream CRM parapet (not shown) and downstream solid concrete parapet (above)

Culvert Components

CRM abutment and adjacent EMI structures

Description

- Width does not meet HDOT requirement of 24 feet for a two-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Upstream CRM abutments and downstream concrete abutments
- Reinforced concrete top slab
- Unlined bottom channel

Recommendation

- Remove excessive asphalt overlay
- Widen on downstream side to obtain a minimum clear curb-to-curb distance of 24 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Replace upstream parapet with stone masonry guardwall
- Replace downstream parapet with best match TL-2 solid parapet
- Deck, abutments, and foundations are to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

Parapet / Railing Description

Upstream solid concrete parapet

21C Culvert #04

Year Built	Circa 1937-1940
Lanes	2
Span	1
Clear Span (ft.)*	12.67 (upstream) 13.08 (downstream
Curb-to-Curb (ft.)	21.16
Culvert Length (ft.)*	22.50

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Description

- Width does not meet HDOT requirement of 24 feet for a two-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Upstream CRM abutments and downstream concrete abutments
- Reinforced concrete top slab
- Unlined bottom channel

Recommendation

- Remove excessive asphalt overlay
- Widen on downstream side to obtain a minimum clear curb-to-curb distance of 24 feet
- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Replace upstream parapet with stone masonry guardwall
- Replace downstream parapet with best match TL-2 solid parapet
- Deck, abutments, and foundations are to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM wingwalls with reinforced concrete walls with new rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

42C East Hanawi

Year Built	Unknown
Lanes	1 (listed as 2)
Span	1
Clear Span (ft.)*	12.00
Curb-to-Curb (ft.)	15.10
Culvert Length (ft.)*	16.50

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Parapet / Railing Description

Solid panel parapets

Culvert Components

View of Kahului approach

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Reinforced concrete abutments and top slab
- Unlined bottom channel

Recommendation

- Remove excessive asphalt overlay
- Remove and retain CRM rocks from approach walls; rebuild with a TL-2 reinforced concrete walls; re-install CRM rocks as façades of approach walls
- Add concrete bridge name panel on the CRM approach wall
- Widen downstream side of culvert to obtain a minimum clear curb-to-curb distance of 16 feet
- Retain existing historic parapet
- Relocate downstream historic parapet to meet width criteria (refer to Section C, Culvert 42C for more details)
- Add detached crash-tested rail across interior face of historic parapets
- Retain existing appearance of CRM wingwalls, which show evidence of historic craftsmanship
- Document existing rock configuration of CRM wingwalls, and carefully remove rocks; rebuild wingwalls with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Culvert (deck and walls) and foundations are to be investigated as to whether they meet current seismic codes and are able to support the 40 ton load carrying capacity; rehab/replacement may be necessary if found to be non-compliant
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

52C Culvert #05

Year Built	Unknown
Lanes	1
Span	1
Clear Span (ft.)*	14.50
Curb-to-Curb (ft.)	14.83
Culvert Length (ft.)*	16.25

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Parapet / Railing Description

Open picket railings

Culvert Components

CRM culvert abutment

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Reinforced concrete top slab
- Unlined bottom channel
- Load carrying capacity is assumed 10 tons

Recommendation

- Remove excessive asphalt overlay
- Install new stone masonry guardwall at the approach corners
- Widen upstream side of culvert to obtain a minimum clear curb-to-curb distance of 16 feet; currently, there appears to be private property directly upstream and downstream of the bridge; HDOT to determine which property they will acquire for the widening
- Retain existing historic railings
- Relocate the historic railing affected by the widening width criteria (refer to Section C, Culvert 52C for more details)
- Add detached crash-tested rail across interior face of historic railings
- Deck and foundations to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Retain existing appearance of CRM abutments and wingwalls, which show evidence of historic craftsmanship
- Document existing rock configuration of CRM abutments and wingwalls, and carefully remove rocks; rebuild wingwalls and abutments with reinforced concrete and re-install CRM rocks to match historic craftsmanship
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

Parapet / Railing Description

Open picket railings

53C Culvert #06

Year Built	Unknown
Lanes	1
Span	1
Clear Span (ft.)*	11.58
Curb-to-Curb (ft.)	15.08
Culvert Length (ft.)*	16.50

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Recommendation

- Remove excessive asphalt overlay
- Install new stone masonry guardwall at the approach corners
- Widen upstream side of culvert to obtain a minimum clear curb-to-curb distance of 16 feet
- Retain existing historic railings
- Relocate upstream historic railings to meet width criteria (refer to Section C, Culvert 53C for more details)
- Add detached crash-tested rail across interior face of historic railings
- Deck and foundations to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab with may be necessary if found to be non-compliant
- Remove and replace CRM culvert walls and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs
- Install two new utility poles to replace the single pole that is currently in the path of the temporary by-pass bridge

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane culvert
- Existing railings do not meet TL-2 crash requirements
- Reinforced concrete top slab
- Unlined bottom channel

54C Culvert #07

Year Built	Unknown
Lanes	1
Span	1
Clear Span (ft.)*	5.33
Curb-to-Curb (ft.)	14.58
Culvert Length (ft.)*	15.66

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Parapet / Railing Description

Open picket railings

Culvert Components

Concrete slab and CRM abutments

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane culvert
- Existing railings do not meet TL-2 crash requirements
- Reinforced concrete top slab
- Unlined bottom channel

Recommendation

- Remove excessive asphalt overlay
- Install new stone masonry guardwall at the approach corners
- Widen upstream side of culvert to obtain a minimum clear curb-to-curb distance of 16 feet
- Retain existing historic railings
- Relocate upstream historic railings to meet width criteria (refer to Section C, Culvert 54C for more details)
- Add detached crash-tested rail across interior face of historic railings
- Deck and foundations to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM culvert walls and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

Parapet / Railing Description

Open picket railing

55C Culvert #08

Year Built	Unknown
Lanes	1
Span	1
Clear Span (ft.)*	11.5
Curb-to-Curb (ft.)	15.08
Culvert Length (ft.)*	16.25

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Recommendation

- Remove excessive asphalt overlay
- Install new stone masonry guardwall at the approach corners
- Widen upstream side of the culvert to obtain a minimum clear curb-to-curb distance of 16 feet
- Retain existing historic railings
- Relocate the historic railing affected by the widening width criteria (refer to Section C, Culvert 55C for more details)
- Add detached crash-tested rail across interior face of historic railings
- Deck and foundations to be investigated as to whether it is able to support 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM culvert walls and CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs
- Install two new telephone poles to replace single pole immediately adjacent to proposed temporary by-pass bridge

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane culvert
- Existing railings do not meet TL-2 crash requirements
- Reinforced concrete top slab
- Unlined bottom channel

56C Culvert #09

Year Built	1915
Lanes	2
Span	1
Clear Span (ft.)*	14.08 (upstream) 23.00 (downstream)
Curb-to-Curb (ft.)	26.30
Culvert Length (ft.)*	28.16

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Description

- Width exceeds HDOT requirement of 24 feet for a two-lane culvert
- Reinforced concrete abutments and top slab
- Unlined bottom channel
- Load carrying capacity is assumed 10 tons (due to lack of information on existing culvert); new widened culvert, built downstream of existing, has a load carrying capacity of 40 tons
- Historic upstream solid concrete parapet
- Note: Downstream parapet replaced in 2014 and 1915 inscription lost
- New concrete name plaque on the exterior side of upstream parapet: “Holoina wa wae Gulch 1951”

Parapet / Railing Description

Upstream solid concrete panel parapet (above) and downstream solid concrete parapet (left)

Recommendation

- Remove CRM approach walls; rebuild approach walls with TL-2 reinforced concrete walls with new natural rock façades
- Add concrete bridge name panel on the CRM approach wall
- Retain upstream historic parapet
- Add detached crash-tested rail across interior face of upstream historic parapet
- Original culvert and foundations to be investigated as to whether they meet current seismic codes and are able to support the 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs
- Concrete plaque’s date is wrong and should be fixed to 1915 (remove the current panel and install at the new approach wall)

Parapet / Railing Description

Solid concrete parapets

57C Culvert #10

Year Built	Unknown
Lanes	1
Span	1
Clear Span (ft.)*	14.08
Curb-to-Curb (ft.)	12.50
Culvert Length (ft.)*	14.10

* Culvert width is width of barrel (clear span). Culvert length is measured from upstream to downstream.

Recommendation

- Remove excessive asphalt overlay
- Install new approach walls with TL-2 reinforced concrete walls with new natural rock façades at all approach corners
- Widen upstream side of culvert to obtain a minimum clear curb-to-curb distance of 16 feet
- Retain existing historic parapet
- Relocate upstream historic parapet to meet width criteria (refer to Section C, Culvert 57C for more details)
- Add detached crash-tested rail across interior face of historic parapets
- Culvert deck, abutments, and foundations to be investigated as to whether they meet current seismic codes and are able to support the 40 ton load carrying capacity; rehab may be necessary if found to be non-compliant
- Remove and replace CRM wingwalls with reinforced concrete walls with new natural rock façades
- Recalculate load rating after rehabilitation
- Localized topographic study recommended for further drainage analysis
- Replace/add roadway signs

Description

- Width does not meet HDOT requirement of 16 feet for a one-lane culvert
- Existing parapets do not meet TL-2 crash requirements
- Reinforced concrete abutments and top slab
- Unlined bottom channel
- Inset inscription “1915” on outside face of downstream parapet

SECTION A

REPORT

CHAPTER 1
GENERAL

i. O V E R V I E W

This study focuses on the 43 historic bridges and 12 identified historic culverts located within the state-owned portion of the Hana Belt Road Historic District. The district also includes seven hillside bridges and 45 additional culverts that are not readily visible to drivers, as identified in this report. The Hana Belt Road Historic District also includes several historic structures located within the county-owned portion, along Piilani Highway and within Haleakala National Park (refer to Section A, Chapter 7. i. a. *Maui Island & Hana Belt Road Historic District* for a full overview of the structures identified within each boundary area); those structures are not included in this study. A map of the entirety of the Hana Belt Road Historic District graphically illustrates the two different highways located within the boundaries of the historic district, as well as the boundary scope for structures addressed in this preservation plan (refer to *Figure 1 – 1*). The purpose of this report is to develop a preservation plan for these structures found within the state-owned portion of the Hana Belt Road Historic District. As a recognized historic site, the State of Hawaii Department of Transportation and Federal Highways Administration must consult with the State Historic Preservation Division (SHPD) when a project may affect the historic district or structures located within the district.

Treatment of an historic property addresses the course of action that is deemed most appropriate for each structure. It takes into account historic features still existing and the bridge's ability to convey its historic significance and the story of Hana Highway, Route 360. The recommended treatment will involve options for preservation, rehabilitation, restoration, and replacement (for further details, refer to Section A, Chapter 4. ii. *Federal Standards for the Treatment of Historic Bridges*). A conceptual plan for the treatment of each bridge and culvert that contributes to the Hana Belt Road Historic District is included to assist future designers, engineers, and HDOT. The team looked into context sensitive design philosophies, informed by public input early in the planning process. The conceptual plans were developed in consideration of the historic significance and value of each individual bridge and its surroundings, while taking into account public safety and federal funding constraints.

The community's perceptions of issues and concerns may affect the timing, outcome, and cost of any project involving historic sites. A community outreach process that includes collaboration and discussions at the earliest stage of the project and for the duration of the project may help provide opportunities for overall cost-effectiveness.

a. How to Use This Report

A goal of the *Hana Highway Historic Bridge Preservation Plan* (2015) is to provide HDOT with an informational tool that can be used by HDOT and future design consultants as a reference manual for bridge construction projects along the Hana Highway, Route 360. For ease of reference, the *Hana Highway Historic Bridge Preservation Plan* (2015) is formatted such that each historic bridge or culvert forms an individual chapter within the overall report document, which provides a framework and context for the team's recommendations.

Basis of Information: Section A, Chapters 1 and 2
Regulatory information and literature review of known, long-range community plans are presented first, to provide a foundation for the team's methodology and community outreach.

Identification and Evaluation: Section A, Chapter 3
Identification of bridge components and evaluation methods per historic guidelines follow the informational foundation, in order to ensure consistency within the team's approach.

Balancing, Enhancing, and Protecting: Section A, Chapters 4 and 5
Design standards and guidelines, including public safety issues, form the crux of this preservation plan, balancing present day safety priorities with sensitivity to historic and cultural context.

Additional Considerations: Section A, Chapter 6

This portion addresses several concerns and topics that the team identified while preparing the *Hana Highway Historic Bridge Preservation Plan* (2015). Due to the limited scope of this project, these concerns were not directly addressed, but it is strongly encouraged that these concerns are taken into consideration when planning for future projects.

Development of East Maui through History – A History: Section A, Chapter 7

A detailed overview of the development of East Maui and the Hana Belt Road can be found in this chapter, with additional historic and cultural context provided in the individual bridge and culvert chapters, and appendices.

Site Specific Conditions and Detailed Treatment Recommendations: Sections B and C

Included in the individual chapters for each particular bridge and culvert are relevant cultural, historical, and technical information presented and recommended treatment for each bridge and culvert in Section B. *Bridges* and Section C. *Culverts*, respectively, of this report:

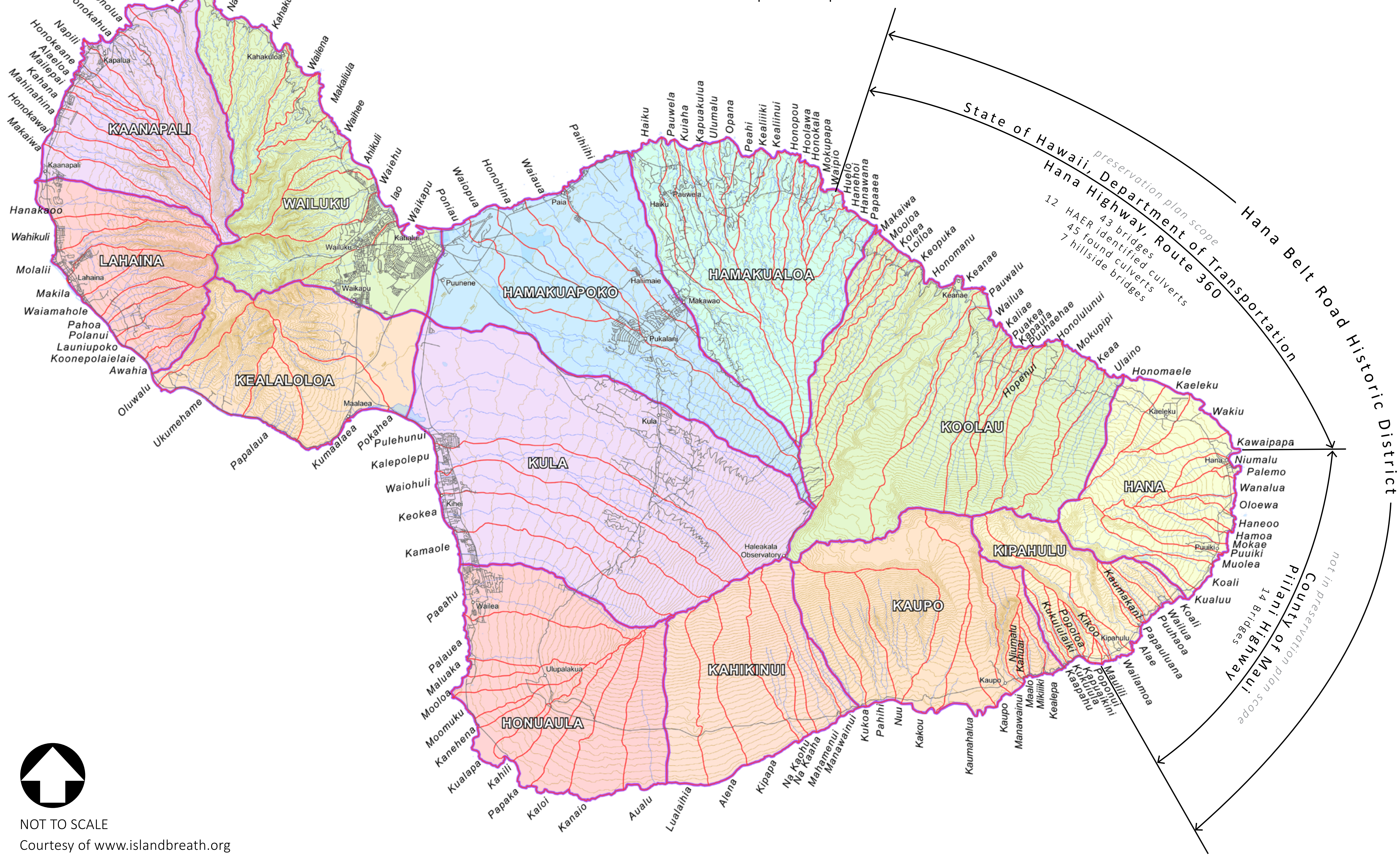
- An at-a-glance inventory sheet for each bridge or culvert, with:
    - Photograph and map location,
    - Documentation of existing conditions,
    - Pertinent considerations adjacent to bridge and culvert locations, such as private property, utilities, and signage,
    - Structural conditions, such as load rating and overall condition,
    - Statement of historic/cultural significance and historic references, and
    - Character-defining features of each bridge and culvert, as well as:
- Detailed information pages that address:
    - References to current civil, electrical, and structural inspections, and identified issues,
    - Historic and cultural site context pertinent to each historic bridge or culvert location, and
    - Site-specific recommendations by the team for each individual bridge or culvert.

Additional Structures along the Hana Highway, Route 360: Sections D and E

General reference information is provided for the State of Hawaii Department of Transportation's use regarding the 45 found culverts and 7 hillside bridges.

Hana Belt Road Historic District

overlaid on Ahupuaa map



Courtesy of www.islandbreath.org

Figure 1 – 1: Hana Belt Road Historic District, State and County Boundary Map

ii. SCOPE OF SURVEY

The Hana Belt Road Historic District begins at mile marker 2.8 near #01 Hoalua Bridge and extends past Kipahulu to the south end of Koukouai Bridge near mile marker 40.6 of Piilani Highway. The term "mile marker" is used in this sole context per measurement data provided in the National Register Nomination. Throughout the remainder of this report, the term "mile point" or "MP" is used to indicate accuracy in bridge and culvert locations consistent with measurements in the HDOT bridge database. Koukouai Bridge is the final bridge in the historic district. The width of the district is the historic highway right-of-way (ROW), which is approximately 40 feet wide but varies.[1]

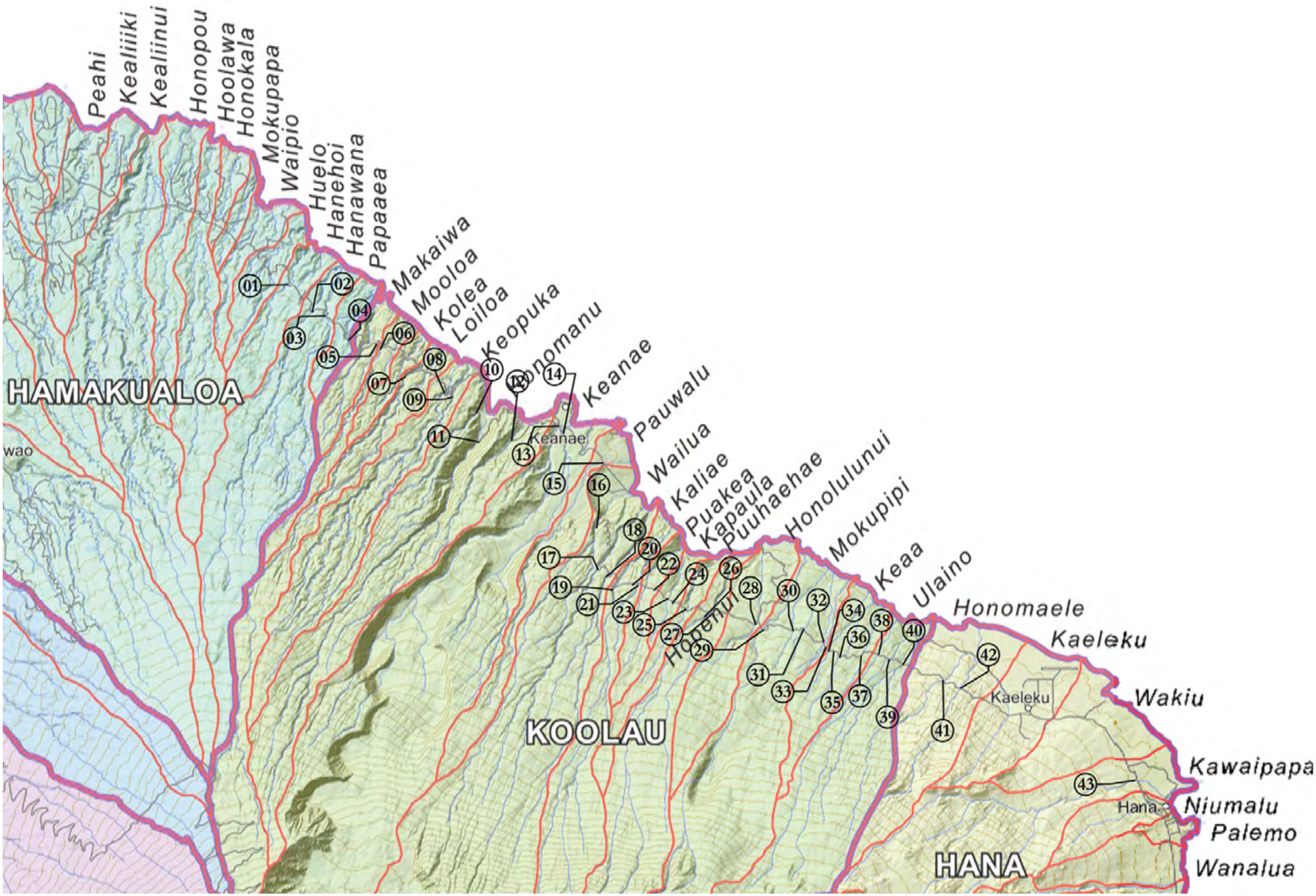
The scope of this preservation plan project is defined by those State bridges within the Historic District, along the portion of highway identified as State Route 360, or simply "Route 360" as it shall be referred to within this report, between the mile marker 5.00 to the mile marker 34.00, respectively (see map on previous page, labeled "Hana Belt Road Historic District"). These bridges are numbered beginning from #01 Hoalua Stream Bridge on the Huelo side to #43 Kawaipapa Stream Bridge in Hana (refer to *Figure 1 – 2*, below, and *Figure 1 – 3*, the map on the following page, labeled "Hana Highway, Route 360").

Historic Bridges Along Hana Highway, Route 360

1	Hoalua Stream	1929	23	Unnamed Stream No. 2	1920
2	Kailua Stream	1929	24	Unnamed Stream No. 3	1920
3	Nailiilihaele Stream	1930	25	Kapaula Stream	1926
4	Oopuola Stream	1925	26	Hanawi Stream	1926
5	Makanali Stream	1928	27	East Hanawi Stream	1926
6	Kaaiea Stream	1928	28	Makapipi Stream	1926
7	Waikamoi Stream	1912	29	Kuhiwa Stream	1926
8	Puohokamoa Stream	1912	30	Kupukoi Stream	1926
9	Haipuaena Stream	1912	31	Kahalaowaka	1926
10	Kolea (Punalau Stream)	1911	32	Pupape Stream	1926
11	Honomanu Stream	1911	33	Kahawaihapapa Stream	1922
12	Nuaailua Stream	1911	34	Keaaiki Stream	1921
13	Piinaau Stream	1916	35	West Waioni Stream	1920
14	Palauhulu Stream	1916	36	Waioni Stream	1920
15	Waiokamilo Stream	1921	37	Lanikele Stream	1925
16	Waikani Stream	1926	38	Heleleikeoha Stream	1917
17	West Wailuaiki Stream	1926	39	Ulaino Stream	1914
18	East Wailuaiki Stream	1926	40	Mokulehua Stream	1908
19	Kopiliula Stream	1926	41	Oilowai Stream	1914
20	Puaakaa Stream	1926	42	Honomaele Stream	1924
21	Waiohue Stream	1937	43	Kawaipapa Stream	1947
22	Unnamed Stream No. 1 (Waiohuolua)	1920			

Figure 1 – 2: State-owned bridges numbered in order of appearance, from Huelo towards Hana

[1] *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 6.



NOT TO SCALE
Courtesy of www.islandbreath.org
Figure 1– 3: Map of Historic Bridges along the Hana Highway

Hana Highway, Route 360
overlaid on Ahupuaa map

iii. SCOPE OF WORK

The *Hana Highway Historic Bridge Preservation Plan* (2015) identifies known conditions at each bridge or culvert, as well as possible strategies for HDOT to apply to each structure. The scope of this preservation plan does not include construction or design, since it is recognized that future design teams will need to address specific concerns and potentially unforeseen issues that are dependent upon various project factors at each location. Conceptual drawings are included in this report for reference; however, this remains a document solely intended to aid in HDOT's future planning goals and objectives.

This project aims to provide treatment recommendations for each bridge, taking into account its historic significance and contribution to the historic district in combination with public safety and structural considerations. An essential aspect of this task is also to interface with community groups in order to better understand the needs and issues facing East Maui, which will further inform HDOT's strategy for the long term care of structures along the Hana Highway, Route 360.

The scope of work included the following major tasks:

- Document each bridge's historic character.
- Review and be familiar with previous studies and preservation guidelines for historic bridges.
- Review and be familiar with public safety considerations including applicable design standards, National Bridge Inspection Standards (NBIS) and ratings, and tort liability issues.
- Evaluate each bridge with respect to condition and public safety considerations. Factors such as safety, liability, cost, aesthetics, historic value, and agency and community input will be included.
- Develop a community and agency consultation process to ensure that input is received regarding the bridge evaluation and preservation process. The community outreach component is an integral part of project implementation in terms of providing information and education, and obtaining input for completion of the *Hana Highway Historic Bridge Preservation Plan* (2015). An important aspect to the preparation of this preservation plan is obtaining an assessment of the potential community perceptions, issues, and concerns that may affect the timing and outcome of this project.
- Develop and prepare recommendations for each bridge considering historic qualities, public safety, funding options, and community/agency input.
- Recommend alternate roadside protections that will have both community and visitor appeal, such as rock-faced structures, special bridge rails, and finishes compatible with the historic bridges where appropriate.
- Review and be familiar with federal funding alternatives to optimize the use of limited resources and appropriate programs.

iv. REGULATORY BACKGROUND

The laws noted below affect the way HDOT conducts their projects and treats historic sites. The Hana Belt Road is a recognized historic district; therefore, HDOT must consult with government agencies and the community before a project may proceed. Because of extensive community and agency outreach involved with this project, it is intended that the *Hana Highway Historic Bridge Preservation Plan* (2015) be considered early consultation with the SHPD.

a. State Law

Hawaii Revised Statutes (HRS), Chapter 6E (1976). Chapter §6E-8 of the HRS *Review of effect of proposed State and County projects*, requires HDOT to provide the SHPD with an opportunity for review and must receive a written concurrence before a project can proceed.[2] In HRS §6E-2, a "project" is defined as any activity affecting an historic site or property directly undertaken by the State or its political subdivisions or supported in whole, or in part, through appropriation, contracts, grants, subsidies, loans, or other forms of funding assistance from the State or its political subdivisions or involving any lease, permit, license, certificate, land use change, or other entitlement for use issued by the State or its political subdivisions (Hawaii Senate Bill SB 3010).

Since any construction project along the Hana Highway, Route 360 would be considered a project that may affect an historic site, the SHPD must be provided an opportunity to review and concur with the project at the earliest opportunity.

Hawaii Revised Statutes, Chapter 343. Chapter §343-5 of the HRS, requires HDOT to provide an environmental assessment (EA) for actions which propose use within any historic site designated in the State or National Registers of Historic Places, per the National Historic Preservation Act (NHPA) of 1966, Public Law 89-665, as noted in the discussion of Chapter 6E mentioned above. Following preparation of an EA, it shall be determined if preparation of an environmental impact statement (EIS) shall be required.

b. Federal Law

Since the 1960s, Congress has passed various federal laws to protect cultural resources. The laws that impact the HDOT process of protecting Hawaii's cultural resources are summarized below. The aforementioned consultation process with the SHPD must be followed whenever federal funds are utilized.

State agencies managing federally-funded projects must also comply with and are subject to the rules and regulations that comprise the NHPA and the National Environmental Policy Act (NEPA) and their applicable components, Section 106 and Section 4(f), respectively.

National Environmental Policy Act of 1969 (42 U.S.C. §§4321-4347). NEPA requires federal agencies to identify and consider the environmental impacts of federal actions and includes consideration of impacts on cultural resources, as well as reasonable alternatives to proposed actions. Through the processes of NEPA and the NHPA, federal agencies provide for the identification and consideration of historic properties prior to undertaking any action that may potentially affect these resources. Compliance with NEPA may be completed and enforced at state and federal levels, through the Section 106 and Section 4(f) processes, as described below and on the following page.

National Historic Preservation Act of 1966 (as amended) (16 United States Codes and Statues (U.S.C.) §470). NHPA recognizes the nation's historic heritage and establishes a national policy for the preservation of historic properties. The act contains several sections, each specifying procedures and mechanisms for developing and implementing historic preservation programs. Section 106 notes that any project involving federal monies to

[2] State of Hawaii, *§6E-8 Review of effect of proposed State and County projects,* under Hawaii Revised Statutes Chapter 6E, http://www.state.hi.us/dlnr/hpd/hpfctsht.htm (accessed March 28, 2013).

obtain permitting, licensing, and approval must follow an established review process to ensure that historic partners have an opportunity to comment. Since most major bridge projects involve federal funding, Section 106 review process applies to projects along Hana Highway, Route 360. There are three types of effect determinations, or "findings," that may result from a proposed HDOT project within the Hana Belt Road Historic District:

No Adverse Effect
With a finding of "no adverse effect," an agency may proceed with the proposed undertaking and any agreed-upon conditions.

Conditional No Adverse Effect
A finding of "no adverse effect" with conditions may be determined if "…the undertaking is modified or conditions are imposed, such as the subsequent review of plans for rehabilitation by the SHPO/THPO to ensure consistency with the Secretary's Standards for the Treatment of Historic Properties (36 CRF part 68) and applicable guidelines, to avoid adverse effects."[3]

Adverse Effect
An "adverse effect" is defined in 36 Code of Federal Regulations (CFR) § 800.5(a)(1) as an action that may: "alter, directly or indirectly, any of the characteristics that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. …Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative."[4] Adverse effects include, but are not limited to: demolition; alteration; removal of a property from its original setting; neglect; abandonment; or the introduction of visual, atmospheric, or audible elements.[5] When a finding of "adverse effect" is established, a memorandum of agreement (MOA) shall be created. The MOA outlines mitigation measures that an agency (i.e., HDOT) will take to avoid, minimize, or mitigate adverse effects to an historic property.

Department of Transportation Act (DOT Act) of 1966. This act includes a special provision called Section 4(f), which applies to all transportation projects that utilize federal funds and involve historic sites, and which stipulates that the FHWA and other DOT agencies cannot approve the use of land from publicly-owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless the following conditions apply:

- There is no feasible and prudent alternative to the use of land, and
- The action includes all possible planning to minimize harm to the property resulting from use.

"Use" of a property protected under Section 4(f) may be defined as any of the following:

a) As permanent incorporation of land,
b) As temporary occupation of land if that temporary occupancy meets certain criteria, or
c) By effect of proximity where noise, visibility, or other like conditions substantially impair the protected features of the property.

The Section 4(f) provision for proposed transportation projects may be addressed through the "Programmatic Section 4(f) Evaluation and Approval" for FHWA Projects, overseen by the FHWA State of Hawaii Division. The programmatic Section 4(f) approval sets forth the basis that there are no feasible and prudent alternatives to the

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[3] "§ 800.5 Assessment of adverse effects.," 36 CFR Part 800 – Protection of Historic Properties, Subpart B – The Section 106 Process, § 800.5 Assessment of adverse effects., (b) Finding of no adverse effect., Advisory Council on Historic Preservation, http://www.achp.gov/regs-rev04.pdf (accessed September 17, 2015).
[4] "§ 800.5 Assessment of adverse effects.," 36 CFR Part 800 – Protection of Historic Properties, Subpart B – The Section 106 Process, § 800.5 Assessment of adverse effects., (a) Apply criteria of adverse effect., (1) Criteria of adverse effect., Advisory Council on Historic Preservation, http://www.achp.gov/regs-rev04.pdf (accessed September 17, 2015).
[5] "Working with Section 106," Advisory Council on Historic Preservation, http://www.achp.gov/work106.html (accessed September 19, 2014).

use of certain historic bridge structures proposed for replacement or rehabilitation with federal funds, and that such projects have included all possible planning to minimize harm resulting from such use.[6]

Bridges located along Hana Highway, Route 360, are considered applicable projects for the "Programmatic Section 4(f) Evaluation and Approval," which must meet the following criteria:

1. Bridge is to be replaced or rehabilitated with federal funds,
2. Project will require the use of an historic bridge structure which is on or is eligible for listing on the National Register of Historic Places (NRHP),
3. Bridge is not a National Historic Landmark,
4. FHWA Division Administrator determines that the facts of the project match those set forth in "Eligibility Criteria," "Alternatives Considered," and "Measures to Minimize Harm" (refer to Section G, Appendix 6. *"Programmatic Section 4(f) Determination & Approval Form for Historic Bridges"*),
5. Agreement among the FHWA, SHPD, and the Advisory Council on Historic Preservation (ACHP) has been reached through procedures pursuant to Section 106 of the NHPA.[7]

In 2005, as part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU, Public Law 109-59, Aug. 10, 2005), Congress amended Section 4(f) to provide an alternative method of approving the use of protected resources where the impact is *de minimis*. The *de minimis* impact determination provides the basis for U.S. DOT to approve the minor use of a Section 4(f) property without identifying and evaluating avoidance alternatives—thus streamlining the approval process. The use of an historic resource that has received an "adverse effect" determination through the Section 106 process, however, may not be considered *de minimis*. The new regulations were also codified, for the first time, in a stand-alone section of the regulations—23 C.F.R. §774.[8]

[6] "Programmatic Section 4(f) Evaluation and Approval for FHWA Projects that Necessitate the Use of Historic Bridges," U.S. Department of Transportation, Federal Highway Administration, http://environment.fhwa.dot.gov/4f/4fbridge.asp (accessed December 16, 2014).

[7] "Programmatic Section 4(f) Evaluation and Approval for FHWA Projects that Necessitate the Use of Historic Bridges," U.S. Department of Transportation, Federal Highway Administration, http://environment.fhwa.dot.gov/4f/4fbridge.asp (accessed December 16, 2014).

[8] "23 CFR §774 – Parks, Recreation Areas, Wildlife and Waterfowl Refuges, and Historic Sites (Section 4(f))," United States Government Publishing Office, Code of Federal Regulations, United States of America, http://www.gpo.gov/fdsys/pkg/CFR-2011-title23-vol1/pdf/CFR-2011-title23-vol1-part774.pdf (accessed September 17, 2015).

v. COUNTY GENERAL PLANS & COMMUNITY PLANS

This section identifies several long-range county and general plans prepared for specific areas within the County of Maui, and which identify additional resources, core principles, and stated objectives to help improve the cultural experience and biodiversity of the landscape for residents of and visitors to this scenic community. Pertinent aspects of four plans are excerpted here to provide summary and context for the *Hana Highway Historic Bridge Preservation Plan* (2015).

a. County of Maui 2030 General Plan – Countywide Policy Plan

"Chapter 2.80B" of the *Maui County Code* relating to the *General Plan and Community Plans*, implements the County's Charter provisions through legislation which calls for a *Countywide Policy Plan* and a *Maui Island Plan*. The *Countywide Policy Plan* was adopted by Ordinance No. 3732 on March 24, 2010.

The following sections identify objectives, policies, implementing actions and other related provisions pertinent to the *Hana Highway Historic Bridge Preservation Plan* (2015).

The *Countywide Policy Plan* has ten core principles cited to accomplish its vision which, in part, states, *"…the people of our islands must foster and respect the Aloha Spirit. We must consider the future generations of Maui County and be true to these core principles":*[9]

1. *Excellence in the stewardship of the natural environment and cultural resources;*
2. *Compassion for and understanding of others;*
3. *Respect for diversity;*
4. *Engagement and empowerment of Maui County residents;*
5. *Honor for all cultural traditions and histories;*
6. *Consideration of the contributions of past generations as well as the needs of future generations;*
7. *Commitment to self-sufficiency;*
8. *Wisdom and balance in decision making;*
9. *Thoughtful, island-appropriate innovations; and*
10. *Nurturance of the health and well-being of our families and our communities.*[10]

The *Countywide Policy Plan* is the over-arching document for the *Maui Island Plan* and community plans described in the following sections. The process of developing the *Hana Highway Historic Bridge Preservation Plan* (2015) considers core principles 1, 2, 3, 4, 5, 6, and 8.

The plan recognizes the potential to lose places and characteristics that make the County of Maui unique and special. Primary concerns are to protect the environment and natural, cultural, and scenic resources. The *Hana Highway Historic Bridge Preservation Plan* (2015) places a high priority on these factors and will balance them with transportation safety standards which do not adversely impact residents' use of the highway.

The *Countywide Policy Plan* describes the early Hawaiian's unique system of land utilization by dividing lands into large regional boundaries known as *moku* sections, which are further subdivided into many wedged shaped land divisions known as *ahupuaa*, running from the mountains to the sea. These land divisions are still recognized today (refer to Section A, Chapter 7. i. b. *Hawaiian Land Divisions: East Maui Moku & Ahupuaa*). In this regard, State

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[9] County of Maui, *County of Maui 2030 General Plan: Countywide Policy Plan*, cover, forward & table of contents, County of Maui, State of Hawaii, http://www.co.maui.hi.us/index.aspx?NID=420 (accessed July 2014), iii.
[10] Ibid.

legislation has established an Aha Moku Advisory Committee.[11] The community outreach program for the bridge preservation plan recognizes these *moku* representatives through the outreach consultation process.

The *Countywide Policy Plan* chronicles the Maui Island ditch system which was built in the 1800s. These ditches conveyed water from East Maui to sugarcane fields in Paia. The East Maui Irrigation (EMI) Company manages the water system and is being consulted with as part of the preservation plan development process to discuss EMI's irrigation facilities adjacent to affected historic bridges along the Hana Highway, Route 360.

The *Countywide Policy Plan* highlights the components of the natural, historic and cultural environment that make the County of Maui special, unique, and world renown. Native and endemic species are threatened by introduced invasive species. Scenic resources are a prime quality of life feature for residents, and they attract national and international visitors. Maintaining the presence of historic resources within the islands' landscape is invaluable. And, within the geographical environment are past and present Hawaiian practices that define our deep rooted culture. Natural and cultural resources are significant considerations in the planning processes.

Goals, objectives, policies and actions of the *Countywide Policy Plan* that are relevant to the bridge preservation plan are noted below:

Protect the Natural Environment

- Goal: *Maui County's natural environment and distinctive open spaces will be preserved, managed, and cared for in perpetuity.*
  - Objective: *Improve the opportunity to experience the natural beauty and native biodiversity of the islands for present and future generations.*[12]
    - Policy: *Protect the natural state and integrity of unique terrain, valued natural environments, and geological features.*[13]

Preserve Local Cultures and Traditions

- Goal: *Maui County will foster a spirit of pono and protect, perpetuate, and reinvigorate its residents' multi-cultural values and traditions to ensure that current and future generations will enjoy the benefits of their rich island heritage.*
  - Objective: *Perpetuate the Hawaiian Culture as a vital force in the lives of residents.*[14]
    - Policy: *Encourage the use of traditional Hawaiian architecture and craftsmanship.*[15]
    - Policy*: Promote, encourage, and require the correct use of traditional place names, particularly in government documents, signage, and the tourism industry.*[16]
  - Objective: *Preserve and restore significant historic architecture, structures, cultural sites, cultural districts, and cultural landscapes.*[17]
    - Policy: *Perpetuate the authentic character and historic integrity of rural communities and small towns.*[18]
    - Policy: *Provide opportunities for public involvement with restoration and enhancement of all types of cultural resources.*[19]

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[11] House of Representatives, "HB2806 HD2 SD2 CD1: A Bill for an Act, Relating to Native Hawaiians Act 288 (12)," House of Representatives, Twenty-Sixth Legislature 2012, State of Hawaii, http://www.ahamoku.org/wp-content/uploads/2011/09/GM1405_signed.pdf (accessed July 2014).
[12] County of Maui, *County of Maui 2030 General Plan: Countywide Policy Plan*, section iv, County of Maui, State of Hawaii, http://www.co.maui.hi.us/index.aspx?NID=420 (accessed July 2014), 46.
[13] Ibid., 46.
[14] Ibid., 49.
[15] Ibid.
[16] Ibid.
[17] Ibid., 51.
[18] Ibid.

Diversity Transportation Options

- Goal: *Maui County will have an efficient, economical, and environmentally sensitive means of moving people and goods.*
    - Objective: *Provide an effective, affordable, and convenient ground-transportation system that is environmentally sustainable.*[20]
        - Policy: *Ensure that roadway systems are safe, efficient, and maintained in good conditions.*
        - Policy: *Preserve roadway corridors that have historic, scenic, or unique physical attributes that enhance the character and scenic resources of communities.*
        - Policy: *Design new roads and roadway improvements to retain and enhance the existing character and scenic resources of the communities through which they pass.*[21]
        - Policy: *Evaluate all alternatives to preserve quality of life before widening roads.*[22]
    - Objective: *Improve and expand the planning and management of transportation systems.*[23]
        - Policy: *Support the revision of roadway-design criteria and standards so that roads are compatible with surrounding neighborhoods and the character of rural area.*[24]

Strive for Good Governance

- Goal: *Government services will be transparent, effective, efficient, and responsive to the needs of residents.*[25]
    - Objective: *Promote civic engagement.*[26]
        - Policy: *Foster consensus building through in-depth, innovative, and accessible public-participatory processes.*
        - Policy: *Promote and ensure public participation and equal access to government among all citizens.*[27]
        - Policy: *Encourage the State to improve its community-involvement processes.*[28]
        - Policy: *Expand opportunities for all members of the public to participate in public meetings and forums.*[29]

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[19] County of Maui, *County of Maui 2030 General Plan: Countywide Policy Plan*, section iv, County of Maui, State of Hawaii, http://www.co.maui.hi.us/index.aspx?NID=420 (accessed July 2014), 51.
[20] Ibid., 66.
[21] Ibid.
[22] Ibid.
[23] Ibid., 69.
[24] Ibid.
[25] Ibid., 78.
[26] Ibid., 79.
[27] Ibid.
[28] Ibid.
[29] Ibid.

b. Maui Island Plan – General Plan 2030

The *Maui Island Plan* provides specific policy-based strategies for a number of planning categories that includes transportation. The *Maui Island Plan* was adopted by Ordinance No. 4004 on December 28, 2012.

The *Maui Island Plan* brings specificity to the *Countywide Policy Plan's* goals and objectives. The *Maui Island Plan* promotes:

- The perpetuation of the Hawaiian culture in its practices and its language, and
- The protection of cultural, historic, and archaeological resources.

"Chapter 2. Heritage Resources" of the *Maui Island Plan* covers subjects relevant to the *Hana Highway Bridge Preservation Plan* (2015). Relevant sections of this chapter include:

- Cultural, Historic, & Archaeological Resources,
- Watersheds, Streams, & Wetlands,
- Wildlife & Natural Areas, and
- Scenic Resources.[30]

Cultural, Historic, & Archaeological Resources

- Goal: *Our community respects and protects archaeological and cultural resources while perpetuating diverse cultural identities and traditions.*[31]
    - Objective: *A more effective and efficient planning and review process that incorporates the best available cultural resources inventory, protection techniques, and preservation strategies.*[32]
        - Policies listed under this objective address the need for a comprehensive inventory of historic and archaeological resources and their cultural significance. The policies promote updates to existing planning and regulatory mechanisms and to ensure cultural, historic and archaeological resources are protected.
    - Objective: *Enhance the island's historic, archaeological, and cultural resources.*[33]
        - Policies listed under this objective promote rehabilitation and adaptive reuse of historic sites, and support opportunities for public involvement and consultation with stakeholders to facilitate protection and restoration of these sites. These policies seek to ensure compliance with historic preservation laws and discourage demolition of properties on the Hawaii Register of Historic Places and National Register of Historic Places.

Watersheds, Streams, & Wetlands

- Goal: *Healthy watersheds, streams, and riparian environments.*
    - *Objective: Greater protection and enhancement of watersheds, streams, and riparian environments.*[34]
        - Policy: *Enforce water pollution related standards and codes.*[35]
    - Objective: *Greater preservation of native flora and fauna biodiversity to protect native species.*[36]

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[30] Maui County Department of Planning, *Maui Island Plan: General Plan 2030*, Maui County Department of Planning, County of Maui (Wailuku: The County of Maui, 2012), table of contents.
[31] Ibid., 2-10.
[32] Ibid., 2-11.
[33] Ibid., 2-12.
[34] Ibid., 2-30.
[35] Ibid., 2-31.
[36] Ibid., 2-32.

- Objective: *Enhance the vitality and functioning of streams, while balancing the multiple needs of the community.*[37]
    - Policy: *Protect and enhance* natural streambeds and discourage stream alteration.[38]

The *Maui Island Plan* identifies the East Maui Watershed as one of two large scale watersheds on Maui. Corresponding major streams are Waikamoi Stream, Kailua Stream, Hanawi Stream, and Makapipi Stream, which cross the Hana Belt Road Historic District ROW.

Wildlife and Natural Areas

- Goal: *Maui's natural areas and indigenous flora and fauna will be protected.*[39]
    - Objective: *A comprehensive management strategy that includes further identification, protection, and restoration of indigenous wildlife habitats.*[40]

Goals, objectives, policies, and implementing actions under this section advance the *Hana Highway Historic Bridge Preservation Plan* (2015) and its implementation. State and federal environmental assessment processes will ensure consultation with the U.S. Fish & Wildlife Service. A biological resources consultant will be used to confirm the presence of protected wildlife and to assess the need for special protective provisions during the construction phase and ongoing maintenance of the bridge structures.

Scenic Resources

- Goal: *Maui will continue to be a beautiful island steeped in coastal, mountain, open space, and historically significant views that are preserved to enrich the residents' quality of life, attract visitors, provide a connection to the past, and promote a sense of place.*
    - Objective: *A greater level of protection for scenic resources.*[41]
        - *Policy: Protect scenic resources along Maui's scenic roadway corridors.*[42]
            - Implementing Action: *Adopt a management plan that identifies right-of-way improvements, utility controls, roadside maintenance activities, signage, potential new vehicular turn-offs, and land acquisition opportunities that would protect the resource.*[43]

This section stresses Maui's spectacular views being a driving force behind the island's thriving visitor industry that plays an important part of Maui's economy. The *Maui Island Plan* sets objectives to establish a Scenic Roadway Corridor Overlay District with an important component of establishing design guidelines and a view corridor management plan. The *Hana Highway Historic Bridge Preservation Plan* (2015) will essentially serve to establish design guidelines that will encompass the above listed aspects within the Hana Belt Road Historic District, in parallel with the implementing actions associated with establishing a *Scenic Roadway Corridor Management Plan* and design guidelines.

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[37] Ibid., 2-33.
[38] Maui County Department of Planning, *Maui Island Plan: General Plan 2030*, Maui County Department of Planning, County of Maui (Wailuku: The County of Maui, 2012), 2-33.
[39] Ibid., 2-39.
[40] Ibid., 2-40.
[41] Ibid., 2-46.
[42] Ibid.
[43] Ibid., 2-47.

In addition to the foregoing, the "Infrastructure & Public Facilities" section of the *Maui Island Plan* addresses relevant objectives and policies:

Infrastructure and Public Facilities (Transportation Section)

- Goal: *An interconnected, efficient, and well-maintained, multimodal transportation system.*[44]
  - Objective: *Safe, interconnected transit, roadway, bicycle, equestrian, and pedestrian network.*
    - Policy: *Ensure transit-, roadway-, and pedestrian-facilities design and level-of-service standards respect the unique character of our communities.* [45]
    - Policy: *Identify and improve hazardous and substandard sections of roadways, drainage infrastructure, and bridges, provided that the historical integrity of the roads and bridges are protected.*[46]
  - Objective: *An island-wide, multimodal transportation system that respects and enhances the natural environment, scenic views, and each community's character.*[47]
    - Policy: *Ensure that the roadway and transit alignments respect the natural environment and scenic views.*
    - Policy: *Ensure that roadways and transit systems in rural areas and small towns enhance community character.*[48]

The above objectives and policies set forth the need for balancing safety and current standard roadway elements while protecting the historical integrity of the Hana Belt Road Historic District. As presented to the community, the preservation plan will evaluate each bridge/culvert to consider historic qualities, public safety, funding options, and community/agency input.

c. Hana Community Plan (1994)

The *Hana Community Plan* was first adopted by Ordinance 1247 (1982) and was updated in 1992 – 1993.

The district outlined in the *Hana Community Plan* encompasses the eastern portion of Maui and includes the communities of Nahiku, Hana, Kipahulu, and Kaupo. The first three bridges –– #01 Hoalua Stream Bridge, #02 Kailua Stream Bridge, and #03 Nailiilihaele Stream Bridge –– in the Hana Belt Road Historic District lie outside of the district outlined in the *Hana Community Plan*. #04 Oopuola Stream Bridge at MP 7.92 along the Hana Highway is the first in the series of bridges in the *Hana Community Plan* starting from the west end of the district.

The *Hana Community Plan* describes the environmental and historical context of the region as containing more than 90 *ahupuaa* within five traditional districts of Koolau, Hana, Kipahulu, Kaupo, and Kahikinui. The Koolau and Hana *moku* land districts are the regions that overlay the Hana Belt Road Historic District under HDOT's jurisdiction.

The *Hana Community Plan* states:

> *It is necessary to balance infrastructure needs with the environmental and cultural sensitivities of the residents of the region. For example, roadway improvements to Hana Highway are needed to maintain the safety of the travelling public. On the other hand, roadway design standards must recognize and preserve the historic nature of the highway and the rural character of the community it serves.*[49]

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[44] Ibid., 6-29.
[45] Ibid., 6-30.
[46] Maui County Department of Planning, *Maui Island Plan: General Plan 2030*, Maui County Department of Planning, County of Maui (Wailuku: The County of Maui, 2012), 6-31.
[47] Ibid.
[48] Ibid.
[49] Maui County Council, *Hana Community Plan (1994)*, County of Maui (1994), 10.

The following goals, objectives and policies cited in the *Hana Community Plan* are considered pertinent to this preservation plan:

Environment

Goal

Protection and management of Hana's land, water and ocean resources to ensure that future generations can enjoy the region's exceptional environmental qualities.[50]

Objectives and Policies

- *Manage, protect, and where appropriate, restore areas which have significant indigenous flora and fauna habitat resource value.*[51]
- *Protect, restore and preserve native aquatic habitats and resources within and along all streams within the Hana District by (1) protecting existing in stream flows, and (2) regulating diversions of stream waters.*[52]
- *Ensure that groundwater and surface water resources are preserved and maintained at capacities and levels to meet the current and future domestic, agricultural, commercial, ecological and traditional cultural demands of each area in the Hana District.*[53]

Physical Infrastructure

Goal

Timely and environmentally sensitive development and maintenance of infrastructure systems which protect and preserve the safety and health of the Hana region's residents and visitors, including … effective transportation systems which meet the needs of residents and visitors while protecting the region's rural character.[54]

Objectives and Policies

Transportation

- o *Encourage a program of roadway safety improvements, including shoulder widening, pull-over spots and installation of new signage and guardrails that do not detract from the regions scenic and rural character.*
- o *Balance traffic flow and safety requirements with the preservation of the Hana region's historic bridges.* [55]

Implementing Actions

- o *Prepare a Hana Highway and Piilani Highway roadway management plan which identifies: (1) significant natural and structural features to be preserved; (2) comprehensive road signage requirements; (3) long-term roadway maintenance requirements; and (4) a traffic management system which provides for pull-over spots, and interpretive scenic lookouts.*
- o *Improve Hana Highway to allow safe passage of two-way vehicular traffic.*[56]

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[50] Ibid., 15.
[51] Maui County Council, *Hana Community Plan (1994)*, County of Maui (1994), 15.
[52] Ibid., 15.
[53] Ibid., 15-16.
[54] Ibid., 22.
[55] Ibid., 23.
[56] Ibid., 24.

The following two implementing actions are among the responsibilities of the State DOT:

<u>Government</u>

Goal

The provision of accessible, cost effective, and responsive government services and programs which meet the unique needs of residents and the cultural, geographic and socio-economic characteristics of the Hana region.[57]

Objectives and Policies

- *Ensure the participation of native Hawaiian residents and community representatives in all Capital Improvement Programs and program planning those impacts on the Hana region.*[58]

The *Hana Community Plan's* "Part III – Policy Recommendations, Implementing Actions and Standards for the Hana Region: C. Planning Standards" section advances the following about roadway planning standards:

Highways and major roadways shall have a minimum pavement width of 16 feet and shoulder width of two feet, to provide for the safe passage [on a one-lane] of two-way traffic [roadway], except in areas where natural landforms, historic structures and other environmental constraints preclude widening beyond existing roadway widths.[59]

Thus, the *Hana Community Plan* reiterates the goals, objectives, and policies described in the overarching *Countywide Policy Plan* regarding striking a balance between environmental, cultural, historic, safety, and rural character of the community.

d. Paia-Haiku Community Plan (1995)

The *Paia-Haiku Community Plan* was first adopted in 1983 and was updated in 1992 - 1993.

The district outlined in the *Paia-Haiku Community Plan* encompasses the north shore of Maui between the districts outlined in the *Wailuku-Kahului Community Plan* and the *Hana Community Plan*. The *Paia-Haiku Community Plan* touches the western fringe of the district outlined in the *Hana Community Plan* where their boundaries cross Hana Highway.

The *Paia-Haiku Community Plan* region contains the Haliimaile and Hamakualoa *moku* which contain numerous *ahupuaa* sub-partitions. Within the Hamakualoa *moku* lie the first three bridges — #01 Hoalua Stream Bridge, #02 Kailua Stream Bridge, and #03 Nailiilihaele Stream Bridge — in the Hana Belt Road Historic District.

The *Paia-Haiku Community Plan* does not focus on the historic bridges or narrow-winding rural roadway character, to the extent considered by the *Hana Community Plan*. Nonetheless, the following goals, objectives and policies cited in the *Paia-Haiku Community Plan* are considered pertinent to the *Hana Highway Historic Bridge Preservation Plan* (2015).

<u>Environment</u>

Goal

The preservation and protection of the natural environment, marine resources and scenic vistas to maintain the rural and natural ambiance and character of the region.[60]

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[57] Ibid., 28.

[58] Maui County Council, *Hana Community Plan (1994)*, County of Maui (1994), 28.

[59] Ibid., 29.

[60] Maui County Council, *Paʻia-Haʻiku (1995)*, County of Maui (1995), 17.

Objectives and Policies

- *Preserve and protect scenic vistas along Hana Highway.*
- *Preserve and protect unique natural areas with significant conservation value, including, but not limited to, the native rain forest at Waikamoi.*[61]

Cultural Resources

Goal

Identification, protection, preservation, enhancement and appropriate use of cultural resources, cultural practices and historic sites that provide a sense of history and define a sense of place for the Paia-Haiku region.[62]

Implementing Actions

- *Flag for preservation of the following general site types and areas:*
  - *Ancient Trails/Old government roads.*[63]
  - *Old bridges.*[64]
- *Formulate and adopt rural and historic district roadway standards to promote the maintenance of historic landscapes and streetscapes in character with the region.*[65]

[61] Ibid.
[62] Maui County Council, *Paʻia-Haʻiku (1995)*, County of Maui (1995), 18.
[63] Ibid., 20.
[64] Ibid.
[65] Ibid., 21.

vi. TRANSPORTATION MASTER PLANS

a. Federal-Aid Highways 2035 Transportation Plan for the District of Maui

The *Federal-Aid Highways 2035 Transportation Plan for the District of Maui* is an update of the *Maui Long-Range Land Transportation Plan* developed in 1997, intended to guide land transportation decisions for the federal-aid highway network within the County of Maui. The *Federal-Aid Highways 2035 Transportation Plan for the District of Maui* is part of a statewide plan, which recognizes that the resources required to address projected land transportation needs far exceed available funds. Federal legislation places emphasis on highway system preservation and infrastructure maintenance, and the *Federal-Aid Highways 2035 Transportation Plan for the District of Maui* provides direction and guidance to sensibly allocate limited funding to appropriately address transportation needs comprehensively. Coordinated statewide and regional planning efforts are required by the federal government and highlighted in Title 23, Sections 134 and 135 of the United States Code (23 U.S.C § 134 and § 135). Therefore, the *Federal-Aid Highways 2035 Transportation Plan for the District of Maui* is in alignment with federal laws and provides a necessary link between statewide and regional planning efforts.

The *Federal-Aid Highways 2035 Transportation Plan for the District of Maui*, through meetings with a Technical Advisory Committee and Stakeholder Advisory Committee, developed and refined several goal statements to reflect the County of Maui's values. Eight federal planning factors are used as a framework to ensure the comprehensive plan addresses federal requirements. The factors are listed as follows:

1. Environment and Sustainability,
2. Modal Integration,
3. System Preservation,
4. Security,
5. Economic Vitality,
6. System Efficiency Management and Operations,
7. Transportation Access Mobility, and
8. Safety.

The first planning factor yields goals to preserve and enhance the natural environment, cultural resources, archaeological and historical sites, all features which are richly contained within the Hana Belt Road Historic District. The third planning factor, "System Preservation," sets the goal to manage transportation assets and optimize investments along the Hana Highway with numerous deficient and aging bridges. This bridge preservation plan employs strategies of the *Federal-Aid Highways 2035 Transportation Plan for the District of Maui* to support system preservation principles concerning bridge replacements or rehabilitation. Also, the *Hana Highway Historic Bridge Preservation Plan* (2015) is intended to help focus on sustainable practices and suggest solutions that do not compromise the environment. All of the other planning factors and resulting goals are considered at appropriate degrees in the development of preservation recommendations for each of the bridges evaluated.

CHAPTER 2
METHODOLOGY

i. PROJECT PERSONNEL

The project team consists of the following organizations. An overview of the role of each team member is provided below.

State Department of Transportation, Bridge Design Section – *State Managing Agency*

- As managers of this historic site, HDOT provided all applicable government guidelines and information necessary for the team to make appropriate recommendations.
- HDOT reviewed team recommendations to ensure that public safety as well as federal and state guidelines were considered.

Federal Highways Administration, Hawaii Division – *U.S. DOT Agency*

- FHWA provides support to HDOT in the design, construction, maintenance and preservation of Hana Highway, Route 360 bridges consistent with their efforts to address stewardship and help ensure a high safety standard of the Nation's highway system comprised of highways, bridges, and tunnels.
- FHWA is a key partner in providing necessary federal funds and oversight of HDOT's bridge inspection and bridge rehabilitation/replacement program.
- FHWA also reviewed team recommendations to ensure that public safety as well as federal and state guidelines were considered.
- Provided technical assistance and resource recommendations to the team.

Nagamine Okawa Engineers, Inc. (NOEI) – *Prime Consultant and Structural Engineers*

- Conducted field work along with the rest of the team to document existing conditions.
- Worked together with project team to develop context sensitive solutions and provide recommendations for repair, rehabilitation, or replacement of individual bridges.
- Provided recommendations and conceptual designs for each historic bridge and identified culvert.
- Provided conceptual designs for historic culverts considered non-contributing elements to the historic district, as well as non-historic hillside bridges as respective categories, such that they fit into the historic district.
- Provided public safety considerations including applicable design standards, National Bridge Inspection Program standards and ratings, and tort liability issues.

Fung Associates, Inc. (FAI) – *Architectural Preservation Specialists*

- Identified, assessed and documented character-defining features and detracting features of each bridge.
- Addressed historic integrity of each bridge.
- Worked together with project team to develop conceptual designs and preservation solutions.
- Engaged with preservation community to develop solutions to mitigate possible adverse effects by future projects.

Austin Tsutsumi & Associates, Inc. (ATA) – *Traffic and Civil Engineers*

- Verified existing traffic volumes to develop an effective Traffic Management Plan and general approach for phasing traffic control and detours during construction.
- Considered future community developments and possible traffic impacts at community meetings.
- Addressed proper signage in accordance with the MUTCD, without overpopulating the route to detract from its aesthetic nature.

- Identified impacts to the underlying stream crossings, and involvement of reviewing agencies such as the Army Corps of Engineers for a jurisdictional determination and 404 permits; Department of Health, 401 Water Quality Certification; and Department of Land and Natural Resources (DLNR), Stream Channel Alteration Permit. Evaluated the adjacent grounds and embankment areas for evidence of current erosion or future erosion potential, and proposed mitigation, such as subsurface soil stabilization fabrics or structures.

Ronald N.S. Ho & Associates, Inc. (RNSH) – *Electrical Engineers*

- As a result of field investigations, approximately 15 bridges appear to have power lines that may be affected by major repairs/construction.
- Provided information for future designers to consider that may impact the existing electrical lines.

Munekiyo + Hiraga, Inc. (MHI) – *Planning and Community Outreach Consultants*

- As with many projects involving features of critical historic and cultural value, a key element of success included formulation and implementation of an effective community outreach program. In addition, it was necessary to translate items discussed at community meetings into appropriate technical elements of the project, applying the information gathered and ensuring that community concerns could be appropriately addressed within the context of the team's analysis and recommendations. MHI created a community outreach program that was the crucial link between the innovative technical improvements developed by the team and the community these bridges service.
- Identified and coordinated with landowners along the corridor of the bridges that may be impacted by future bridge work.
- Through community outreach, provided connection to the Native Hawaiian Organizations (NHO) and individuals who are knowledgeable about the culture of the area.

Cultural Surveys Hawaii (CSH) – *Archaeological & Cultural Consultants*

- Provided a report on any known or observed cultural or archaeological issues along the route and provided treatment recommendations for further studies as necessary, prior to construction at each bridge.

Stakeholders

- Community groups and individual members interested provided input as to which bridges had problems and if the project team addressed their issues with the bridges
- SHPD and Historic Hawaii Foundation (HHF) provided guidance and comments during the process to ensure treatment recommendations would meet SOI standards while maintaining a safe road.

ii. INVESTIGATION METHODS

a. Background Research/Data Collection

Numerous documents and resources were used as reference for this project. The following items were the most frequently used references.

1. Data on the history of Hana Highway was obtained from the following sources:
   - Historic American Engineering Record (HAER) *HI-75 Report* (2005),
   - Hana Belt Road Historic District nomination form (2001),
   - Community input, and
   - Historic design drawings (original design drawings, alterations, and as-built drawings; various years).

2. Preservation Resources:
   - *Final Preservation Plan for County of Maui Bridges Within the Hana Highway Historic District* (2001) with documented community comments, prepared by Wilson Okamoto & Associates, Inc.,
   - *Guidelines for Historic Bridge Rehabilitation and Replacement* (2007), prepared by Lichtenstein Consulting Engineers in association with Parsons Brinckerhoff Quade & Douglas, Inc.,
   - *Design and Management of Historic Roads* (2012), National Cooperative Highway Research Program (NCHRP) Web Document 189,
   - State and Federal Laws and Regulations (for more details, refer to Section A, Chapter 1. iv. *Regulatory Background*), and
   - *The Secretary of Interior's Standards for the Treatment of Historic Properties* (for more details, refer to Section A, Chapter 4. ii. *Federal Standards for the Treatment of Historic Bridges*).

3. Design Resources:
   - Structural assessments and references (refer to Section A, Chapter 4. vii. *Highway References & Design Specifications* for more information),
   - Existing NBIS bridge inspection reports,
   - Context sensitive solutions derived from *A Guide for Achieving Flexibility in Highway Design* (2004), published by AASHTO, as well as pertinent case studies, and
   - Maui County general plans and community plans (refer to Section A, Chapter 1. v. *County General Plans & Community Plans* for a summary of the various plans to date).

4. Public Safety References & Design Specifications:
   - A detailed list of applicable design specification reference manuals that were consulted is listed in Section A, Chapter 4. vii. *Highway References & Design Specifications.*

b. Field Work

Field work was undertaken by all members of the team to get a holistic impression of the historic district and to record pertinent information as noted below:

- Identified character-defining features of each bridge,
- Observed physical condition,
- Performed a reconnaissance level survey to see if other structures on or near the highway, especially within the right-of-way, are eligible for listing on historic register and to note character-defining features of the entire historic district,

- Performed a survey to find previously unknown culverts along the road by the structural engineers, and
- Performed a survey to determine if there are conflict issues with nearby electrical utility lines and bridge/culvert recommendations by electrical engineers.

c. Data Analysis

Data analysis was completed during the process of numerous team meetings and in consultation with HDOT and various stakeholders. Important issues addressed at these meetings included:

- Community interest in using Hawaiian words and meanings to identify each bridge,
- Identification and documentation of bridge features, and development of criteria to evaluate each bridge,
- Documentation of each bridge including any known cultural issues surrounding the bridge, as well as recommendations to mitigate any archaeological or cultural sites that may be affected by construction,
- Development of conceptual designs and recommendations for the treatment of each bridge or contributing culvert,
- Overall design guidelines for replacement of individual bridge or components, and
- Overall design guidance for culverts and hillside bridges that are considered non-contributing elements to the historic district.

iii. COMMUNITY OUTREACH & AGENCY CONSULTATIONS

a. Overview

Since the preservation plan extends across multiple communities and *ahupuaa*, the community outreach strategy addresses multiple communities, organizations, and individuals, enabling an iterative approach for stakeholders to hear project presentations, dialog with HDOT, and provide input. Through these multiple meeting venues, HDOT's consultants were able to connect with new stakeholders that could not be reached via conventional methods. One conventional method is to typically conduct a large venue public informational meeting advertised through a major local newspaper publication. Importantly, prior to conducting broader community and group meetings, relevant government agencies and elected officials were individually briefed on the preservation project.

b. Stakeholder Identification

The stakeholder identification process involved the review of the project's geographic limits and its relationship to various communities and traditional *moku* regional boundaries. From this analysis, it was determined that the *Hana Highway Bridge Preservation Plan* (2015) project limits affects the sub-regional communities of Haiku, Keanae, Nahiku, and Hana. The route limits span across *moku* of Hamakualoa, Koolau, and Hana. Since the County completed a bridge preservation plan in 2001 for the Hana Belt Road Historic District between Hana and Kipahulu, and some of the bridges have since been replaced, the community associations of Kipahulu and Kaupo were also presented with HDOT's *Hana Highway Bridge Preservation Plan* (2015) project to solicit input, especially with their prior experience participating in implementing the County's bridge preservation plan.

Federal, State, and County government agencies, commissions and advisory groups, resource organizations, and other notable private entities were identified, to include:

- Federal Highways Administration
- State of Hawaii, Department of Land and Natural Resources – Historic Preservation Division and Land Division
- County of Maui, Department of Public Works (DPW)
- County of Maui, Department of Planning
- Maui County, Cultural Resources Commission (CRC)
- Hana Advisory Committee (HAC)
- Hana Cultural Center and Museum Board
- Historic Hawaii Foundation
- East Maui Irrigation Company
- The Outdoor Circle

Recognizing that elected officials would become key players in supporting the *Hana Highway Bridge Preservation Plan* (2015) relative to budget priorities and funding its implementation, the following officials were consulted:

- Mayor Alan Arakawa
- Councilmember Robert Carroll (East Maui, Hana-Keanae-Kailua)
- State Senator J. Kalani English (District 7: Hana, East and Upcountry Maui, Molokai, Lanai, and Kahoolawe)
- State Representative Mele Carroll (District 13: Kahoolawe, Molokini, Lanai, Molokai, Haiku, Kaupo, Kipahulu, Paia, Nahiku, Hana)

Last but not least, community organizations have the significant benefit of local knowledge and background as it relates to many of the historic bridge structures in the study area. The following community groups were consulted as part of the outreach process:

- Hana Community Association
- Nahiku Community Association
- Kaupo Community Association
- Kipahulu Community Association
- Hana Lani Senior Citizens
- Hawaiian Aha Moku Advisory Committee Representatives

c. Outreach Program Implementation

Group and individual meetings were conducted in three cycles at the following stages of the project:

1. Initiation Stage (team introduced project purpose, objectives, and approach),
2. Preliminary Plan Stage (team presented findings and preliminary recommendations), and
3. Final Plan Stage (team informed stakeholders of the process, issues, and final outcome of plan).

For each of the three cycles of meetings with government agencies, elected officials, Hawaiian cultural organizations, community associations, and other stakeholder groups and individuals, the team presented each with project information in order to promote an open dialogue and solicit public input on the project. Meeting summaries were prepared, documenting public comments and questions (refer to Section G, Appendices 7. i., 8. i., and 9. i. *Attachments & Indexes*, for summaries of community meetings during the *Project Initiation Stage, Preliminary Plan Stage,* and *Final Plan Stage*, respectively.

d. Issues Management Matrix

Based on questions, concerns, and issues that arose at meetings with the community, groups, individuals, and consulted parties, an "Issues Management Matrix" was developed and maintained throughout the outreach program. The matrix was used to track each issue to its resolution by assigning a responsible project team member who formulated an appropriate response, action, or plan of action. A separate matrix was prepared for each of the three cycles of meetings. Refer to Section G, Appendices 7. ii., 8. ii., and 9. ii. *Issues Management Matrix* from the *Project Initiation Stage, Preliminary Plan Stage,* and *Final Plan Stage*, respectively.

e. Outreach Outcomes

Phase 1: Project Initiation Stage

The initial agency meeting was held on May 22, 2014 with the County Planning Departments' Deputy Director, current Planning Division Administrator, and staff planner. The purpose of the meeting was to discuss the project scope, outreach strategy, and requests to be on meeting agendas for the Maui County Cultural Resources Commission (CRC) and Hana Advisory Committee (HAC). The CRC meeting was confirmed for July 3, 2014. It was noted that the HAC did not have a scheduled meeting during the outreach initiation stage; however, Ward Mardfin, Hana bridges researcher and a member of the Hana Advisory Committee, was consulted.

On June 3, 2014, the County of Maui, Department of Public Work's (DPW) Director, Deputy Director and their Engineering Division Chief were introduced to the project. They were asked if they could offer any "lessons learned" with the *Final Preservation Plan for County of Maui Bridges Within the Hana Highway Historic District (2001)*. An open line of communication was established between the DPW and the project team. The DPW and its Engineering Division recognized that the plan encompassed bridges under the State's jurisdiction.

County of Maui Councilmember Robert Carroll, who represents the Hana District, was consulted on June 4, 2014. The Councilmember brought up constituent concerns such as the need for signs identifying bridge names, and comments regarding the modern looking metal guardrails. The Councilmember suggested including a dialogue with the Kaupo Community Association, which is beyond the project plan limits. He offered anecdotal information on a few of the bridges being studied.

Mayor Alan Arakawa and his executive assistant for East Maui were consulted with on June 5, 2014. The Mayor thought it was a good idea to meet with the Kipahulu Community Association, because that area would be affected by road closure detours. His executive assistant asked whether metal bridges will be used for detours. They were informed that recommendations are still being developed.

Scheduling meetings to consult with State elected officials Senator J. Kalani English and the late Representative Mele Carroll before the first public meeting with the CRC proved difficult with their legislative schedules. In lieu of individual meetings, the PowerPoint presentation was transmitted to both of them on June 25, 2014 for their review and input. Coordination efforts will continue with Senator English and Representative Carroll's replacement.

Input from the various Aha Moku Advisory Committee representatives of Hamakuapoko, Hamakualoa, Koolau, and Hana was sought through a meeting with Kyle Nakanelua, Maui *Poo* (Director) on June 6, 2014. His principal concern was that traffic should not be disrupted for residents' work commutes. He noted that Hana Highway, Route 360 has a high number of bicyclists on the roadway with insufficient room and that there is increased visitor traffic than previously observed. No further comments were received during this initial meeting.

The Hana Cultural Center and Museum Board was consulted on June 19, 2014. Seven members, one volunteer, and one guest attended. Questions raised concerned historic preservation decision making, such as replacing guardrails with historic looking features, considerations for repairs first before replacement, avoiding road realignments to preserve the highway right-of-way, and to replicate bridge designs to the extent practicable. Concerns were also expressed to consider traffic flow, signage to remind slow moving traffic to pull over, parked vehicles at scenic views, bridges constricting traffic flow, and maintaining the structural integrity of bridges to avoid a catastrophic failure.

On the evening of June 19, 2014, the team presented the project to the Hana Community Association. Nine people attended, including a representative from the Hana Council office and the President of the Kaupo Community Association. Questions and comments concerned structural attributes of the bridges, environmental impacts during construction, implementation priorities, construction activities disrupting traffic flow and flood waters impacting some bridges. Other related issues, such as better signage to manage parking along the road and placing names on bridges, were noted as well. Members expressed concern with increased weight capacities encouraging larger loads, to which the HDOT representative responded that strengthening of existing bridges is not intended to change the character of Hana Highway, Route 360 and types of vehicles ordinarily traversing the highway. Subject matters not directly related to the *Hana Highway Bridge Preservation Plan* (2015) project were mentioned such as hillside erosion at mile marker 21 and safety along the entire stretch of highway. It was recommended that the team meet with *kupuna* from the Hana Lani Senior Citizens group.

The Kaupo Community Association presentation was made on June 21, 2014. Questions and comments touched upon funding feasibility, alternative routing scenarios, and recommending the plan address traffic calming and pedestrian safety issues at the bridges. Traffic disruption was a concern, and a motion was unanimously approved that HDOT's bridge preservation work shall not cause traffic to be diverted through Kaupo except in case of emergency.

The meeting with the Nahiku Community Association was held on June 29, 2014 with nine people in attendance including a representative from the Hana Council Office and an officer with the Hana Police Station. Questions and comments mirrored some points raised in previous meetings, such as roadway etiquette for visitors, parking and traffic congestion at #16 Waikani Stream Bridge, adverse impact of any bridge closures, and adverse impacts to streams and EMI ditches during construction. Maintenance issues were noted, such as eroding roadway approaches at #16 Waikani Stream Bridge, missing bridge signs, water conveyance capacities of bridges, and standing rain water found on some bridges. Other issues raised that were not directly related to the preservation plan concerned HDOT's slow response to making roadway repairs and night safety at Puaa Kaa State Wayside Park.

At the CRC regular meeting of July 3, 2014, the team presented the project to six commission members in attendance. The commissioners were supportive of the plan and appreciated the outreach and public input process. Questions concerned what prompted the project and how traffic issues would be addressed.

An EMI Company manager was contacted by phone on July 9, 2014 and was also e-mailed the project information PowerPoint to query the organization on EMI facilities near bridges for future coordination.

The SHPD Maui Archaeologist was consulted on July 24, 2014, to solicit initial comments on the plan's objectives and contents. The project team's archaeologist expressed the importance of continuing communications with the SHPD office. The Maui Archaeologist did not have specific comments to offer at this stage of the study.

HDOT, FHWA, and the architectural design consultants met with Historic Hawaii Foundation and SHPD's Architectural Branch in Oahu on August 4, 2014. The SHPD asked if bridges will be upgraded if scheduled for repair. Points of discussions covered the historic and structural design criteria to be used, design exceptions, retaining the historic design parameters, and other design aspects such as railing designs, pull-offs, drainage issues, and construction detours.

The Kipahulu Community Association presentation was held on August 16, 2014 with 24 people in attendance including the Mayor, Senator, and Councilmember for East Maui, and a representative from the Hana Council office. Questions raised concerned #16 Waikani Stream Bridge potholes on its approaches and the possibility of restricting parking. Safety considerations were acknowledged as a priority.

A presentation to the Hana Lani Senior Citizens was conducted on August 25, 2014 to 15 members. The group was asked for any input on special historical knowledge on any of the bridges being studied. No one provided any information or connections to other *kupuna* that may have such knowledge. One member requested that the bridge names be painted on the bridges. Another question concerned whether the existing bridges will be preserved or how they will maintain their historical look if replaced.

Requests to meet with the Haiku Community Association in the initiation phase received no response.

Also, attempts to contact the Alliance for the Heritage of East Maui by phone, email, and letter were unsuccessful.

Phase 2: Preliminary Plan Stage

In the Preliminary Plan Stage of the project, the amount of information compiled was significant with extensive draft documentation on background information, methodology, findings, and proposed recommendations for all 43 bridges, 12 culverts, and 45 found culverts found during the site reviews.

Therefore, individual community associations and organizations were invited to attend an evening community meeting held on February 23, 2015. The Hana Lani Senior Citizens group invited the Hana Cultural Center and Museum Board to their morning meeting on February 23, 2015. In addition to the community meeting, the residents were also able to attend other presentations at other public forums such as the CRC on March 5, 2015, and HAC on March 9, 2015. The presidents of each community association were contacted to confirm whether they preferred an exclusive presentation of the 75% draft report. Only the Kaupo Community Association requested an individual meeting. Therefore, the project team also made a presentation at the Kaupo Community Association's regular monthly meeting on February 21, 2015.

Prior to holding meetings, compact discs (CDs) containing electronic copies of the 75% draft report were distributed to all stakeholders communicated with during the Project Initiation Stage of the community outreach program. Also included in the distribution were instructions to access a portable document file (PDF) copy of the

75% draft report through the internet. In addition, hard copies of the report were made available for public review at the Hana Public and School Library, HDOT Maui District Office, Hana Council District Office, and Hana Cultural Center and Museum. Letters responding to all concerns and questions documented in the "Issues Management Matrix" compiled from the Project Initiation Stage of community meetings were provided to various organizations. Copies of response letters sent to address community concerns from the Project Initiation Stage are referenced and included in Section G, Appendix 7. ii. *Issues Management Matrix – Project Initiation Stage*. Section G, Appendix 8. i. *Attachments & Indexes – Preliminary Plan Stage* reflects the meeting summaries for each meeting during this second phase of the plan's development. Following the second phase of meetings, response letters were provided again to address additional concerns and questions that arose during the Preliminary Plan Stage; these letters are referenced and included in Section G, Appendix 8. ii. *Issues Management Matrix – Preliminary Plan Stage*.

The first team presentation of the 75% draft report was made at the Kaupo Community Association regular monthly meeting of February 21, 2015, at which 20 members were in attendance. A member commented that there is drainage overtopping at certain bridges, whereby the team requested that the community identify these locations. A question on funding sources was raised to which the team noted that there is a list of priority bridges that will be completed first and repairs along the entire route will follow in subsequent years. A concern was raised on whether bridges have been examined for safety and the team assured the members that inspections occur every two years and the bridges are safe. There were a number of questions on the railing designs. A specific request was made that no metal railing be used as interior railings to keep the historic look of the bridges. The team responded that designs are attempting to maintain the historic material per the Secretary of the Interior's Standards. Other questions on the rail design concerned crash-test rating design criteria, why the additional rail is placed on the interior, and the gap between the interior rail and existing historic rail possibly serving as a pedestrian walkway. The structural engineer explained that the design criteria must meet current code requirements and that railing placement on the interior wall is intended to avoid obscuring the view when approaching the bridge around the curve. Also, the interior wall is necessary for deflection in a crash, with the gap being inadequate for a pedestrian walkway. A question was asked regarding how the concrete rubble masonry (CRM) façade abutments would be replaced. The structural engineer explained the process of numbering and photographing the rocks in its existing configuration prior to disassembling and rebuilding the abutment back to its original look. A last request was made to take into account safe passage for bicyclists and pedestrians along the route and to engage members of the Hawaii Bicycling League (HBL) and Maui Bicycling League (MBL) in community discussions.

On February 23, 2015, a morning presentation was made to 27 members of the Hana Lani Senior Citizens and Hana Cultural Center & Museum Board member. A question raised concerned bridge closures that could result in detouring around Kaupo. The team responded that temporary bypass bridges are being looked at to avoid major traffic detouring. Another question related to the use of current design standards, to which the HDOT bridge engineer responded that bridge replacements will be in-kind with a stronger capacity to carry emergency vehicles. A request was made to have the 10-ton weight limit postings remain. Other bridge problems were noted, including ponding that occurs at both solid parapet and open picket railing bridges. Other inquiries addressed definition of terms used in the 75% draft report, and whether bridge failures have occurred. The HDOT bridge engineer responded that there have been no incidents of bridge failures on Maui.

A Hana Lani Senior Citizens member provided additional information through a phone call on February 26, 2015 regarding ponding of water on bridges and after heavy rainfall. She mentioned that this occurred on all solid parapet bridges and also on open picket railing bridges, but could not recall which bridges they were.

In the afternoon of February 23, 2015, a presentation was made to 16 Hana community residents. With respect to presentation slide 35 depicting a bridge widening schematic of a crash-tested rail/parapet in front of the original railing, two attendees questioned whether the space indicated on the road section is designated for a pedestrian walkway. The structural engineer responded that the space is a buffer to protect the original railing from damage if a crash occurs at the inside rail. There were concerns expressed to not replace bridges on curved approach alignments. A postal carrier was concerned for construction road closures causing delays in mail deliveries to communities. Other questions related to the design loading of 40 tons, maintaining the 10-ton posted limit, the bridge priority list and expected schedule, and whether safety rails suggested are acceptable. A list of issues not directly related to bridge preservation plan were raised, including the need for reflectors on bridges and safety rails, tourist that block traffic, disregard for “No Parking” signs, increase in bicycle traffic, and ponding issues on bridge decks.

At the CRC regular meeting of March 5, 2015, the team presented the 75% draft report to six commission members. The Vice Chair thanked the team for the presentation and acknowledged the thoroughness of the draft report. A member stressed the importance of Hawaiian names being correctly spelled, as even a slight misspelling would change its meaning. Another member requested that diacritical marks not be used in naming of the bridges/culverts to avoid inaccuracies. Concern was expressed regarding the need to replace #11 Honomanu Stream Bridge. The structural engineer assured the commission that this bridge is monitored and inspected on a 12-month cycle versus the standard 24-month cycle.

At the HAC meeting of March 9, 2015, the team presented the 75% draft report to five committee members. The team brought special attention to the CRC member request to omit diacritical marks from the bridge names. W. Mardfin stated that the community may be divided on this issue and further community consultation will be needed. He later pointed out that two bridge names are incorrectly referenced and that Waianapanapa is misspelled. T. Hoeffken, an attendee at the meeting, spoke of truckers’ difficulty to negotiate curves if the widening is towards the mountain side of the bridge.

HAC Vice Chair Ward Mardfin subsequently submitted follow-up comments. On March 12, 2015 he emailed a request to include updated information in Section G, Appendix 1. *Archaeological Literature Review for the Hana Highway*, “Chapter 3.3 Settlement Pattern and Predictive Model,” to which the team archaeologist made appropriate revisions. On April 3, 2015, he emailed name and distance corrections on #20 Puaakaa Stream Bridge at MP 22.23 and #21 Waiohue Stream Bridge at MP 22.41 next to Puaa Kaa Park.

On March 24, 2015, the team conducted a project presentation to FHWA, SHPD, HHF, and The Outdoor Circle. All were briefed on the first cycle of community meetings effort to gather early input. Described were a few community concerns such as traffic construction detours, emergency vehicle access into Hana, maintaining the rural character of Hana, having Hawaiian names on the bridges, and maintaining the 10-ton weight load posting. SHPD – Archaeology Branch noted possible burial mounds in the vicinity of Wailuanui Culvert near Keanae Lookout and will provide a mile marker reference for the team. SHPD commented that their review and concurrence on the report is a good basis for the formulation of a Programmatic Agreement (PA). SHPD offered to seek additional sources regarding Hawaiian names/meanings. FHWA confirmed that incorporating a panel design on the exterior face of solid parapets is acceptable and will not affect crash-test ratings.

Phase 3: Final Plan Stage
During the Final Plan Stage, similar to the previous stages, individual community associations, organizations, and residents were invited to attend an evening community meeting held on July 30, 2015. Prior to the meeting, CDs containing electronic copies of the Pre-Final Plan and instructions to access the pre-final draft report online were distributed to all stakeholders communicated with during the Project Initiation and Preliminary Plan Stages. HDOT also released a public announcement in the local newspaper inviting the general public to attend the meeting, also noting instructions to access the pre-final draft report online or to view hard copies of the plan available at the Hana School and Public Library, Hana Cultural Center and Museum, Hana District Council office, and the HDOT Maui District office. The announcement also listed the upcoming public presentations to be made in Hana town, to the CRC, and to the HAC.

The first public presentation of the Pre-Final Plan was made in Hana town on July 30, 2015, to seven residents, including Councilmember Robert Carroll who represents the east side communities. Although public attendance appeared low, the individual attendees were part of a key core group that was actively engaged with developing the *Hana Highway Bridge Preservation Plan* (2015) and providing input at more than one cycle of community meetings. At this stage of the plan development, detailed recommendations were included that took into account public and agency input received during the previous stages. A series of questions and concerns focused on specific bridge weight limit, loading capacity, and postings. With many examples of historic railing options presented, the attendees posed comments and questions relating to aesthetics of various bridge railing features. Other questions, comments, and suggestions concerned avoiding using asphalt to minimize oils from entering streams, using concrete surfacing which is much more durable than asphalt at bridge locations, implementing “Turnout” signs to encourage tourists to pull off to the side, mile post discrepancies, and long term maintenance considerations for ground cover.

A second public presentation of the pre-final draft report was done at the CRC’s regular monthly meeting of August 6, 2015 with seven commission members present. When the commission chair opened the floor to public testimony, a tour van company representative provided his observations that bridges 16 feet wide are where accidents occur, due to drivers perceiving them as wide enough for two-way traffic. It was also pointed out that railing heights are taller than rental car windows which encourages tourists stopping and exiting their car to take photos on the bridges. Commission members discussed railing designs relative to its historic appearance, crash-tested in-kind replacement options, and discouraging tourists from standing on railings for a better scenic view or photo opportunity. The commission chair was concerned with using genuine rock material for replacement of existing rock walls. Other notable points made by commission members concerned the importance of bridge name spellings being accurate and how the PA would address concerns of the community.

On August 20, 2015, the team conducted a third meeting with FHWA, SHPD, HHF, and The Outdoor Circle, to present further developments in the plan. Also discussed were follow-up items to subjects discussed at the March 24, 2015 Preliminary Plan Stage meeting, formulating PA requirements, resolving Hawaiian name spellings and diacritical markings, and exploring preferred railing options and approach wall designs. The Wailuanui Burial Mounds issue brought up at the previous meeting was resolved by further coordination between the project’s archaeologist and SHPD. PA details were agreed upon as to who the points of contacts and concurring parties will be, a review process for new railing designs and other technological advances, and incorporating further research of Hawaiian names by a Hawaiian scholar. Kepa Maly, an archaeologist who has done extensive research with Hawaiian names in the study area, will be contracted to perform this task.

The last public presentation of the pre-final draft report was made to the HAC on September 14, 2015, with five committee members present. One of the members, who is with the Fire Department, expressed concerns with responding to emergencies and the importance of bridge alignments and approaches being appropriately designed to allow fire trucks and other emergency vehicles to effectively negotiate through. Also, road closures during construction need to be avoided and mitigated with temporary bypass bridges. Furthermore, there is a concern with tourists disregarding “No Parking” signs at bridges, which constricts traffic flow. Another member suggested more enforcement at bridges, such as Wailuanui Bridge, that constantly experience these problems. Other bridge concerns expressed were that an EA be prepared for the bridges and addressed in the PA, considering technologically-appropriate materials or methods implementing economical means of constructing bridge improvements, and to retain the posting of the low bridge weight limits to protect the “*aina”* of Hana. The members also encouraged use of in-kind railing replacements versus new protective rails in front of the original historic rails, rehabilitation of bridges versus replacements, and leaving out diacritical marks from bridge names. Other comments or suggestions made, related to “Falling Rock” signage, bridge names being verified by Kepa Maly, and placing bridges in a cultural context of “*Wai,*” the Hawaiian word for water. Chair W. Mardfin stressed that the other 1,400 pages of the report were not specifically discussed and the committee’s acceptance of the report at this time does not imply that the members are in full agreement with the entire plan. The committee wants to retain the right on any individual situation that will be brought before the committee again, to be addressed at that future time. The team confirmed that, per the plan, each construction project will need to undergo consultations with the community. The committee voted unanimously in-favor to approve and recommend the comments as stated in the meeting to be formally adopted.

During the Preliminary Plan Stage, the Kaupo Community Association expressed the need to consult the MBL and HBL. Therefore, the pre-final draft report was transmitted to the MBL for review and comment by the County-level MBL and State-level HBL. The main points from the comments received from the MBL/HBL were that bicycles have the same rules of the road as well as the same rights as vehicles to occupy the roadway. Also, a blanket use of

“Share the Road” treatment is being recommended over the entire route. Further discussion on bicycles is included in Section A, Chapter 6. *Related Issues Along the Hana Highway* of this report.

Finally, in consulting with EMI on the pre-final draft report, the concern was with #19 Kopiliula Bridge, which has EMI equipment attached to the bridge. As requested by EMI, the team noted in the report where applicable that the dam and sluice gate equipment is an integral part of the EMI aqueduct system and, therefore, must remain in place.

CHAPTER 3

SUMMARY OF IDENTIFICATION GUIDELINES & EVALUATION METHODS

i. HANA BELT ROAD HISTORIC DISTRICT

The Hana Belt Road (Hana Highway, Route 360) is listed on the Hawaii Register of Historic Places and NRHP. To be properly listed as an historic property, the Hana Belt Road Historic District must both satisfy and demonstrate significance (refer to Section A, Chapter 3. ii. b. *Identifying the Type of Significance*) and the seven aspects of integrity (refer to Section A, Chapter 3. ii. c. *Integrity*).

The Hana Belt Road Historic District demonstrates significance under evaluation criterion A, property that is associated with events that have made a significant contribution to the broad patterns of our history and criterion C, property that embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant distinguishable entity whose components lack individual distinction.

The Hana Belt Road Historic District nomination form states the following:

> *The Hana Belt Road achieves state and local significance in the areas of engineering, transportation, commerce, and social history under criteria A and C. The construction of bridges and a road to Hana between 1900 and 1947 was a major engineering achievement, as the County of Maui and private contractors benched a road into precipitous mountainsides and through the wilderness of East Maui. Fifty-nine of the bridges built between 1908 and 1947 remain along the route as an example of bridge engineering and construction in Hawai'i during the early twentieth century. The completion of an automobile route to Hana in 1926 ended that community's isolation from the rest of Maui. The road opened East Maui to settlement, agricultural enterprises, and tourism. The Hana Belt Road is the best remaining intact example of the old belt road system in Hawai'i.*[1]

The Hana Belt Road Historic district retains its historic character and integrity. Most of the road is unaltered; alignment and narrow lanes at the rural location have not been changed since the completion of the road in 1926 and many of the bridges’ original materials and designs along the road remain intact.

The Hana Belt Road can thus be considered previously identified as an historic site. Individual bridges and culverts contribute to the historic character of the road.

[1] *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001).

ii. NATIONAL REGISTER CRITERIA

Managed by the National Park Service under the U.S. Department of the Interior, the NRHP is an inventory that documents numerous historic properties in the United States of America. Each nomination (individual property) delves into history, significance, condition, location, and other related information pertaining to the property. "The National Register Criteria for Evaluation define the scope of the National Register of Historic Places; they identify the range of resources and kinds of significance that will qualify properties for listing in the National Register."[2]

The National Register Bulletin can be found here: http://www.cr.nps.gov/nr/publications/bulletins/nrb15/

a. National Register Criteria

Criteria for Evaluation
The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, association, and:

A. That are associated with events that have made a significant contribution to the broad patterns of our history; or

B. That are associated with the lives of significant persons in or past; or

C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. That have yielded or may be likely to yield, information important in history or prehistory.[3]

b. Identifying the Type of Significance

The following criteria are used when evaluating a property to be eligible for listing on the NRHP. It must meet at least one of the criteria and have sufficient integrity to convey its significance.

Criterion A: Event
To be considered for listing under Criterion A, a property must be associated with one or more events important in the defined historic context. Criterion A recognizes properties associated with single events, such as the founding of a town, or with a pattern of events, repeated activities, or historic trends, such as the gradual rise of a port city's prominence in trade and commerce. The event or trends, however, must clearly be important within the associated context: settlement, in the case of the town, or development of a maritime economy, in the case of the port city. Moreover, the property must have an important association with the event or historic trends, and it must retain historic integrity.[4]

This criterion overlaps the Historic American Engineering Record (HAER) Standards No. 1 and No. 2 which relate to the property's contributions to the economic or industrial development of an area and its significance in the history of a branch of engineering. A bridge that was a significant contribution to state or local transportation patterns, an area's broad history (economic,

[2] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: Introduction," U.S. Department of the Interior, National Park Service, http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_int.htm (accessed July 2014).
[3] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: National Register Criteria for Evaluation; Criteria for Evaluation," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_2.htm (accessed July 2014).
[4] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: How to Identify the Type of Significance of a Property; Criteria for Evaluation, Criterion A: Event," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_6.htm (accessed July 2014).

industrial, or other trend), or where a specific significant event occurred and/or was important in the history of bridge engineering, would be considered eligible under this criterion if the bridge is documented to have existed at the time of these events.[5]

Criterion B: Person

Criterion B applies to properties associated with individuals whose specific contributions to history can be identified and documented. Persons "significant in our past" refers to individuals whose activities are demonstrably important within a local, State, or national historic context. The criterion is generally restricted to those properties that illustrate (rather than commemorate) a person's important achievements.[6]

If the bridge is uniquely and directly associated with an historic person during the person's productive life and reflects the time period in which he or she achieved significance, it may be considered eligible under Criterion B. Under this criterion, a significant person must be demonstrably important within a local, national or international context, and the property must be demonstrably associated with said person(s). Properties shall illustrate, not commemorate, a person's significant achievements.[7]

Few bridges in the state are known to be linked with famous historical figures. Among these bridges, none of them are associated with the person's most productive period, and it was determined that none of these bridges have acquired significance through attrition as the sole remaining example of work. Thus this criterion was not used for bridge significance. Bridges designed by known builders are discussed in the "Work of a Master" [section] under Design/Construction (National Register Criterion C).[8]

Criterion C: Design/Construction

This criterion applies to properties significant for their physical design or construction, including such elements as architecture, landscape architecture, engineering, and artwork. To be eligible under Criterion C, a property must meet at least one of the following requirements:

- *Embody distinctive characteristics of a type, period, or method of construction.*
- *Represent the work of a master.*
- *Possess high artistic value.*
- *Represent a significant and distinguishable entity whose components may lack individual distinction.*

The first requirement, that properties "embody the distinctive characteristics of a type, period, or method of construction," refers to the way in which a property was conceived, designed, or fabricated by a people or culture in past periods of history. "The work of a master" refers to the technical or aesthetic achievements of an architect, [engineer], or craftsman. "High artistic

[5] MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013).
[6] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: How to Identify the Type of Significance of a Property; Criteria for Evaluation, Criterion B: Person," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_6.htm (accessed July 2014).
[7] MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013).
[8] Ibid.

values" concerns the expression of aesthetic ideals or preferences and applies to aesthetic achievement.[9]

Distinctive Characteristics of:
Type, period, and method of construction are inter-related criteria. A bridge … [is often] an example of a given time period and method of construction. [Hana Highway bridges are typically a common bridge type still used today, though it is still part of its character defining features.]

- *Type: Type categorization of bridges [can be] based largely on structural designations given by the HDOT. This … is similar to the first part of HAER Standard No. 5 regarding a "sole remaining example" and also mentions "representative" examples of specific types, even when multiple examples exist.*
- *Period: Where structural or maintenance concerns affect the level of integrity or quality of a bridge … [the bridge may still be able to convey a period of construction, or be excellent or distinctive examples of their time.]*
- *Method of Construction: This constitutes [the] technological component [of bridges]. The [more] critical dimensions are the maximum span (distance between supports), length of the bridge, and height of the bridge over the bed… Depending on bridge type, the span and dimensions of each bridge [can be taken] into consideration and analyzed to determine significance and value. Engineering complexity of a bridge [relating] to the above dimensions … [and other factors may display] a standard level of engineering for … period[s] of [design and] construction... [P]atented technology, [being] innovative or complex for its time, and/or had a longer span/length than was typical for its type [may also be considered].*[10]

Work of a Master: If the designer and/or builder were well-known within the state or county and the bridge retained a level of historic integrity, the bridge [can be] considered eligible under [Criterion B]. There do~~es~~ not appear to be any bridges in [Hana] designed by engineers of national renown, [however designers and builders of local significance are noted in the National Register Nomination and referenced in this Plan.] Bridges by undocumented designers and builders may be considered eligible under different criteria.[11]

High Artistic Value: … [Relates] to a bridge's overall design or certain ornamental elements. Typically, the design and pattern of the railing [and arches for Hana Highway, Route 360 are] considered the most ornamental part of the bridge; sometimes the piers, end posts or other component of the bridge has aesthetic appeal.[12]

Distinguishable Entity Whose Components Lack Individual Distinction: … [A]pplies to districts such as Hana Highway (Route 360) or Kuhio Highway (Route 560) where multiple bridges strung together make a district that conveys a greater sense of an historic association.[13] *[Although Hana Highway, Route 360 has 17 exceptional bridges and one exceptional culvert, most of the other bridges and culverts in the district are typical representations of a type.]*

[9] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: How to Identify the Type of Significance of a Property; Criteria for Evaluation, Criterion C: Design/Construction," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_6.htm (accessed July 2014).
[10] MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013), 1-12 – 1-13.
[11] Ibid., 1-13.
[12] Ibid.
[13] Ibid.

Criterion D: Information Potential

Certain important research questions about human history can only be answered by the actual physical material of cultural resources. Criterion D encompasses the properties that have the potential to answer, in whole or in part, those types of research questions. The most common type of property nominated under this Criterion is the archeological site (or a district comprised of archeological sites). Buildings, objects, and structures (or districts comprised of these property types), however, can also be eligible for their information potential.

Criterion D has two requirements, which must both be met for a property to qualify:

- *The property must have, or have had, information to contribute to our understanding of human history or prehistory, and*
- *The information must be considered important.*

Under the first of these requirements, a property is eligible if it has been used as a source of data and contains more [that has not yet been retrieved.] A property is also eligible if it has not yet yielded information but, through testing or research, is determined a likely source of data.

Under the second requirement, the information must be carefully evaluated within an appropriate context to determine its importance. Information is considered "important" when it is shown to have a significant bearing on a research design that addresses such areas as: 1) current data gaps or alternative theories that challenge existing ones or 2) priority areas identified under a State or Federal agency management plan.[14]

While this criterion is generally used for archeological sites, use within this category is typically reserved for preservation of unique information that is only attainable by [studying] the existing site. Determination of the research potential of a bridge may include noting specific construction techniques that are otherwise unusual and not documented in another manner. Bridges deemed unlikely to yield unique important information not otherwise obtainable from documents and other sources are not considered under this criterion.[15]

[14] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: How to Identify the Type of Significance of a Property; Criteria for Evaluation, Criterion D: Information Potential," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_6.htm (accessed July 2014).

[15] MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013), 1-13.

c. Integrity

Integrity is defined as "the ability of a property to convey its significance."[16] Properties listed under the NRHP are required to demonstrate its significance under the National Register Criteria and satisfy the seven aspects of integrity. It is the combination of these seven aspects that determine if the property has enough integrity.

1. Location

Location is the place where the historic property was constructed or the place where the historic event occurred. The relationship between the property and its location is often important to understanding why the property was created or why something happened. The actual location of a historic property, complemented by its setting, is particularly important in recapturing the sense of historic events and persons. Except in rare cases, the relationship between a property and its historic associations is destroyed if the property is moved. [All Hana bridges have retained its location over streams or gulches.]

2. Design

Design is the combination of elements that create the form, plan, space, structure, and style of a property. It results from conscious decisions made during the original conception and planning of a property (or its significant alteration) and applies to activities as diverse as community planning, engineering, architecture, and landscape architecture. Design includes such elements as organization of space, proportion, scale, technology, ornamentation, and materials.

A property's design reflects historic functions and technologies as well as aesthetics. It includes such considerations as the structural system; massing; arrangement of spaces; pattern of fenestration; textures and colors of surface materials; type, amount, and style of ornamental detailing; and arrangement and type of plantings in a designed landscape.

Design can also apply to districts, whether they are important primarily for historic association, architectural value, information potential, or a combination thereof. For districts significant primarily for historic association or architectural value, design concerns more than just the individual buildings or structures located within the boundaries. It also applies to the way in which buildings, sites, or structures are related: for example, spatial relationships between major features; visual rhythms in a streetscape or landscape plantings; the layout and materials of walkways and roads; and the relationship of other features, such as statues, water fountains, and archeological sites. [The design of the historic bridges are apparent in almost all the Hana bridges in this study.]

3. Setting

Setting is the physical environment of a historic property. Whereas location refers to the specific place where a property was built or an event occurred, setting refers to the character of the place in which the property played its historical role. It involves how, not just where, the property is situated and its relationship to surrounding features and open space.

Setting often reflects the basic physical conditions under which a property was built and the functions it was intended to serve. In addition, the way in which a property is positioned in its environment can reflect the designer's concept of nature and aesthetic preferences.

[16] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: How to Evaluate the Integrity of a Property," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_8.htm (accessed July 2014).

The physical features that constitute the setting of a historic property can be either natural or manmade, including such elements as:

- *Topographic features (a gorge or the crest of a hill);*
- *Vegetation;*
- *Simple manmade features (paths or fences); and*
- *Relationships between buildings and other features or open space.*

These features and their relationships should be examined not only within the exact boundaries of the property, but also between the property and its surroundings. This is particularly important for districts [such as the Hana Belt Road Historic District.]

4. Materials

Materials are the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property. The choice and combination of materials reveal the preferences of those who created the property and indicate the availability of particular types of materials and technologies. Indigenous materials are often the focus of regional building traditions and thereby help define an area's sense of time and place.

A property must retain the key exterior materials dating from the period of its historic significance. If the property has been rehabilitated, the historic materials and significant features must have been preserved. The property must also be an actual historic resource, not a recreation; a recent structure fabricated to look historic is not eligible. Likewise, a property whose historic features and materials have been lost and then reconstructed is usually not eligible. [The use of local lava rocks in the rubble masonry is an example of the use of materials that help convey the story of Hana Highway.]

5. Workmanship

Workmanship is the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory. It is the evidence of artisans' labor and skill in constructing or altering a building, structure, object, or site. Workmanship can apply to the property as a whole or to its individual components. It can be expressed in vernacular methods of construction and plain finishes or in highly sophisticated configurations and ornamental detailing. It can be based on common traditions or innovative period techniques.

Workmanship is important because it can furnish evidence of the technology of a craft, illustrate the aesthetic principles of a historic or prehistoric period, and reveal individual, local, regional, or national applications of both technological practices and aesthetic principles. [Examples among the Hana Highway, Route 360 bridges include techniques in the construction of rubble masonry and board-formed concrete.]

6. Feeling

Feeling is a property's expression of the aesthetic or historic sense of a particular period of time. It results from the presence of physical features that, taken together, convey the property's historic character. For example, a rural historic district retaining original design, materials, workmanship, and setting will relate the feeling of agricultural life in the 19th century. A grouping of prehistoric petroglyphs, unmarred by graffiti and intrusions and located on its original isolated bluff, can evoke a sense of tribal spiritual life. [For the Hana Belt Road Historic District, the integrity in its rural beauty exudes a sense of discovery and wonder that must have occurred for anyone first driving along this road for nearly a century. Though this aspect is a product of the other integrity aspects, it is often the most important one to capture.]

7. Association

Association is the direct link between an important historic event or person and a historic property. A property retains association if it is the place where the event or activity occurred and is sufficiently intact to convey that relationship to an observer. Like feeling, association requires the presence of physical features that convey a property's historic character. For example, a Revolutionary War battlefield whose natural and manmade elements have remained intact since the 18th century will retain its quality of association with the battle.

Because feeling and association depend on individual perceptions, their retention alone is never sufficient to support eligibility of a property for the National Register.[17]

[17] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation: How to Evaluate the Integrity of a Property," http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_8.htm (accessed July 2014).

iii. STATE HISTORIC PRESERVATION OFFICE GUIDE TO HISTORIC ROADS

A key role in the identification and preservation of the significant historic bridges is that of the State Historic Preservation Officer (SHPO) – or, State Historic Preservation Division, in the case of Hawaii. In an attempt to assist the SHPD to become familiar with highway history, types, and terminology, a guide was prepared and published in 2010: *The Preservation Office Guide to Historic Roads*. Its stated goals are:

- Clarifying Preservation Goals for State Historic Preservation Offices
- Establishing Preservation Expectations for State Transportation Departments

The Preservation Office Guide to Historic Roads states that,

> *State Historic Preservation Offices (SHPOs) across the nation have had difficulty defining and defending historic roads in the face of overwhelming political, social, and judicial pressures predicated on highway safety and efficiency. This is due, in part, to a limited familiarity with roads as historic resources, but more importantly, to the absence of a clear taxonomy [terminology] defining our nation's historic roads. Without uniform definitions and standard historic road language within the preservation nomenclature, SHPOs, and their tribal counterpart (THPOs) cannot effectively define the impacts of proposed transportation projects on historic roads, nor can they establish clear expectations for the transportation department during the scoping, planning, or implementation process.*[18]

The guide gives an historic overview of the development of roads and highways and goes on to define roadside elements that add to the character of the roadways. It makes the case that SHPOs must be able to converse with the State DOT's to arrive at meaningful solutions that balance safety and preservation.

> *Across the United States historic roads are being lost through demolition, neglect and poor management. Sometimes this is due to transportation policy, sometimes due to external pressures (such as land use development) and sometimes simply ignorance. These losses can be swift and devastating or slow and incremental—hardly noticed until it is too late.*
>
> *It is important to recognize and preserve historic roads. One need only consider the lost resources of earlier transportation eras now lamented. Canals, railroad stations and the pony express route. The U.S. has already lost long stretches of Route 66 and segments of the Columbia River Highway—our first great scenic automobile highway.*[19]

The author cites many examples including key references to Hawaii:

> *Increasingly, communities across the United States are beginning to recognize that their roads are historic. From Duluth, Minnesota… to East Maui, Hawaii where the preservation of the historic Hana Highway (circa 1920) was recognized as a critical component for the preservation of the larger historic landscape, communities are viewing roads as credible historic features defining their past and culture.*[20]

The Hana Highway, Route 360 is part of Hana Belt Road Historic District, listed on the Hawaii State and National Registers of Historic Places. Registration is most notable recognition for the historic roads. Bridges and culverts along the highway are contributing features of the Hana Belt Road Historic District. Also mentioned in Section A,

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[18] Paul Daniel Marriott, "The Preservation Office Guide to Historic Roads*: Clarifying Preservation Goals for State Historic Preservation Offices, Establishing Preservation Expectations for State Transportation Departments,"* (Washington, D.C., 2010), 3-4.
[19] Ibid., 4-5.
[20] Ibid., 5.

Chapter 3. i. *Hana Belt Road Historic District*, the road, bridges and culverts retain their historic character and integrity. Therefore, implementing newer policies adopted by the FHWA and AASHTO, such as flexible design and context sensitive solutions, are encouraged.

iv. BRIDGE IDENTIFICATION

a. Definition of Bridges

Bridge

> *A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller continuous opening.*[21]

Culvert

A structure designed hydraulically to take advantage of submergence to increase hydraulic capacity. Culverts, as distinguished from bridges, are usually covered with embankment and are composed of structural material around the entire perimeter, although some are supported on spread footings with the streambed serving as the bottom of the culvert. Culverts may qualify to be considered "bridge" length.[22] Generally speaking, the 12 historic HAER culverts along the Hana Highway, Route 360 appear to be short bridges.

Hillside Bridge

A bridge with portion of its roadway width on embankment and portion of it cantilevered off the side of the embankment.

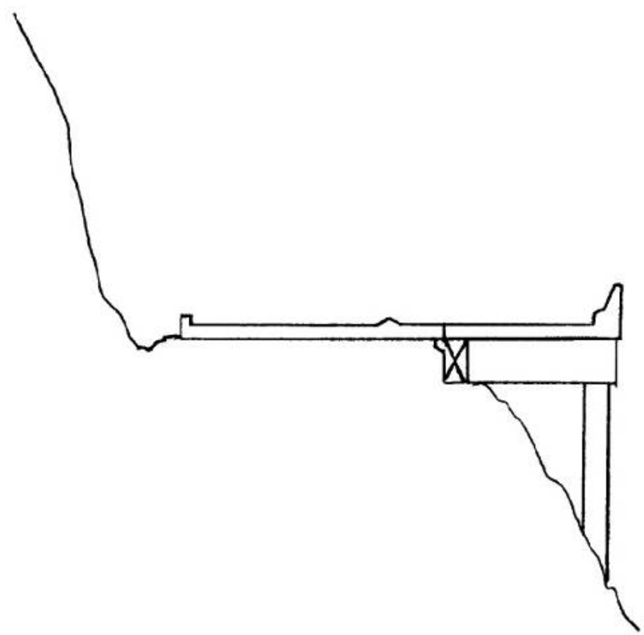

Figure 3 – 1: Hillside Bridge, Courtesy of Federal Highways Administration[23]

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[21] "§650.403 Definition of Terms," 23 CFR Part 650 – Bridges, Structures, and Hydraulics, Subpart D – Highway Bridge Replacement and Rehabilitation Program, §650.403 Definition of Terms, http://www.gpo.gov/fdsys/pkg/CFR-2011-title23-vol1/pdf/CFR-2011-title23-vol1-sec650-403.pdf (accessed September 17, 2015). *Note: This is an FHWA definition of the bridge. It is different from the bridges that are eligible for bridge funding and those that are required to be included under the National Bridge Inventory (NBI) and inspected every 24 months (maximum) under the NBIS.*

[22] USDOT and FHWA, *Recording and Coding Guide for Structure Inventory and Appraisal of Nation's Bridges*, December 1995 with June 2011 Errata.

[23] Ibid.

b. Identification of Bridge Components

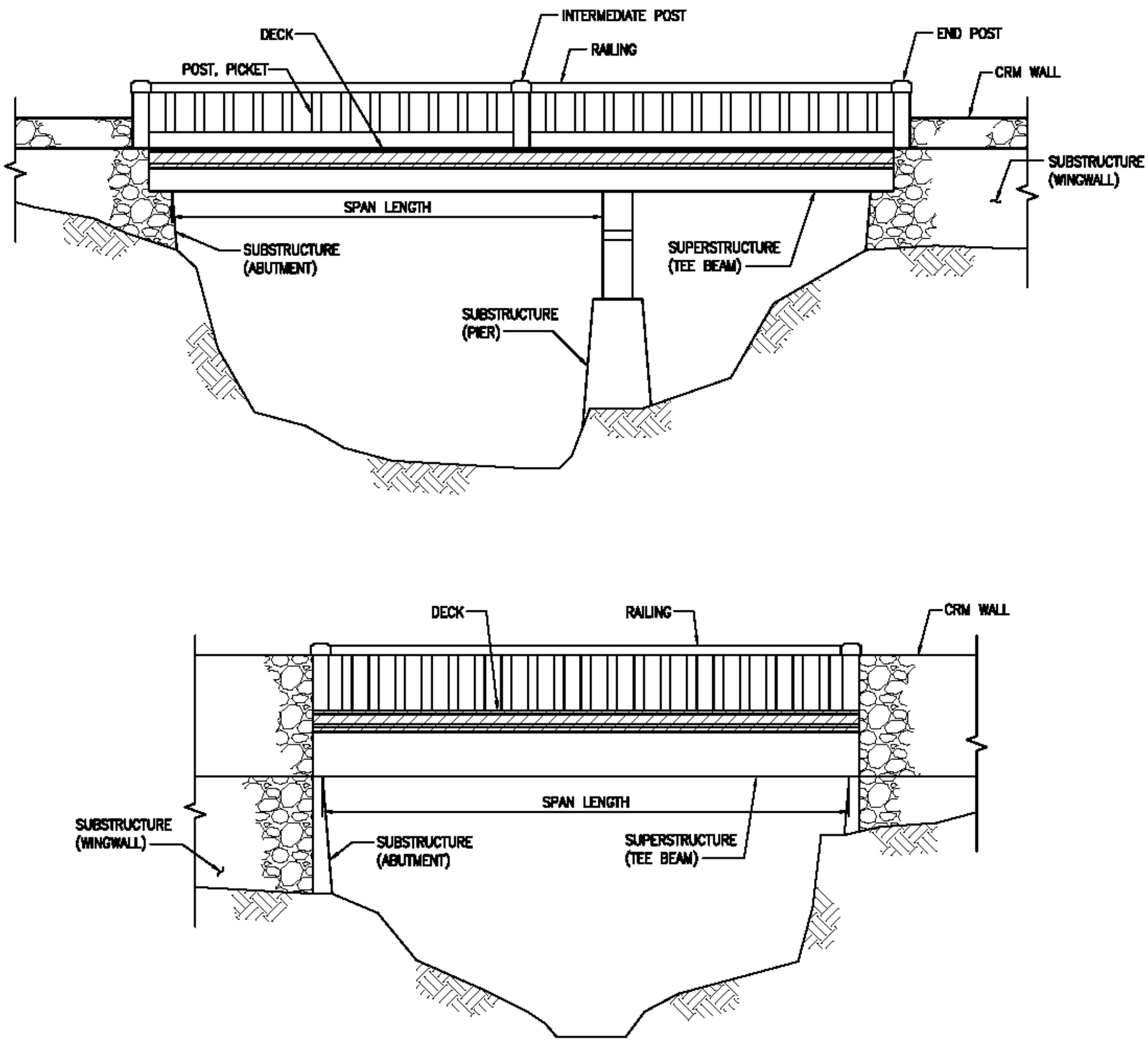


Figure 3 – 2: Components of a Typical Concrete Open Vertical Railing Bridge, Courtesy of Nagamine Okawa Engineers, Inc.

Bridges and culverts identified in the *Hana Highway Bridge Preservation Plan (2015)*, in general, exhibit the same structural components and technical terms identified here and used throughout this report. As a character-defining feature, however, the term "parapet" is used to further distinguish the difference between solid concrete parapet bridges and those with open vertical post or picket "railings."

Concrete parapets may be characterized by additional character-defining details, including but not limited to: dimensions, paneling, cap shape (saddle coping, rounded, or rectangular) or lack thereof, and date inscriptions.

Concrete open vertical railings may be characterized by additional character-defining details, including but not limited to: the solid to open relationship and spacing (i.e., post/picket spacing), end and intermediate post designs (often rectangular with panels, or at #16 Waikani rounded), unique shapes (i.e., Greek Cross railing), and rail caps.

c. Summary of Bridge Types

Bridge type is defined by the form or method in which the structure functions. It is not exclusively determined by any of the following: materials, method of construction, type of span, or if the bridge structure exists above or below the grade. However, many bridge structures were patented with the material type and/or form detail.

[The historic bridges on Hana Highway, Route 360 are constructed of concrete using several structural types that includes:] concrete tee beam, concrete slab, concrete arch deck, and concrete floor system. [The extensive use of concrete is due to the corrosive nature of salt air from the] Pacific Ocean and the presence of the insects [that make] the maintenance of steel and wooden bridges less practical. [Most of the bridges on Hana Highway, Route 360 have CRM abutments and/or wingwalls. CRM construction is a unique type of construction in Hawaii and is typical of its period in its use of materials, method of construction, craftsmanship, and design.] [25]

Concrete Arch Bridges

Description

Concrete arch [bridges] constructed …[along Hana Highway, Route 360] are of two basic types: [closed]- and open-spandrel [arch bridges. A closed spandrel arch bridge is a type of arch bridge where the arch supports vertical walls along each side of the arch barrel. Fill material is placed over the arch between these vertical walls to support the roadway.] … These were generally constructed in two periods in Hawaii: the early solid-spandrel arch bridges date from c.1904 to 1915, and the later solid-spandrel arch bridges date from c.1916-1929. There are two types of open spandrel arch bridge construction: the most common is the arch deck open-spandrel, first constructed on Maui in 1911; the second type is the Rainbow or Marsh arch, a through-arch constructed during the 1920s and 1930s, in which the traffic deck is suspended from the bottom or lateral chord of the arch.

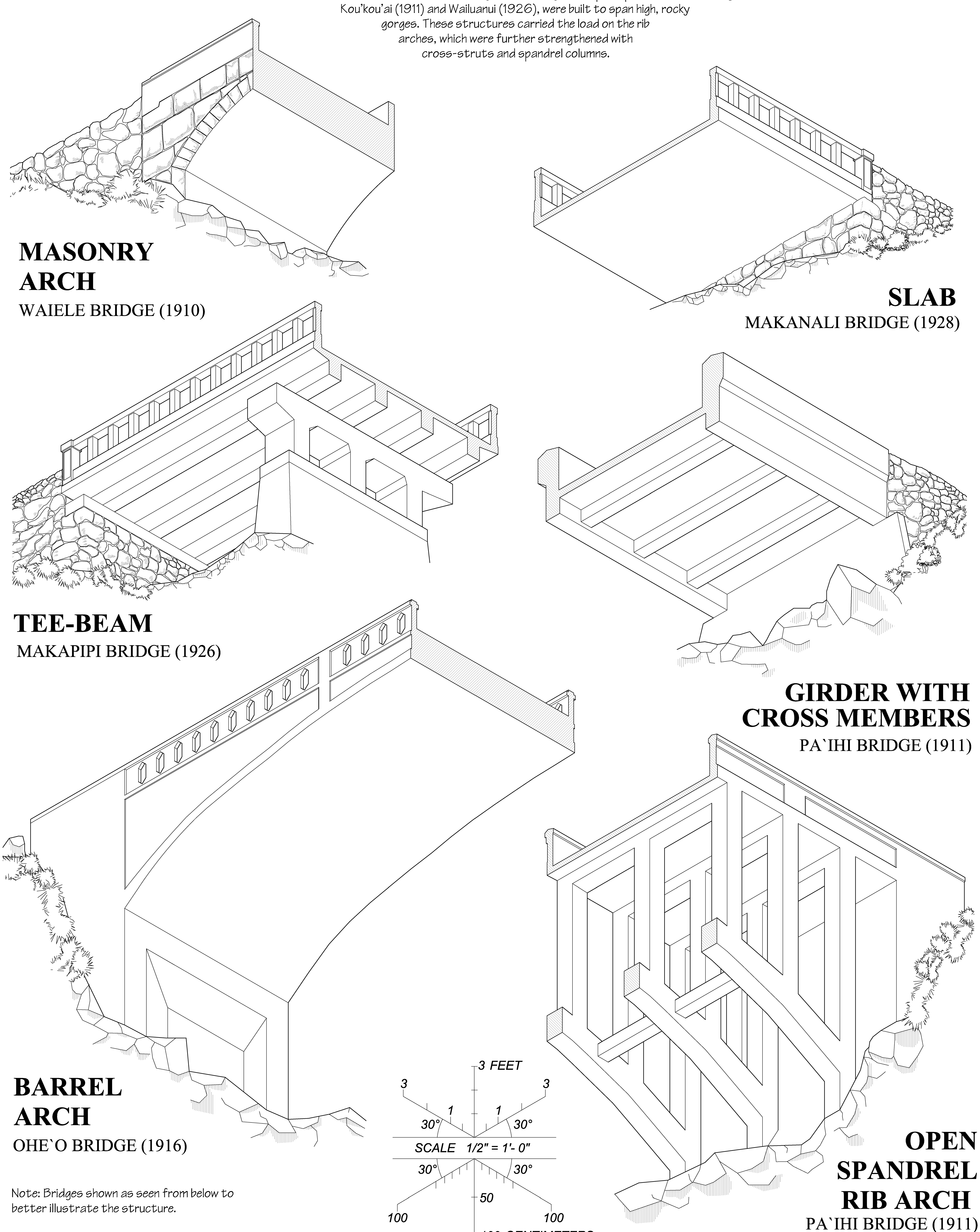
The first reinforced-concrete bridge in America was built in 1889, but the material remained in an experimental phase until the early 1900s. Reinforced-concrete arch bridges were built in Hawaii after 1904, when the territorial government made it their policy to erect strong, low-maintenance bridges. Concrete could be produced locally from crushed coral or stone aggregate and lime produced by burning the coral reefs. Other materials like cement and reinforcing steel were imported.

While stone was cheap and locally available, construction of stone arches was labor intensive and seemed to have died quickly with the advent of concrete. This corresponds to developments in the U.S. mainland where concrete had largely replaced masonry by the turn of the century. Further confirmation that concrete was the prevailing bridge material of the era is apparent in the decision made by the Loan Fund Commission, set up in 1911 to oversee a special construction fund established by the Legislature. The commission announced that "Steel was unanimously discarded. Concrete will be used as far as funds permit, the absence of repairs offsetting the large first cost, but it is possible that wood may be used on some spans over forty feet, if funds get low."

[25] MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013), 1-17 – 1-38.

BRIDGE TYPOLOGIES
OF THE HANA BELT ROAD

The Hana Belt Road Bridges illustrate the history of bridge construction in Hawaii during the late-nineteenth and early-twentieth centuries. Two Concrete rubble masonry structures are fine examples of a bridge type common in the late 1800's. As early as 1908, engineers began designing reinforced-concrete bridges to replace Hawaii's aging collection of timber and steel bridges. Reinforced-concrete structures became the standard as these bridges would last for the ages.
The majority of the Hana Coast bridges were built with reinforced-concrete flat slabs or girders. Flat-slab bridges (and culverts) were constructed when short spans were required. For longer spans, Tee-beam girder bridges were utilized. Some structures, particularly those with very thick rapets such as Pa'ihi Bridge, used Tee-beam girders with cross members. which were poured with the parapets so that all members worked together to support the roadway. Three barrel-arch bridges, built in 1916 and 1926, utilized a solid concrete arch with fill material above the arch to carry the roadway. Two open-spandrel rib-arch bridges, Kou'kou'ai (1911) and Wailuanui (1926), were built to span high, rocky gorges. These structures carried the load on the rib arches, which were further strengthened with cross-struts and spandrel columns.

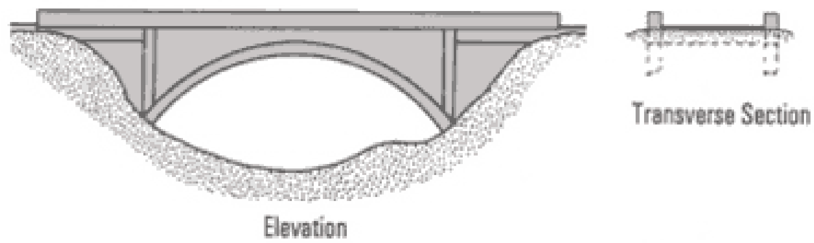


DELINEATED BY: DANIEL SCHAIBLE, 2005

HANA HIGHWAY RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	HANA BELT ROAD (HANA HIGHWAY) BETWEEN HAIKU AND KIPAHULU/STATE HIGHWAY 360/COUNTY HIGHWAY31 HANA VICINITY MAUI HAWAII	SHEET 3 OF 13	HISTORIC AMERICAN ENGINEERING RECORD HI-75	LIBRARY OF CONGRESS INDEX NUMBER

Figure 3 – 3: Bridge Typologies

Courtesy of HAER HI-75

Closed Spandrel Arch	

[Figure 3 – 4: Closed Spandrel Arch Bridge]

The various types of concrete arch bridges are described as follows:

***[Concrete Closed Spandrel Arch Bridges** (refer to Figure 3 – 4), also known as] reinforced-concrete [closed]-spandrel arch bridges were constructed [during] two periods in Hawaii.*

The earliest all-concrete bridges were built in 1904-1906 to standardized plans as a result of territorial policy. Since the first concrete arches echoed the design and form of earlier masonry arch bridges, these utilize concrete, a new material, in a fairly conservative manner from an engineering perspective. Nonetheless, reinforced-concrete was a material requiring skilled designers and builders.

These first reinforced-concrete arch bridges were constructed in lieu of masonry arches, generally in residential areas over small or intermittent streams bisecting major transportation arteries. The arches of these early bridges are circular and earth-filled. The rise of the arch is typically eight feet and the span approximately thirty-two feet. The parapets are of reinforced cast concrete, approximately four to six inches thick and three feet high, with a peaked concrete rail cap. The bridges are quite narrow, usually twelve or thirteen feet [wide].

Concrete, previously used for the arch ring of masonry bridges or the capping of parapets, was used for bridge construction after the territorial government made construction of strong, low-maintenance bridges its stated policy shortly after annexation.

The second period of reinforced-concrete solid-spandrel arch construction occurred, between 1916 and 1929, simultaneously with the development of the technologically innovative open-spandrel arch. Later [closed]-spandrel arch bridges achieved greater spans and further refinement of detail and ornamentation, particularly at parapets and end rails, than earlier examples. These later [closed]-spandrel arches were intended to be significant civic statements reflecting Hawaii's aspirations for beautiful and urbane public works projects. The World's Colombian Exposition in Chicago in 1893 served as the inspiration for the City Beautiful movement and the ensuing neo-classical revival in the United States. The City Beautiful movement reached its height on the U.S. mainland between 1900 and 1910, but affected Hawaii somewhat later. This movement is characterized by an attempt to create beautiful and functional cities. Aesthetic principles such as beauty, order, system, and harmony found physical realization in urban design. Architecture and public works projects, such as road and sewer systems, became civic statements which strengthened the identification of Hawaii to the U.S. mainland…

[In the second period, during the 1920s, two closed-spandrel concrete arch bridges, #26 Hanawi Stream Bridge and #29 Kuhiwa Stream Bridge, were built along Hana Highway, Route 360.]

Open Spandrel Arch

[Figure 3 – 5: Open Spandrel Arch Bridge]

Open-Spandrel Concrete Arch Bridges *[(refer to Figure 3 – 5)] were technologically innovative and are considered to be engineering break-throughs. Open-spandrel [arch] bridges…[have open spaced between the deck and arch members allowing open visibility through the bridge. The structure consists of relatively narrow arch ribs upon which columns and /or beams are built to support the deck system. #16 Waikani Stream Bridge is the only open-spandrel concrete arch bridge on the Hana Highway, Route 360.] The open-spandrel bridge, with its technical innovations, was capable of spanning hundreds of feet. Island engineers had multiplied their arch-spanning capacity by a factor of ten and refined the casting of concrete to create slimmer, lighter-looking structures. They retain their historic associations and feeling due to their rural location, ornamental nature and now uncommon structural type.*

Significance

The period of significance for reinforced-concrete arch bridges [on the Hana Highway Route 360 spans the period 1926 - 1929, during which three arch bridges were constructed.] Concrete arch bridges are eligible under Criterion A if they contributed in a meaningful way to the settlement and development of a geographically definable area, facilitated major passage to or through a region, or have been significantly integral to the development of an effective transportation system. The construction of reinforced-concrete bridges in place of timber and metal bridges is representative of the commitment of the territorial and county governments to implement permanent public works improvements. The construction of these bridges required the mobilization of skilled labor and significant public funds. Many of these bridges were often extremely prominent, both in style and location, and made a significant "civic statement" regarding the technical and aesthetic sophistication of the communities in which they were built. In addition, some of these bridges have survived significant historic preservation battles between the concerned citizenry and governmental transportation agencies or private developers.

Reinforced-concrete arch bridges are eligible under Criterion C as the earliest examples of concrete bridge construction in the state. They also represent a span of engineering innovation and a visual timeline of construction technology. Concrete arch bridges often evidence a high degree of detailing and workmanship and are examples of exceptional work by important local builders. The few remaining examples are rare survivors of this once common bridge type. Reinforced-concrete arch bridges also serve as examples of exceptional work by an important engineer, architect, or builder.

Eligibility Requirements

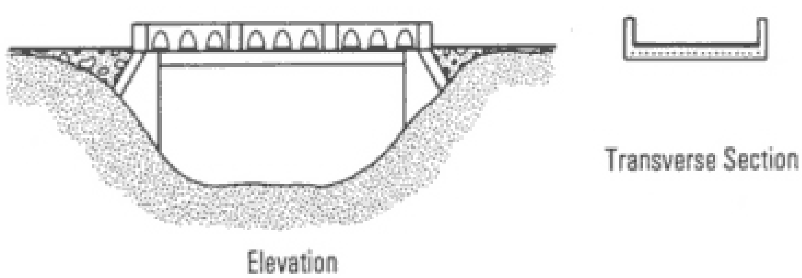
Since reinforced-concrete arch bridges were constructed as permanent structures, the bridge must retain its integrity of location in order to be considered eligible. The design of the bridge, particularly the arch, the spandrel walls and parapets, must also retain its integrity; although alterations early in the bridge's history (i.e., within the period of significance) and in such a way that the alterations are reversible without diminishing the significant historic characteristics of the original bridge (by widening or lengthening the bridge by the construction of an adjacent concrete culvert, for example) are acceptable. The setting of the bridge must remain relatively unchanged; by-passing the original transportation artery with a new highway does not necessarily exclude a property if the bridge's immediate surroundings retain its historic qualities. The bridge's original materials must not be adversely affected by alterations or additions. The quality of the original workmanship must remain apparent, with substantial evidence of the artisan's labor and skill. The bridge must retain a high degree of historic feeling, and its associations must be apparent to the informed or casual observer.

Concrete [Slab and] Deck Bridges

Description

Concrete construction technology rapidly advanced in the early decades of the twentieth-century. Early twentieth century bridges built with county funds often consisted of new simple concrete decks built over the original nineteenth-century stone abutments. Slab bridges are known to have been used in Hawaii since about 1908. However, concrete girders and tee beam types came to dominate Hawaii's early twentieth-century bridge designs. [Most of the bridges on the Hana Highway, Route 360 are concrete tee beam bridges.] As their strength and economy became apparent, concrete deck girders replaced concrete arches and open-spandrel arches for short spans. Like their contemporary flat slab bridges, early concrete girder bridge [#19 Kopiliula Stream Bridge, built in 1926 on the Hana Highway, Route 360 has simply designed] plain solid parapets.

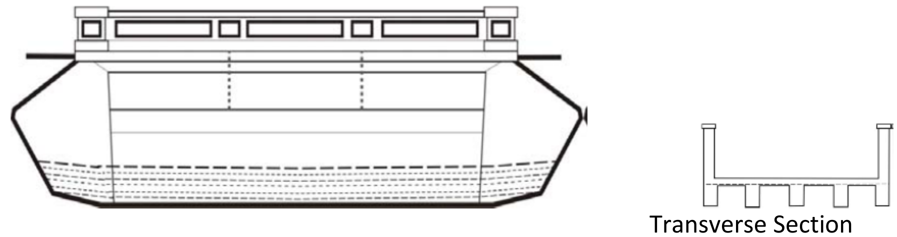
Flat Concrete Slab



[Figure 3 – 6: Flat Concrete Slab Bridge]

Slab [Bridges *(refer to Figure 3 – 6) or s]imple reinforced-concrete slab bridges were an alternative to metal or timber stringer structures. Concrete slab bridges were constructed in [the state of] Hawaii from 1908, when the oldest remaining example … [#40 Mokulehua Bridge was built along the Hana Highway, Route 360], until approximately 1937, when moment-resisting concrete rigid-frame bridges became common [in the state of Hawaii. The last slab bridge constructed along the Hana Highway, Route 360 was #5 Makanali Stream Bridge, built in 1928]. Early slab bridges often consisted of [a single span reinforced concrete slab which replaced the original bridge deck. The concrete slab was supported on the] new simple concrete decks built over the original nineteenth century stone abutments. The slabs were cast on site, with formwork built by local carpenters. The plain appearance of this functional design was augmented by a variety of railings, which ranged from solid parapets to open balustrades. These slab bridges typically had spans of twelve to sixteen feet.*

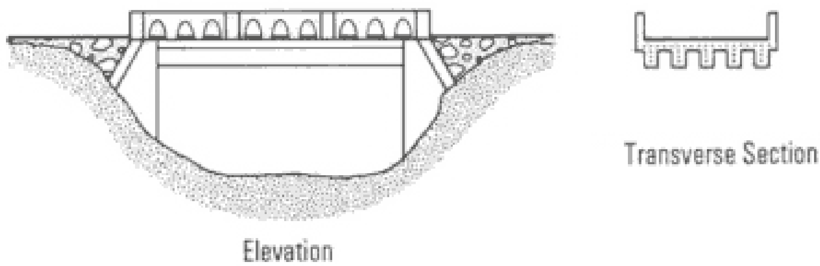
Concrete Girder



[Figure 3 – 7: Concrete Girder Bridge]

Concrete Girder [Bridges *(refer to Figure 3 – 7) are a] …common early concrete bridge type [that] utilized cast concrete girders in order to extend the length of the spans. As their strength and economy became apparent, concrete deck girders replaced concrete arches and open-spandrel arches for short spans. [#19 Kopiliula Stream Bridge built in 1926 is the only concrete girder bridge on the Hana Highway, Route 360. This bridge has plain solid girders that also function as the parapets.]*

Concrete Girder (T-Beam)



[Figure 3 – 8: Concrete Girder (T-Beam) Bridge]

Concrete Tee Beam [Bridges *(refer to Figure 3 – 8) are] the most common remaining type of pre-WWII [bridge] type [along the Hana Highway, Route 360, and] in the state of Hawaii. Although, the majority of concrete tee beam bridges were built by the Territorial Highways Department using local contractors after 1925, many early examples, dating from 1911-12, remain throughout [Hana Highway, Route 360]. These bridges are virtually indistinguishable from concrete girder bridges in appearance, differing only by the number of longitudinal beams and the pattern of steel reinforcing. Later tee beam bridges achieved remarkable spans and are among the longest and highest bridges in the State. This height and length was achieved by utilizing continuous tee beam sections. Continuity allowed for greater spans and the elimination of expansion joints in the deck. Along the Hana Highway, Route 360, concrete tee beam bridges typically feature one of the several standard rail patterns [on the Hana Highway, Route 360], either "Greek-cross," [open vertical, open horizontal, or solid with] reinforced-concrete rail cap.*

Significance

The period of significance for reinforced-concrete deck bridges begins in 1908, when the first example was constructed, and [ended] in [1947 when the last concrete tee beam bridge was built on the Hana Highway, Route 360]. Concrete deck bridges are eligible under Criterion A if they contributed in a meaningful way to the settlement and development of a geographically definable area, facilitated major passage to or through a region, or been significantly integral to the development of an effective transportation system. Concrete deck bridges are representative *of important public works projects initiated by the territorial and county governments. They were generally constructed at important crossings along a major transportation route or belt road. Many of the later concrete deck bridges were constructed with federal work relief programs funds during the Depression era. The early flat slab and girder bridges are an excellent example of the early period of twentieth-century bridge design when new materials and design methods were being tried. Concrete flat slab and girder bridges are early examples of the progressive Territorial Highway System in Hawaii and among the first use of formal engineering expertise in bridge making by the new territorial government, shortly after the annexation of Hawaii by the United States. The [bridges on Hana Highway, Route 360] played a major role in the development of [East Maui] … by connecting previously isolated communities with a paved highway.*

Reinforced-concrete deck bridges are eligible under Criterion C if they are the earliest, sole surviving, longest span, or most intact example of their type, or if they exhibit notable engineering or decorative details. They may also serve as examples of exceptional work by an important engineer, architect, or builder. Later concrete bridges, such as tee beams and rigid-frames, demonstrate the rapid advances in engineering technology in the early decades of the twentieth century.

<u>Eligibility Requirements</u>
Since reinforced-concrete deck bridges were constructed as permanent structures, the bridge must retain its integrity of location. The design of the bridge, particularly the sub-structure, the spandrel walls and parapets, must also retain its integrity. Alterations may be considered acceptable if they were completed early in the bridge's history (i.e., within the period of significance) and in such a way that they are reversible without diminishing the significant historic characteristics of the original bridge. The setting of the bridge must remain relatively unchanged; by-passing the original transportation artery with a new highway does not necessarily exclude a property if the bridge's immediate surroundings retain its historic qualities. The bridge's original materials must not be adversely affected by alterations or additions. The quality of the original workmanship must remain apparent, particularly from a technical rather than aesthetic perspective, with substantial evidence of a builder's labor and skill. The bridges must retain a high degree of historic feeling and their associations must be apparent to the informed or casual observer.[26]

[26] MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013), 1-17 – 1-38.

d. Bridge Parapet / Railing Types

Solid Parapet	Examples
Concrete Solid	 *Figure 3 – 9: Waikamoi Stream Bridge (1912)* *009003600500990* *Courtesy of FAI*
Concrete Solid with Cap	 *Figure 3 – 10: Puohokamoa Stream Bridge (1912)* *009003600501098* *Courtesy of FAI*

Concrete Open Railing	Examples
Concrete Open Vertical, also referred to as Concrete Open Picket	 *Figure 3 – 11: Oopuola Stream Bridge (1925)* *009003600500797* *Courtesy of FAI*
Concrete Open Greek Cross	 *Figure 3 – 12: Waiokamilo Stream Bridge (1921)* *009003600501811* *Courtesy of FAI*

Concrete Open Horizontal	 *Figure 3 – 13: Kawaipapa Stream Bridge (1947)* *009003600503347* *Courtesy of FAI*

BRIDGE PARAPETS
OF THE HANA BELT ROAD

Parapet styles on the Hana Belt Road bridges can be classified into two general categories: solid reinforced-concrete parapets and open parapets with simple vertical balusters. Many parapets also exhibit unique stylistic elements, including rail and post caps, panel details, and in some cases, the addition of dates or other inscriptions. A handful of structures, as illustrated, feature unique parapet designs.

SOLID WALL

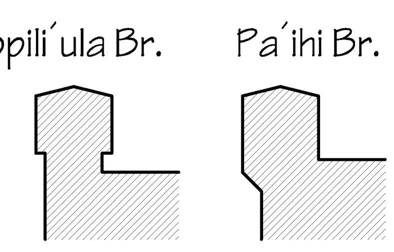
Bridge name	Year	Bridge name	Year
WAIKAMOI	1912	KAPIA (KAHAWAIOKAPIA)	1915/31
PUOHOKAMOA	1912	PAPA´AHAWAHAWA	1913
HAIPUA´ENA	1912	ALA´ALA´ULA	1915
KOLEA (PUNALAU)	1911	WAIKAKOI	1911
HONOMANU	1911	SOUTH WAILUA (HONOIEWA)	1911
NUA´AILUA (*)	1911/40	WAIELE (PAEHALA)	1910
WAIOHUE (**)	1926/37	KAKIWEKA (MAHALAWA)	1910
WAIOHUOLUA	1920/70	HAHALAWE	1910
MOKULEHUA	1908	PUA'ALU'U	1910
HANEO'O (KAHOLOPO)	1910/17	KOUKOU'AI	1911

(*) CONSTRUCTED 1911, ALTERED 1940. DIFFERENT PARAPETS. ORIGINAL SOLID WALL.
(**) CONSTRUCTED 1926, ALTERED 1937. DIFFERENT PARAPETS: NARROW AND WIDE SOLID WALLS.

TWO BRIDGES HAVE WIDER PARAPET WALLS. THESE SERVE AS A STRUCTURAL PART OF THE GIRDER SYSTEM.

Bridge name	Year
KOPILI´ULA	1926
PA´IHI	1912

Profiles
Scale: 1/4



OPEN BALUSTER

ONE PANEL

Bridge name	Year
O´OPUOLA	1925/31
MAKANALI	1928
KA´AIEA	1912
NUA´AILUA (*)	1911/40
PI´INA´AU	1916
PALAUHULU	1916
EAST WAILUAIKI	1926
PUA´AKA´A	1926
KUPUKOI	1926
KAHALAOWAKA	1926
MANAWAIKEAE	1926
KEA´A´IKI	1921
WEST WAIONI	1920
WAIONI	1920
HELELE´IKE´OHA	1917
OILOWAI	1914

TWO PANEL

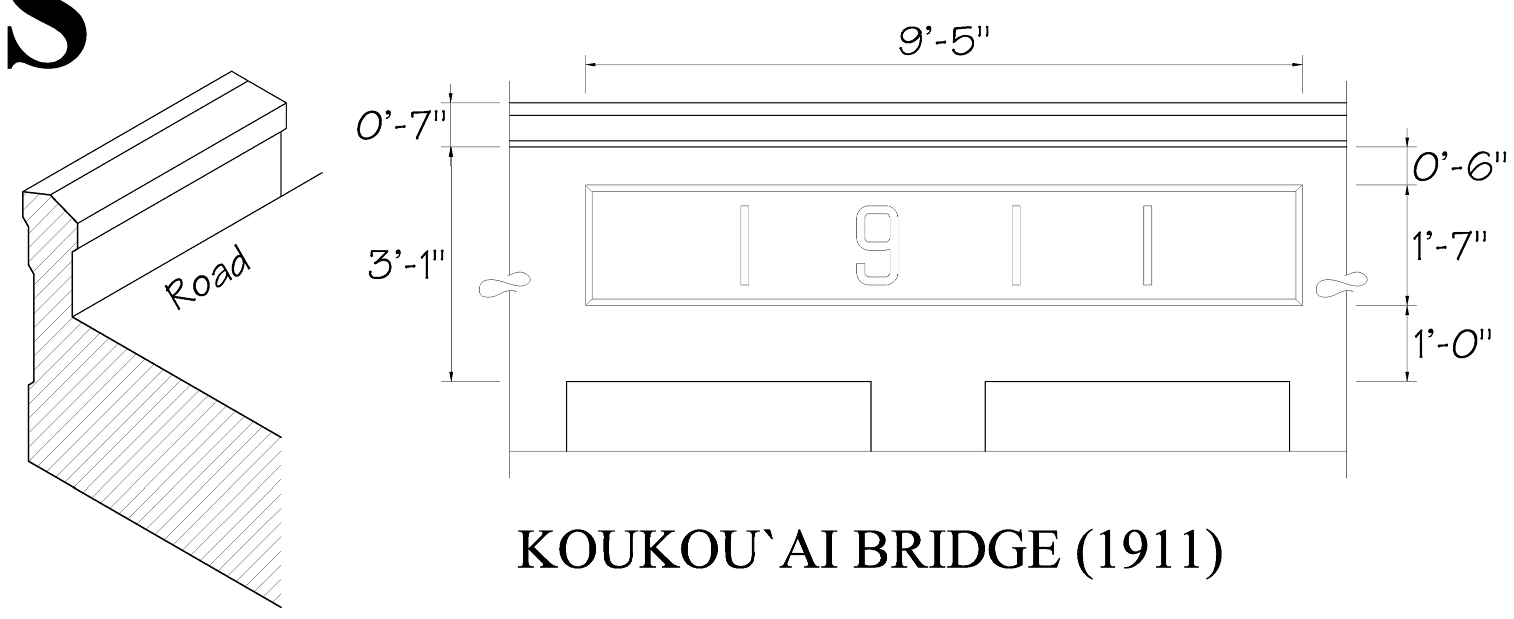
Bridge name	Year
PA´AKEA	1920/37
KAPA´ULA	1926
MAKAPIPI	1926
LANIKELE	1917
ULA´INO	1914
HONOMA´ELE	1924

THREE PANEL

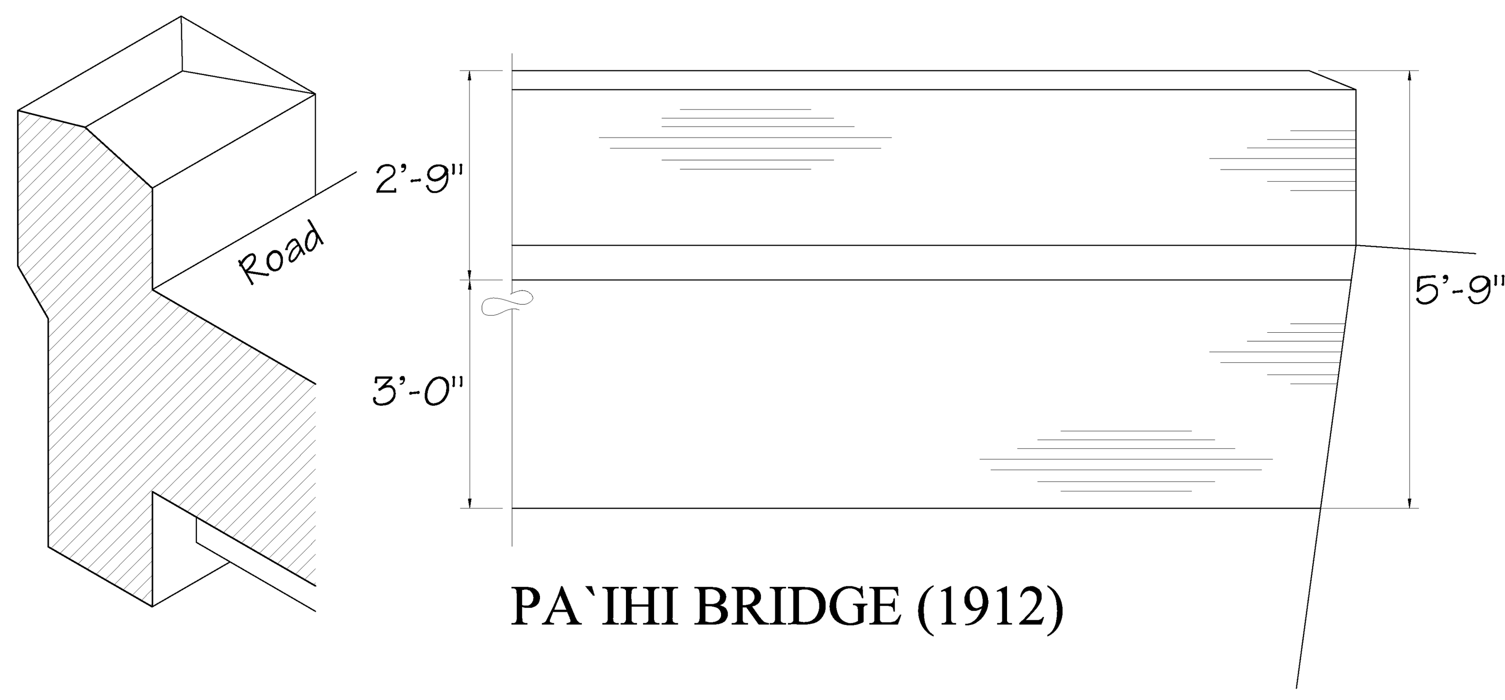
Bridge name	Year
HOLUA	1929
KAILUA	1929
NA´ILI´ILIHA´ELE	1930
WEST WAILUAIKI	1926/37
KAHAWAIHAPAPA	1922

MORE THAN THREE PANEL

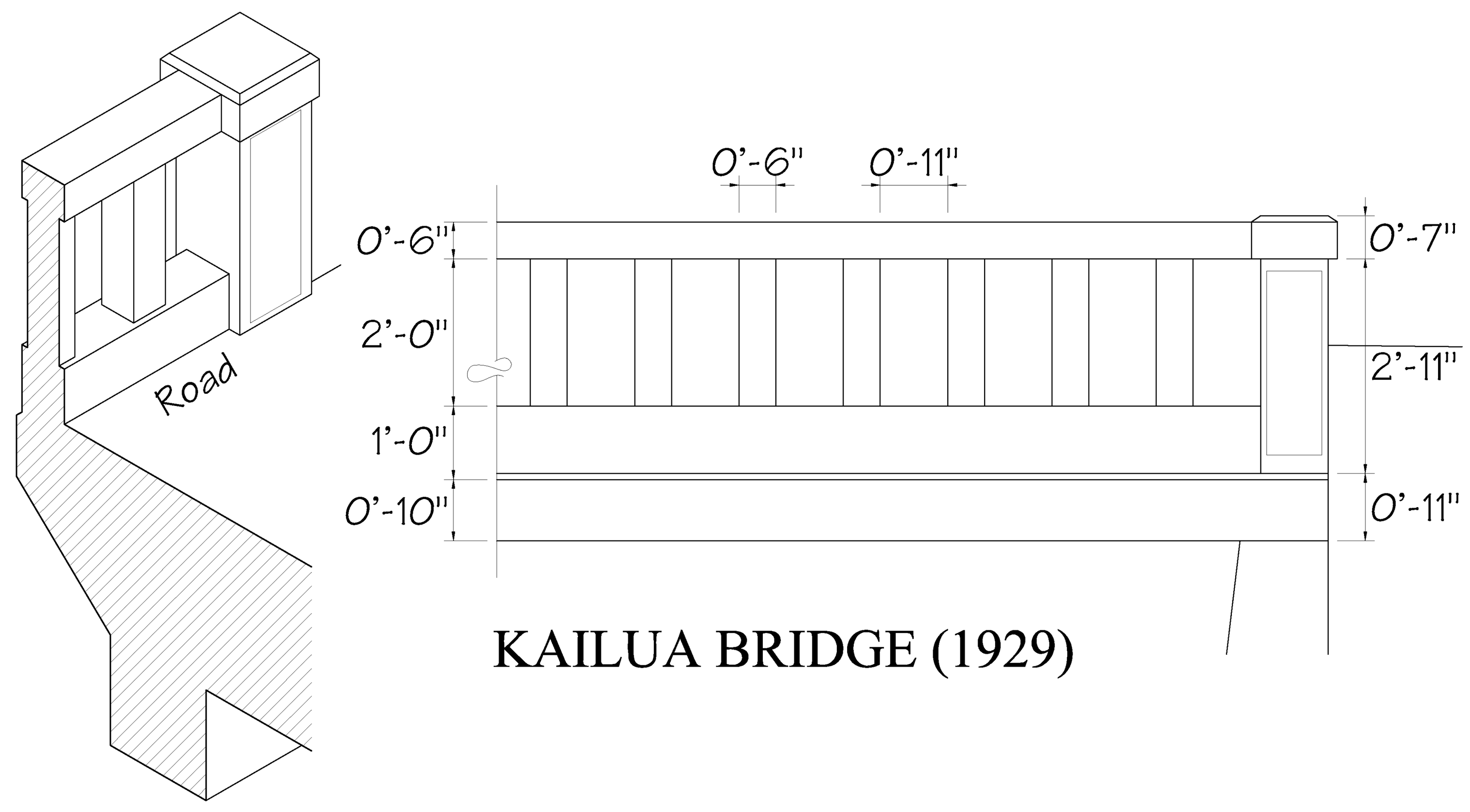
Bridge name	Year	Span
WAIKANI	1926	8
HANAWI	1926	5
KUHIWA	1926	5
WAIOHONU	1915	5



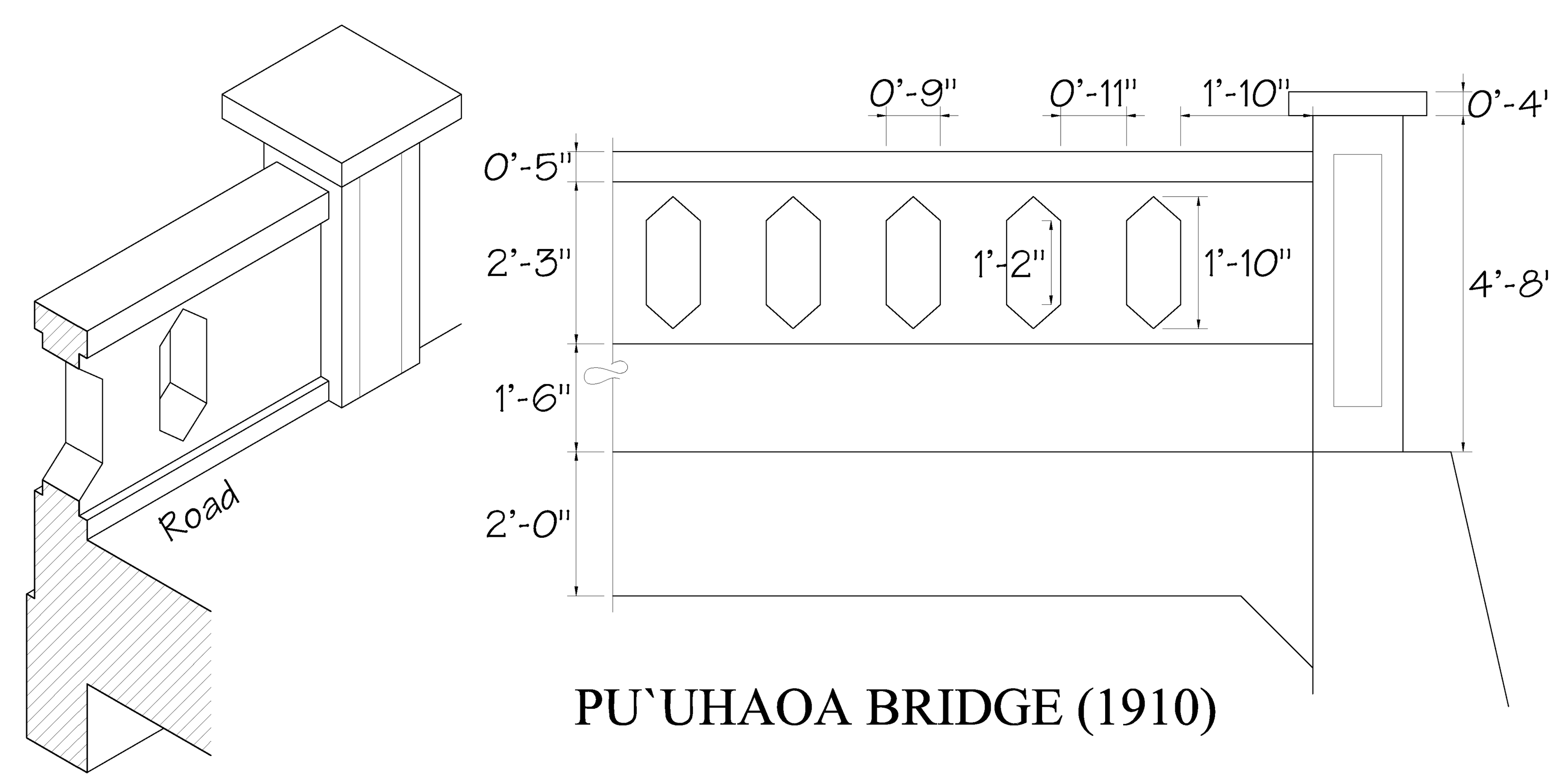
KOUKOU`AI BRIDGE (1911)



PA`IHI BRIDGE (1912)

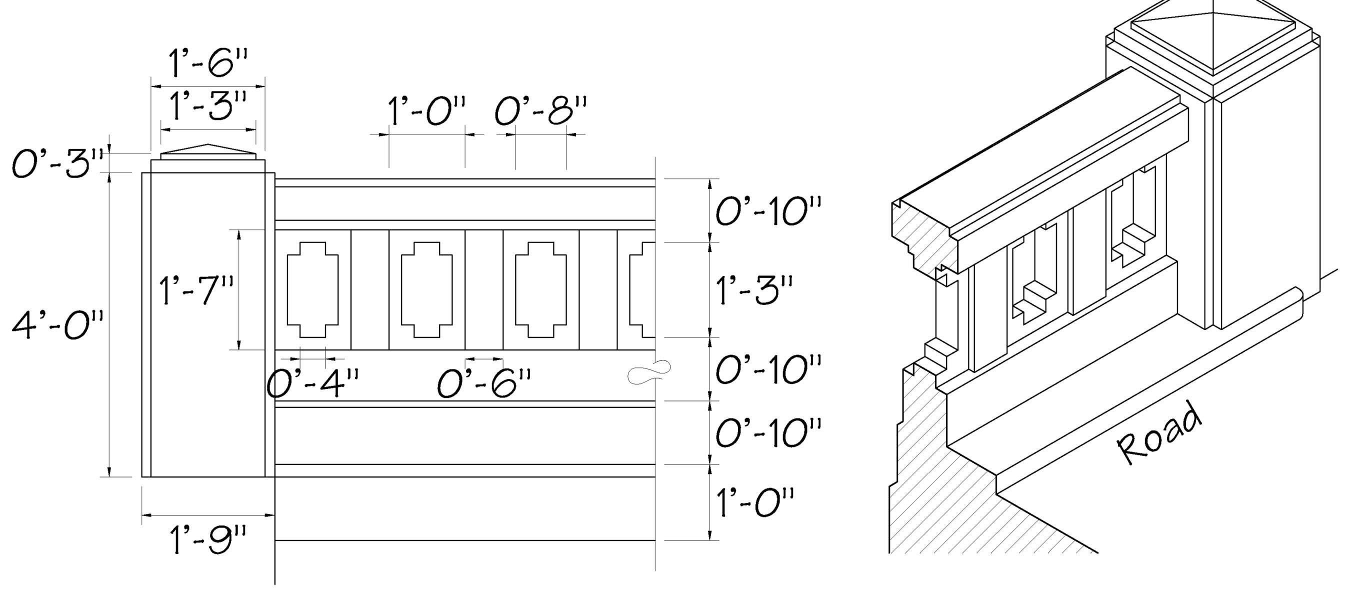


KAILUA BRIDGE (1929)

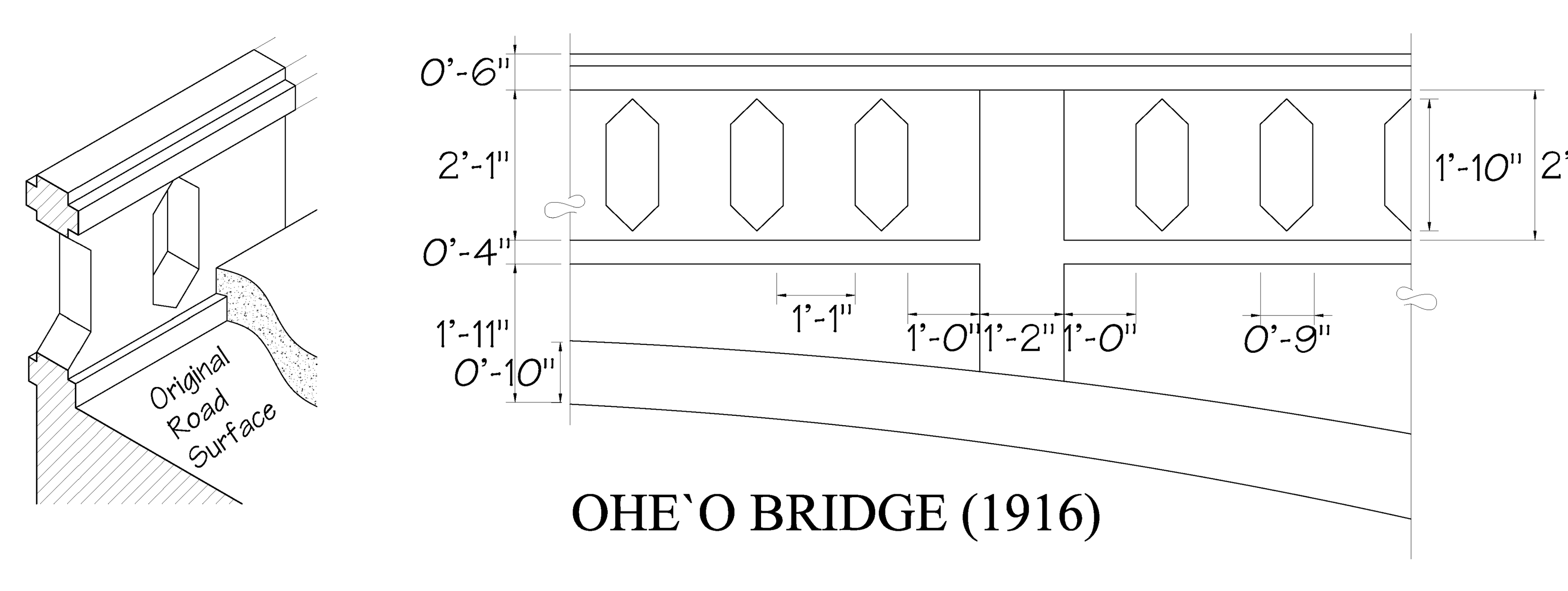


PU`UHAOA BRIDGE (1910)

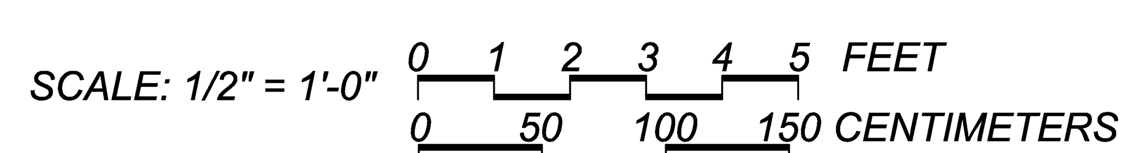
UNIQUE PARAPETS

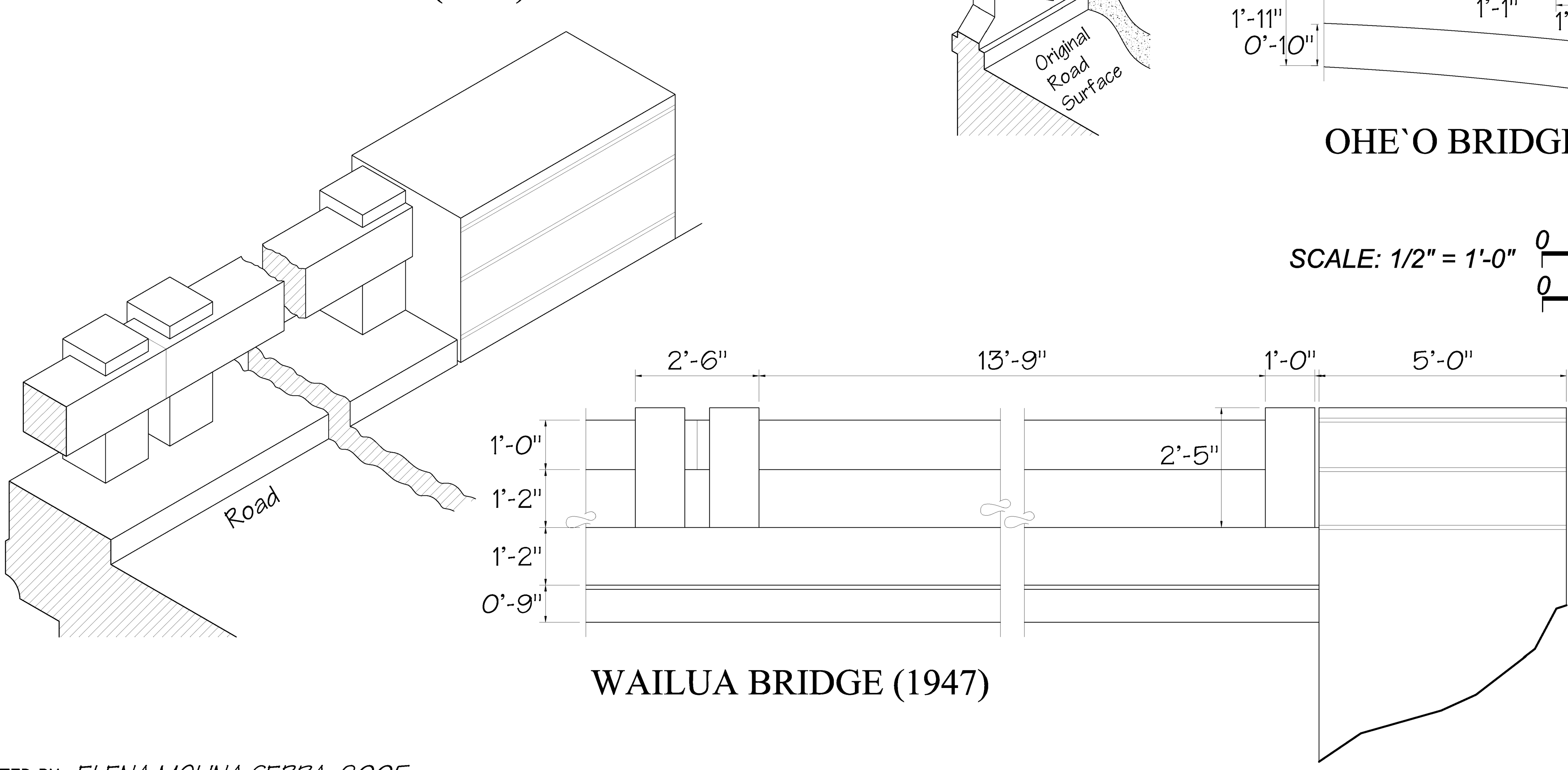


WAIOKAMILO BRIDGE (1937)

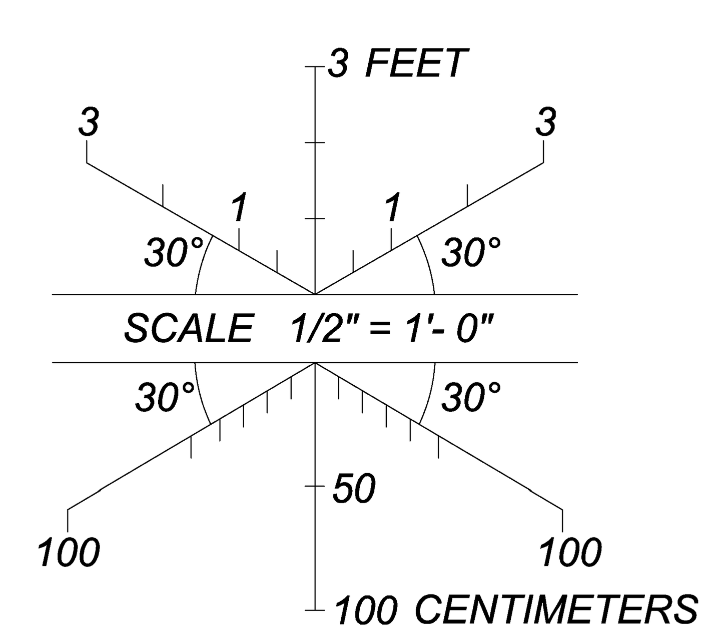


OHE`O BRIDGE (1916)





WAILUA BRIDGE (1947)



DELINEATED BY: *ELENA MOLINA CERPA, 2005*

HANA HIGHWAY RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	HANA BELT ROAD (HANA HIGHWAY) BETWEEN HAIKU AND KIPAHULU/STATE HIGHWAY 360/COUNTY HIGHWAY31 HANA VICINITY MAUI HAWAII	SHEET 9 OF 13	HISTORIC AMERICAN ENGINEERING RECORD HI-75	LIBRARY OF CONGRESS INDEX NUMBER

Figure 3 – 14: Bridge Parapets

Courtesy of HAER HI-75

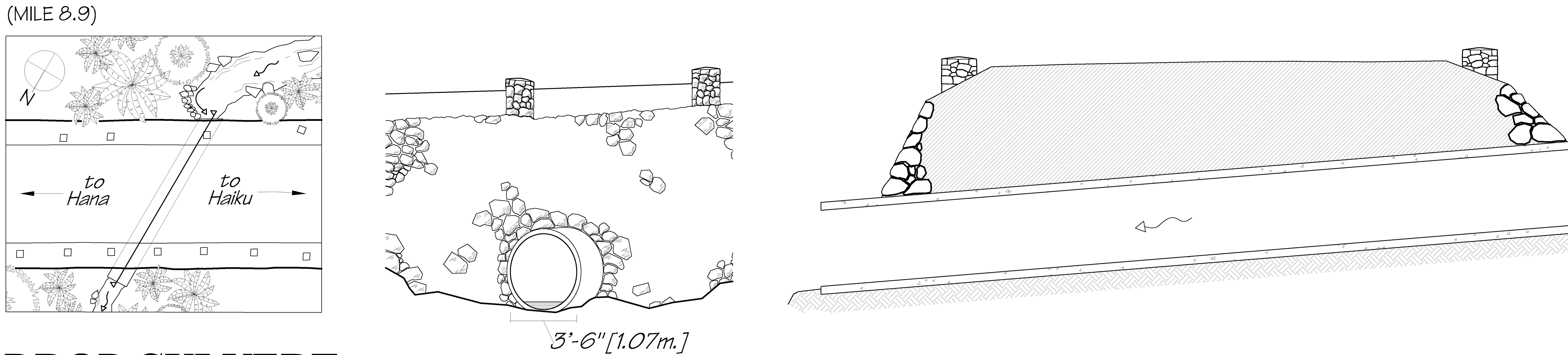
e. Culvert Typologies

CULVERT TYPOLOGIES

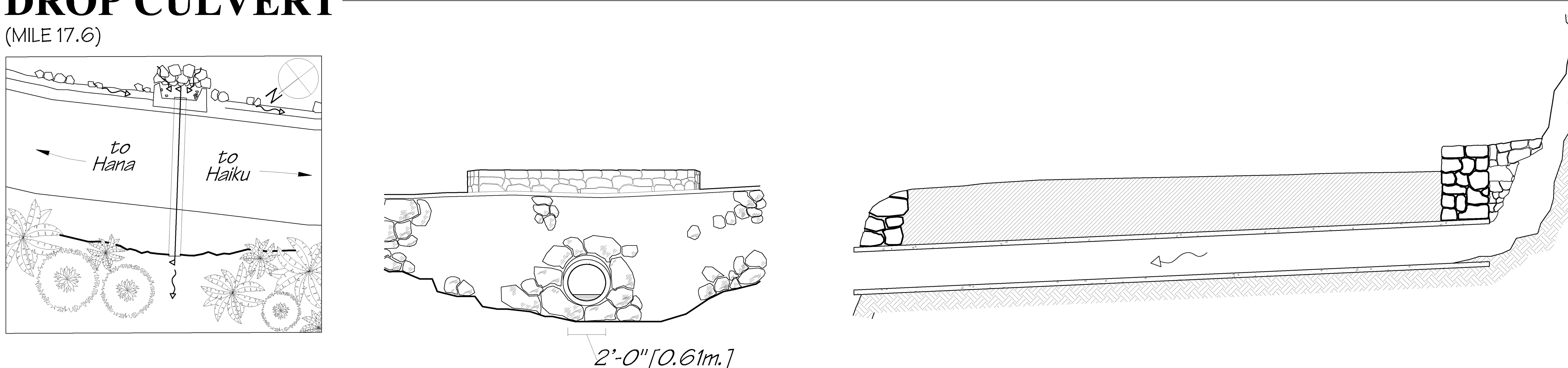
OF THE HANA BELT ROAD

A culvert is a structure that allows water to be carried transversely beneath a roadway. Hundreds of culverts were required to provide drainage along the Hana Belt Road, and over the years, various types of structures were utilized. During the initial construction of the road, corrugated iron-pipe culverts and flat slab culverts were installed. Pipe culverts were built beneath the roadway and sloped at a two to three percent grade to direct the water runoff. Flat slab culverts were bridges with spans less than 20' in length. Just like other bridges on the road, the culverts were built with flat-slabs for the road deck with concrete or rubble masonry abutments and wingwalls. In more recent decades, concrete pipe culverts have been used. Drop culverts are a variation of the pipe culvert, with the defining characteristic being a vertically aligned catch basin that directs water into the pipe. The catch basin is typically built of dry-stacked or mortared lava rock. Pipe and drop culverts are practical where the road has little or no shoulder for an intake basin.

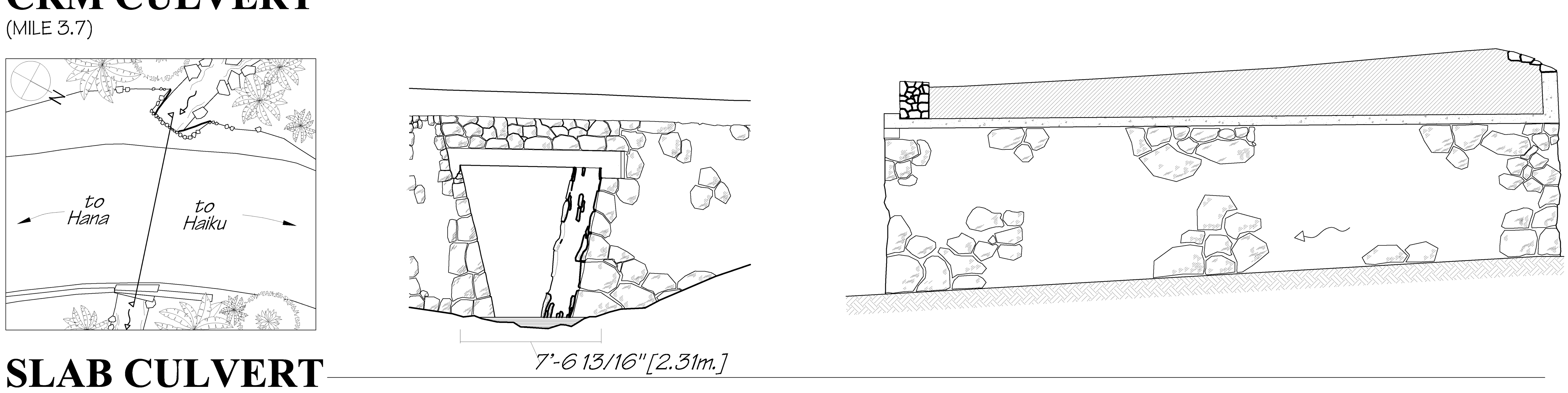
PIPE CULVERT
(MILE 8.9)



DROP CULVERT
(MILE 17.6)

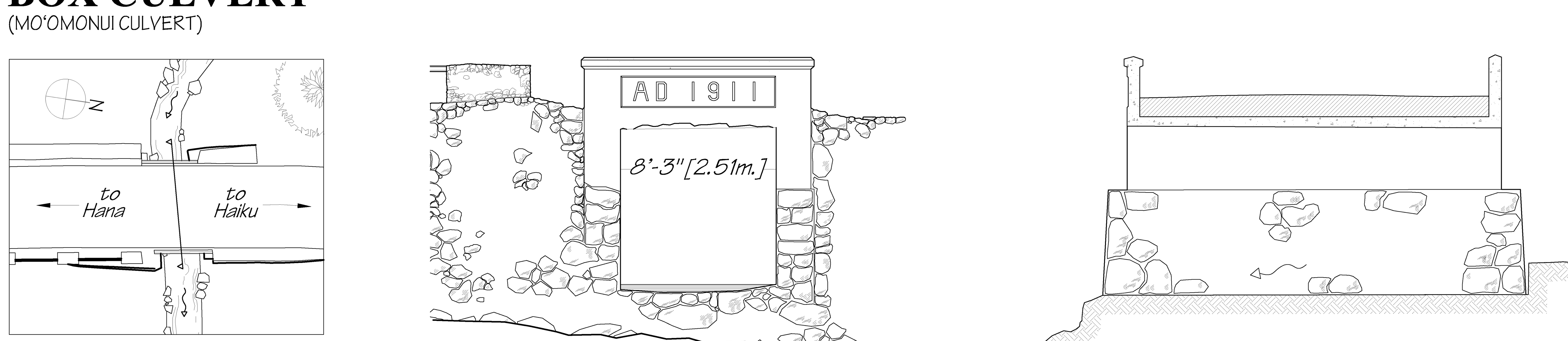


CRM CULVERT
(MILE 3.7)



SLAB CULVERT
(MILE 17.5)

BOX CULVERT
(MO'OMONUI CULVERT)



Plan
SCALE: 1/16" = 1'-0" 0 10 20 40 FEET

Makai Elevation
SCALE: 1/4" = 1'-0" 0 5 10 FEET

Section
SCALE: 1/4" = 1'-0" 0 5 10 FEET

DELINEATED BY: DANIEL SCHAIBLE, 2005

HANA HIGHWAY RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	HANA BELT ROAD (HANA HIGHWAY) BETWEEN HAIKU AND KIPAHULU/STATE HIGHWAY 360/COUNTY HIGHWAY31	HANA VICINITY	MAUI	HAWAII	SHEET 8 OF 13	HISTORIC AMERICAN ENGINEERING RECORD HI-75	LIBRARY OF CONGRESS INDEX NUMBER

IF REPRODUCED, PLEASE CREDIT THE HISTORIC AMERICAN ENGINEERING RECORD, NATIONAL PARK SERVICE, NAME OF DELINEATOR, DATE OF DRAWING

Figure 3 – 15: Culvert Typologies

Courtesy of HAER HI-75

CHAPTER 4

DESIGN STANDARDS & GUIDELINES

i. STANDARDS & GUIDELINES FOR THE TREATMENT OF HISTORIC BRIDGES

The following information, developed by The Heritage Center for the *State of Hawaii Historic Bridge Inventory and Evaluation* (2008), is intended as a brief overview of the standards and guidelines for the treatment of historic bridges. This report, the *Hana Highway Bridge Preservation Plan* (2015), satisfies the 3rd approach to the treatment of historic bridges as a plan for the application of appropriate treatments that includes standards and guidelines.

a. Overview

> *The principles, priorities, and guidelines for rehabilitating historic bridges comprised in [The State of Hawaii Historic Bridge Inventory and Evaluation] are intended as a preliminary guide for evaluating rehabilitation options and determining appropriate treatments of historic bridges. These guidelines should be considered along with other requirements such as safety, cost-effectiveness, and other factors normally considered in bridge rehabilitation projects. The term "historic bridge" is applied to those bridges listed on or determined to be eligible for the NHRP by the application of criteria developed for that purpose.*
>
> *A coherent approach to the treatment of historic bridges requires (1) identification and evaluation of the resources to be preserved or protected, (2) a comprehensive plan for dealing with the resources identified, and (3) a methodology for the application of appropriate treatments, including standards and guidelines.*
>
> *The identification and evaluation of structures and a commitment to preservation plans are necessary steps for the retention of historically significant bridges. The successful implementation of a bridge preservation program is dependent upon acceptable guidelines and standards that accommodate the perspectives of both the preservation community and transportation agencies. Because civil engineering structures primarily serve functions in the public domain, their preservation focuses attention on what appears to be diametrically opposed legislative mandates. Thus, today's bridge repair and replacement projects bring together two sets of professionals whose divergent approaches have been established by legislation whose ultimate aim is the public good.*
>
> *At present, [some of] the standards referred to in bridge rehabilitation projects are: AASHTO* Load and Resistance Factor Design (LRFD) Bridge Design Specifications*, adopted by the American Association of State Highway and Transportation Officials (AASHTO), and the Secretary of the Interior's* Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings*. The first is a detailed manual on bridge design; the second is a set of ten standards and expanded guidelines for the evaluation of proposed rehabilitations. The former must be quantitative and detailed to be useful for safe design practice, while the latter must be qualitative and broad enough to be applicable to a wide variety of historic resources.[1] …* [A full list of resources for highway design specifications and standards that were referenced during the preparation of this preservation plan is included in Section A, Chapter 4, vii. *Highway References & Design Specifications*.]
>
> *Structural inadequacies can be corrected by rehabilitation alternatives which include strengthening the critical members, adding supplemental members, reducing the dead load, modifying the structural system, and repairing or replacing damaged members. The most obvious*

[1] Hawaii Heritage Center, *State of Hawaii Historic Bridge Inventory and Evaluation: Recommendations & Appendices*, vol. 6, prepared for the State of Hawaii Department of Transportation Highways Division (May 2008), VI-4.

structural deficiency is inadequate load-carrying capacity for the superstructure [and substructure]. Other, often hidden deficiencies include mechanical problems with joints, bearings or other details, and substructure deterioration or instability. Engineering concerns are compounded by problems of functional obsolescence which include inadequate geometrics (vertical clearance, deck width, and approach alignments), inadequate safety barriers, and inadequate hydraulic capacity. Solutions to correct these defects are complex because bridges are "pure" structures designed to carry maximum loads with minimal materials. Unlike the case for most buildings, the structural framework of most bridges is exposed and unsheathed. Therefore, working on the structural system without affecting the appearance of the structure is extremely difficult.

It is difficult to force an old bridge, designed for the loads, speeds, and vehicles of decades past, into the design mold for a new bridge. This problem has been acknowledged by the FHWA and the ability to grant exceptions to AASHTO standards for historic bridges has been addressed by officials of that agency in the past few years. A report issued by the FHWA in October 1984, "Mitigation Options Related to Historic and Archeological Properties," states:

> The standards are unlikely to be changed or modified now or in the near future. However, the frequency of granting exceptions is likely to increase as those standards are being questioned more routinely. Division Administrators are authorized to grant exceptions on a case-by-case basis if they believe the exception is justified.

The AASHTO's issued Policy on Geometric Design of Highways and Streets *(2004) includes historical significance as a factor for granting exceptions on local roads and streets:*

> Existing substandard structures should be improved, but because of their high replacement cost, reasonably adequate bridges and culverts that meet tolerable criteria may be retained. Some of the non-technical factors that should be considered are the esthetic value and the historical significance attached to famous structures, covered bridges, and stone arches.

It is important to recognize throughout the rehabilitative process the need to emphasize public safety. Thus, exceptions are granted on a case-by-case basis, and they specifically state that such exceptions are not to be construed as precedent-setting actions. "Tolerable criteria" have sometimes been interpreted to include engineering studies that support the capacity of a bridge to carry the anticipated loads and traffic safely, and an accident frequency that is not abnormally high. Non-technical factors which should be considered when determining the treatment of historic bridges include the degree of local public interest in the bridge; the importance of the bridge as a representative of the period, type of design, or example remaining in the state; the cost-effectiveness of rehabilitation; and the extent and magnitude of variances from AASHTO [and government] standards. The needs of each bridge and its site must be considered in light of the needs of the overall highway network. In cases where a substandard historic bridge meets tolerable criteria, exceptions may be encouraged by local transportation officials when guidelines for the appropriate treatment of historic bridges are readily available.[2]

[2] Hawaii Heritage Center, *State of Hawaii Historic Bridge Inventory and Evaluation: Recommendations & Appendices*, vol. 6, prepared for the State of Hawaii Department of Transportation Highways Division (May 2008), VI-5.

b. Standards & Guidelines for Rehabilitation of Historic Bridges

The STANDARDS, patterned after the Secretary of Interior's "Standards for Rehabilitation," are intentionally general so as to be applicable to all bridges. They are not rigid rules which evaluate all bridges alike. While there is a system of options and alternatives which may apply to most bridges, each historic bridge should be evaluated on its own merits with respect to its historic, character-defining elements. A hierarchy of important elements for each bridge should be established and referred to as rehabilitation plans commence. Thus, creative solutions might be found in the process of designing necessary upgrades.

The GUIDELINES consist of a general section that addresses structural upgrading, geometric modification, materials repair and maintenance, and removal to a less demanding site. following [sic] the general guidelines are additional guidelines which may be necessary when considering non-vehicular uses, replacement, or bridges located in historic districts. [Through AASHTO, Guidelines for Historic Bridge Rehabilitation and Replacement *was published in March 2007 and is available for reference online at:*
http://environment.transportation.org/cop/groups/historic_bridges/media/p/30.aspx]

Additionally, the concepts contained in this document are intended for use in the treatment of all historic bridges, and should not be restricted solely to bridge rehabilitation and replacement projects. The STANDARDS and GUIDELINES are applicable to any historic bridge project, including upgrading for safety or other purposes and bridge maintenance. It is hoped that the document will serve as a framework for an expanded version of guidelines that may be compiled as the body of information from successful bridge rehabilitation projects develops.[3]

[3] Hawaii Heritage Center, *State of Hawaii Historic Bridge Inventory and Evaluation: Recommendations & Appendices*, vol. 6, prepared for the State of Hawaii Department of Transportation Highways Division (May 2008), VI-6.

ii. FEDERAL STANDARDS FOR THE TREATMENT OF HISTORIC BRIDGES

a. Secretary of the Interior's Standards for the Treatment of Historic Properties

The Secretary of the Interior's Standards for the Treatment of Historic Properties are standards set forth by the National Park Service under the United States Department of the Interior. "The Standards are a nationally recognized tool for the preservation, maintenance and rehabilitation of our nation's heritage. These Standards have become the accepted benchmark at all levels of government – national, state, and local – for evaluating the acceptability of proposed changes to historic properties."[4] It is the standard used to develop design guidelines for any historic district throughout the United States.

Treatment of Historic Properties

The Standards are a series of concepts about maintaining, repairing, and replacing historic materials, as well as designing new additions or making alterations. The Standards offer four distinct approaches to the treatment of historic properties – *preservation, rehabilitation, restoration, and reconstruction* with guidelines for each. The standards and guidelines were developed mainly for buildings, but the concepts can be applied to bridges and other structures.

Preservation focuses on the maintenance and repair of existing historic materials and retention of a property's form as it has evolved over time.

> *Preservation is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, general focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction.*[5]

Rehabilitation acknowledges the need to alter or add to an historic property to meet continuing or changing uses while retaining the property's historic character.

> *Rehabilitation is defined as the process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values.*[6]

Restoration depicts a property at a particular period of time in its history, while removing evidence of other periods.

> *Restoration is defined as the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period.*[7]

---

[4] "The Secretary of the Interior's Standards and Guidelines," Office of Historic Resources, Department of City Planning, Los Angeles Department of City Planning, http://www.preservation.lacity.org/resources/secretary-interior%E2%80%99s-standards-and-guidelines (accessed July 2014).
[5] "Technical Preservation Services: Standards for Preservation," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-preservation.htm (accessed July 2014).
[6] "Technical Preservation Services: Standards for Rehabilitation," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-rehabilitation.htm (accessed July 2014).
[7] "Technical Preservation Services: Standards for Restoration," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-restoration.htm (accessed July 2014).

Reconstruction re-creates vanished or non-surviving portions of a property for interpretive purposes.

> *Reconstruction is defined as the act or process of depicting, by means of new construction, the form, features, and detailing of non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location.*[8]

When determining which approach should be utilized in a project, the treatment recommendations can be applied to bridges as the following:

- **Preservation**: Bridges that are intact, maintain original design and materials, and retain character defining features. Bridges under this recommendation "focuses on maintenance and care."[9]
- **Rehabilitation**: Bridges that are mostly intact and retain character defining features but require repair/alteration or modification for safety issues. Bridges under this recommendation "focuses on maintenance, care and thoughtful replacement or modification"[10] following specific criteria.
- **Restoration**: Bridges that maintains original design and materials, and retain character defining features "but require some repair/alteration, or the removal of later additions that are not contributing features."[11] Bridges under this recommendation "focus on maintenance and care of intact historic features, replacement of lost features, and removal of inappropriate additions."[12] Inappropriate additions include modifications from rehabilitation and maintenance made outside the period of significance that detracts from the character and integrity, or otherwise obscures the original craftsmanship of the historic structure.
- **Replacement**: Bridges that are in such poor structural condition that repair/alteration will not be feasible will require complete replacement and new construction of the bridge. This approach will be the last choice after the above treatment options have been evaluated and determined to be in sufficient.

Treatment Standards

Standards for Preservation

When the property's distinctive materials, features, and spaces are essentially intact and thus convey the historic significance without extensive repair or replacement; when depiction at a particular period of time is not appropriate; and when a continuing or new use does not require additions or extensive alterations, Preservation may be considered as a treatment.[13]

1. *A property will be used as it was historically, or be given a new use that maximizes the retention of distinctive materials, features, spaces, and spatial relationships. Where a treatment and use have not been identified, a property will be protected and, if necessary, stabilized until additional work may be undertaken.*
2. *The historic character of a property will be retained and preserved. The replacement of intact or repairable historic materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.*
3. *Each property will be recognized as a physical record of its time, place, and use. Work needed to stabilize, consolidate, and conserve existing historic materials and features will be physically and visually compatible, identifiable upon close inspection, and properly documented for future research.*

---

[8] "Technical Preservation Services: Standards for Reconstruction," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-reconstruction.htm (accessed July 2014).

[9] Paul Daniel Marriott, "The Preservation Office Guide to Historic Roads: Clarifying Preservation Goals for State Historic Preservation Offices, Establishing Preservation Expectations for State Transportation Departments" (Washington, D.C., 2010), 69.

[10] Ibid., 70.

[11] Ibid., 71.

[12] Ibid.

[13] "Technical Preservation Services: Standards for Preservation," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-preservation.htm (accessed July 2014).

4. *Changes to a property that have acquired historic significance in their own right will be retained and preserved.*
5. *Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.*
6. *The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old in composition, design, color, and texture.*
7. *Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.*
8. *Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.*[14]

Standards for Rehabilitation

When repair and replacement of deteriorated features are necessary; when alterations or additions to the property are planned for a new or continued use; and when its depiction at a particular period of time is not appropriate, Rehabilitation may be considered as a treatment.[15]

1. *A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.*
2. *The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.*
3. *Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.*
4. *Changes to a property that have acquired historic significance in their own right will be retained and preserved.*
5. *Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.*
6. *Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.*
7. *Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.*
8. *Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.*
9. *New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.*

[14] "Technical Preservation Services: Standards for Preservation," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-preservation.htm (accessed July 2014).
[15] "Technical Preservation Services: Standards for Rehabilitation," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-rehabilitation.htm (accessed July 2014).

10. *New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.*[16]

Standards for Restoration
When the property's design, architectural, or historical significance during a particular period of time outweighs the potential loss of extant materials, features, spaces, and finishes that characterize other historical periods; when there is substantial physical and documentary evidence for the work; and when contemporary alterations and additions are not planned, Restoration may be considered as a treatment. Prior to undertaking work, a particular period of time, i.e., the restoration period, should be selected and justified, and a documentation plan for Restoration developed.[17]

1. *A property will be used as it was historically or be given a new use which reflects the property's restoration period.*
2. *Materials and features from the restoration period will be retained and preserved. The removal of materials or alteration of features, spaces, and spatial relationships that characterize the period will not be undertaken.*
3. *Each property will be recognized as a physical record of its time, place, and use. Work needed to stabilize, consolidate and conserve materials and features from the restoration period will be physically and visually compatible, identifiable upon close inspection, and properly documented for future research.*
4. *Materials, features, spaces, and finishes that characterize other historical periods will be documented prior to their alteration or removal.*
5. *Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize the restoration period will be preserved.*
6. *Deteriorated features from the restoration period will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials.*
7. *Replacement of missing features from the restoration period will be substantiated by documentary and physical evidence. A false sense of history will not be created by adding conjectural features, features from other properties, or by combining features that never existed together historically.*
8. *Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.*
9. *Archeological resources affected by a project will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.*
10. *Designs that were never executed historically will not be constructed.*[18]

Standards for Reconstruction
When a contemporary depiction is required to understand and interpret a property's historic value (including the re-creation of missing components in a historic district or site); when no other property with the same associative value has survived; and when sufficient historical

[16] "Technical Preservation Services: Standards for Rehabilitation," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-rehabilitation.htm (accessed July 2014).
[17] "Technical Preservation Services: Standards for Restoration," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-restoration.htm (accessed July 2014).
[18] Ibid.

documentation exists to ensure an accurate reproduction, Reconstruction may be considered as a treatment.[19]

1. *Reconstruction will be used to depict vanished or non-surviving portions of a property when documentary and physical evidence is available to permit accurate reconstruction with minimal conjecture, and such reconstruction is essential to the public understanding of the property.*
2. *Reconstruction of a landscape, building, structure, or object in its historic location will be preceded by a thorough archeological investigation to identify and evaluate those features and artifacts which are essential to an accurate reconstruction. If such resources must be disturbed, mitigation measures will be undertaken.*
3. *Reconstruction will include measures to preserve any remaining historic materials, features, and spatial relationships.*
4. *Reconstruction will be based on the accurate duplication of historic features and elements substantiated by documentary or physical evidence rather than on conjectural designs or the availability of different features from other historic properties. A reconstructed property will re-create the appearance of the non-surviving historic property in materials, design, color, and texture.*
5. *A reconstruction will be clearly identified as a contemporary re-creation.*
6. *Designs that were never executed historically will not be constructed.*[20]

The Secretary of the Interior's Standards for the Treatment of Historic Properties – *Adapted for Historic Bridges*

Adapted from: Clark, Kenneth M., Grimes, Mathew C., and Ann B. Miller, Final Report, A Management Plan for Historic Bridges in Virginia, Virginia Transportation Research Council, 2001.

The Secretary of the Interior's Standards for the Treatment of Historic Properties, first codified in 1979 and revised in 1992, have been interpreted and applied largely to buildings rather than engineering structures. In this document, the differences between buildings and structures are recognized and the language of the Standards has been adapted to the special requirements of historic bridges.[21]

1. *Every reasonable effort shall be made to continue an historic bridge in useful transportation service. Primary consideration shall be given to rehabilitation of the bridge on site. Only when this option has been fully exhausted shall other alternatives be explored.*
2. *The original character-defining qualities or elements of a bridge, its site, and its environment should be respected. The removal, concealment, or alteration of any historic material or distinctive engineering or architectural feature should be avoided.*
3. *All bridges shall be recognized as products of their own time. Alterations that have no historical basis and that seek to create a false historical appearance shall not be undertaken.*
4. *Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.*

[19] "Technical Preservation Services: Standards for Reconstruction," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/four-treatments/treatment-reconstruction.htm (accessed July 2014).
[20] Ibid.
[21] Mead & Hunt, "Louisiana Historic Bridge Inventory," appendix D, prepared for Louisiana Department of Transportation and Development (November 2013), http://wwwapps.dotd.la.gov/administration/public_info/projects/docs_test/48/documents/Methodology_to_Identify_Preservation_Priority_Bridges.PDF (accessed September 15, 2014).

5. *Distinctive engineering and stylistic features, finishes, and construction techniques or examples of craftsmanship that characterize an historic property shall be preserved.*
6. *Deteriorated structural members and architectural features shall be retained and repaired, rather than replaced. Where the severity of deterioration requires replacement of a distinctive element, the new element should match the old in design, texture, and other visual qualities and where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.*
7. *Chemical and physical treatments that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the most environmentally sensitive means possible.*
8. *Significant archaeological and cultural resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.*
9. *New additions, exterior alterations, structural reinforcements, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.*
10. *New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.*[22, 23]

b. National Bridge Inspections Standards Program

As defined in the FHWA *Bridge Inspection Reference Manual* (BIRM), "the 'National Bridge Inspection Standards' [was] first established in 1971 to set national policy regarding bridge inspection frequency, inspector qualifications, report formations, and inspection and rating procedures."[24] The NBIS program was established by the FHWA in response to the Federal Highway Act of 1968. A division under FHWA called the National Highway Institute provides training for federal, state, and private organizations responsible for the overseeing of transportation systems.

Routine inspections are performed on Hana Highway, Route 360 bridges within State jurisdiction that are part of the National Bridge Inventory (NBI) program. Bridge inspectors are certified by National Highway Institute to inspect these bridges. Information from the inspection is reported to the bridge owner, who may be the state or county, using the FHWA *Recording and Coding Guide for the Structure Inventory and Appraisal of Nation's Bridges*, AASHTO *Manual for Bridge Element Inspection*, and AASHTO *The Manual for Bridge Evaluation*. Based on the evaluation ratings, the inspector can provide the bridge owner with the current status of the bridge at the time of inspection and provide recommendations for improvement if necessary.

Definition of an NBIS Bridge

A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet (6.1

[22] Mead & Hunt, "Louisiana Historic Bridge Inventory," appendix D, prepared for Louisiana Department of Transportation and Development (November 2013), http://wwwapps.dotd.la.gov/administration/public_info/projects/docs_test/48/documents/Methodology_to_Identify_Preservation_Priority_Bridges.PDF (accessed September 15, 2014).

[23] Standards adapted from: Ann B. Miller, Kenneth M. Clark, and Matthew C. Grimes, "Final Report: A Management Plan for Historic Bridges in Virginia," Virginia Transportation Research Council (Charlottesville: 2001), 13-16, http://www.virginiadot.org/programs/resources/01-r11.pdf (accessed September 15, 2014).

[24] U.S. Department of Transportation, Federal Highway Administration, *Bridge Inspector's Reference Manual*, BIRM vol. 1-2, publication no. FHWA-NHI-12-049 (Moon Township: Michael Baker, Jr., Inc., 2002, 2006, 2012).

meters) between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.[25]

Routine Inspections

- BIRM definition of routine inspection includes, "regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements."[26]
- Bridges are typically inspected at regular intervals that do not exceed 24 months. Shorter intervals or intervals as long as 48 months (with FHWA's approval) can be specified.
- Provides established "criteria to determine inspection frequency and intensity based on such factors as age, traffic characteristics, and known deficiencies."[27]

c. The Surface Transportation & Uniform Relocation Assistance Act of 1987

The memorandum dated July 22, 1987 from the Federal Highway Administrator to the Regional Federal Highway Administrators states that:

> *The Surface Transportation and Uniform Relocation Assistance Act* [STURAA] *of 1987, Public Law 100-17,* [Section 123 (f)] *establishes a series of requirements and emphasis areas concerning historic bridges on and off the Federal-aid system.*

An inventory of all bridges within a state is required by the STURAA (1987) to determine historical significance. *State of Hawaii Historic Bridge Inventory and Evaluation* (2008) and the *Hawaii State Historic Bridge Inventory & Evaluation* (2013) are two such inventories of Hawaii's statewide bridges. Both inventories mention the Hana Bridges along Route 360 within the Hana Belt Road Historic District as a group of significant historic bridges that contributed heavily to Maui's growth and development.

The STURAA (1987) allows for special consideration and reimbursement of specific project costs for bridges that are being preserved, reused, or rehabilitated:

> <u>*Eligibility*</u>
> *The new legislation encourages states to give special consideration to rehabilitating, reusing, and preserving historic bridges by explicitly making these activities eligible for reimbursable project costs on bridges in service for motorized vehicles. …it has been the Federal Highway Administration (FHWA) policy to consider a wide range of preservation options; including avoidance, rehabilitation, modified use, marketing, and relocation. If the load capacity and safety features (geometrics) of a historic bridge are adequate to serve on the public road at its existing location, the bridge should be rehabilitated at a reasonable cost, so it can continue to provide service. If the bridge's load capacity and safety features are adequate to serve on a public road at another location, the movement of the bridge to the new location should be considered as part of the original project... If such relocation of the historic bridge is made part of the Federal-aid proposal, then reasonable costs associated with actions to relocate and preserve the historic integrity of the historic bridge are eligible for reimbursement... without reference to the cost of demolition.*

[25] Office of Engineering, Bridge Division, Bridge Management Branch, "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges," report no. FHWA-PD-96-001 (Washington, D.C.: 1995, 2011 Errata).
[26] U.S. Department of Transportation, Federal Highway Administration, *Bridge Inspector's Reference Manual*, BIRM vol. 1-2, publication no. FHWA-NHI-12-049 (Moon Township: Michael Baker, Jr., Inc., 2002, 2006, 2012), G-41.
[27] Ibid., 2.1.15.

These actions could include work approved by the FHWA which ensures the historical integrity of design, scale, and materials. This would include replacing portions of historic elements of the structure, cleaning, repainting, or rehabilitating to maintain (preserve) both the structural and the historic integrity of the historic bridge. At the completion of the project, the bridge may no longer be classified as deficient for purposes of the National Bridge Inventory for the foreseeable future (at least 10 years which is the established FHWA policy).[28]

The STURAA (1987) makes great advances in the preservation of historic bridges through FHWA funding. The act advocates that demolition of a bridge shall be the last resort after all other options have been exhausted.

<u>*Preservation*</u>
The legislation makes funds, which otherwise would have been used for bridge demolition, available for actions to preserve or reduce the impact of the project on a historic bridge.

…In the case of historic bridges which can no longer be used on a public road, reasonable costs associated with preservation could include modification for recreational use, relocation, etc. The FHWA will determine the reasonable level of funding, not exceeding the estimated cost of demolition which will be based upon professional advice of the state highway bridge engineer. These bridges shall be removed from the National Bridge Inventory and can no longer be eligible for FHWA funding. …

The [STURAA] also imposes a requirement that, prior to demolition of a historic bridge, the state shall market (sell or donate) the bridge to a State or local government agency or responsible private entity. This preservation effort is to be coordinated with the State Historic Preservation Officer and the local historical society to ensure that a reasonable audience is reached and a good-faith effort is made. …

In the marketing effort, the state needs to specify: what preservation work is needed; that reasonable funding is available for the preservation work; and that any potential recipients must be able to demonstrate their ability to assume legal and financial responsibility for the bridge, including holding highway agencies harmless in any liability action. Any non-governmental party must be able to demonstrate its economic and administrative ability to perform the essential obligations necessary for the operation of the bridge … if the structure is turned over to such a party.

If a bridge cannot be sold and a recipient accepts donation of the bridge, the recipient can be reimbursed for costs incurred in such activities as relocation, site preparation, reassembly, etc. Costs eligible for reimbursement to preserve a historic bridge which is no longer used on a public road shall not exceed the estimated cost of demolition. Maintenance costs (including prepaid annuities) are not eligible for reimbursement. No bridge will be marketed or donated to a party unless that party agrees to; (1) accept title, (2) maintain (preserve) the bridge and the features that give it its historic significance (qualities that qualify it to the National Register), and (3) assume all future legal and financial responsibility for the bridge and to hold the state highway agency and the FHWA harmless in any liability action. In the event that no acceptable party is found by a good-faith effort and within a reasonable period of time, the requirements of the new legislation are satisfied and the FHWA may complete the Section 106 and Section 4(f) processes.[29]

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[28] Federal Highway Administrator, "Memorandum: Surface Transportation and Uniform Relocation Assistance Act of 1987, Section 123 (f), Historic Bridges," Federal Highways Administration, United States Department of Transportation, https://www.environment.fhwa.dot.gov/guidebook/vol2/doc10i.pdf (accessed September 2015).
[29] Hawaii Heritage Center, *State of Hawaii Historic Bridge Inventory and Evaluation: Recommendations & Appendices*, vol. 6, prepared for the State of Hawaii Department of Transportation Highways Division (May 2008), VI-8.

d. Hawaii Senate Bill 3010

S.B. No. 3010 S.D. 2 H.D. 1, passed in the summer of 2012, exempts bridges from city and state requirements in order to accelerate projects for rehabilitation and replacement. The legislation notes that of Hawaii's 756 state-owned bridges, 256 of them are functionally obsolete and 39 are structurally deficient.

Currently, under its jurisdiction, HDOT has planned for the rehabilitation and replacement of 30 bridges in the state of Hawaii and the *Hana Highway Bridge Preservation Plan* (2015).

The bill allows HDOT and its contractors to be exempt from state requirements (see below) as necessary to expedite certain projects, including all bridges under the *Hana Highway Bridge Preservation Plan* (2015) and related projects on Maui as of July 1st 2012 until June 30th 2017.

Exempt state requirements:

(1) Chapter 6E, Hawaii Revised Statutes, historic preservation;
(2) Part II of chapter 171, Hawaii Revised Statutes, public lands;
(3) Chapter 174C, Hawaii Revised Statutes, state water code;
(4) Chapter 180, Hawaii Revised Statutes, soil and water conservation districts;
(5) Chapter 180C, Hawaii Revised Statutes, soil erosion and sediment control;
(6) Chapter 183, Hawaii Revised Statutes, forest reserves, water development, and zoning;
(7) Chapter 183D, Hawaii Revised Statutes, wildlife;
(8) Chapter 184, Hawaii Revised Statutes, state parks and recreation areas;
(9) Chapter 195, Hawaii Revised Statutes, natural area reserves system;
(10) Chapter 195D, Hawaii Revised Statutes, conservation of aquatic life, wildlife, and land plants;
(11) Chapter 198D, Hawaii Revised Statutes, Hawaii statewide trail and access system;
(12) Chapter 205, Hawaii Revised Statutes, land use commission;
(13) Chapter 205A, Hawaii Revised Statutes, coastal zone management;
(14) Chapter 341, Hawaii Revised Statutes, environmental quality control;
(15) Chapter 342B, Hawaii Revised Statutes, air pollution;
(16) Chapter 342D, Hawaii Revised Statutes, water pollution;
(17) Chapter 342E, Hawaii Revised Statutes, nonpoint source pollution management and control;
(18) Chapter 342F, Hawaii Revised Statutes, noise pollution;
(19) Chapter 343, Hawaii Revised Statutes, environmental impact statements; and
(20) Chapter 344, Hawaii Revised Statutes, state environmental policy.[30]

[30] State of Hawaii, "Transportation; Bridges, Exemptions," The Senate Twenty-Sixth Legislature, 2012, State of Hawaii, S.B. No. 3010 S.D. 2 H.D. 1, https://legiscan.com/HI/text/SB3010/id/623936 (accessed August 2015).

iii. FEDERAL GUIDELINES FOR THE TREATMENT OF HISTORIC BRIDGES

a. General Guidelines for the Treatment of Historic Bridges

The following treatment of historic bridges is taken from *Trial Guidelines for the Conservation of Virginia's Historic Bridges* which was written in cooperation with the FHWA in 1986.

> *The specifics of each historic bridge and its environment will determine whether rehabilitation options for the continued use of the bridge are feasible. In planning the proposed treatment of a historic bridge, the following priorities should be explored.*
>
> *I. <u>Continued Use for Vehicular Purposes</u>*
> *The preferred use for historic bridges is continued service for vehicular purposes. This alternative will probably require consideration of one or more of the following:*

- *A. Structural Upgrading*
  - *1. Identify the structural system and its individual character-defining features*
    - *a) The structural system should be evaluated using non-destructive testing techniques, where possible.*
    - *b) Passive solutions which adjust the live load by restricting vehicles should be explored, examples include load posting, signaling, and channeling.*
    - *c) The structural system should be respected, and its visual characteristics should be retained if modifications are necessary.*
      - *(1) The original load-carrying system should be retained, if possible.*
      - *(2) The dead load should be reduced by providing a lighter deck system, if possible.*
      - *(3) If the load-carrying system must be altered, the character-defining visual qualities of the original structural system should be retained. Modified systems which can be visually minimized include the introduction of structure continuity and other methods of reinforcement.*
      - *(4) If visual modifications are necessary, they should be kept as unobtrusive as possible.*
        - *(a) Modifications may include changing the configuration of isolated members or the addition of helping structures.*
        - *(b) Supplemental members should be added as needed under the deck of the structure, if possible.*
  - *2. Modifications should follow the following guidelines*
    - *a) Visually intrusive structural modifications should be kept as inconspicuous as possible, and should affect only secondary views, if possible. Consideration should be given to whether there is a primary view.*
      - *(1) Bridges which carry highways are seen by roadway travelers from afar, in elevation, and while traveling on the bridge deck. Modifications should be made with this in mind.*
      - *(2) Where circumstances are such that the primary view is from below the bridge, such as an overpass, modifications should be made accordingly.*

b) Modifications should be so designed that there is the least possible loss of historic material, and so that the character-defining features are not obscured, damaged, or destroyed.

c) Structural modifications, or helping structures, should be clearly differentiated from the historic bridge. The design should be compatible in terms of mass, materials, scale, and detail.

d) Traffic railings, or safety barriers, should be designed to meet requisite load requirements, and at the same time should be designed and installed so that character-defining features of the bridge are not obscured or damaged.

e) Deteriorated structural elements should be replaced in kind or with a material which duplicates the visual appearance of the original element.

B. Geometric Modifications

1. Evaluate the geometric constraints of the bridge in the context of the overall highway network. Determine realistic needs for geometric parameters in light of connecting highways, projected traffic volumes, accident history, and the proposed nature of future traffic needs.

2. Explore passive (off-bridge) solutions.

a) Adjust alignment of the approaches, restrict the bridge to one-way traffic, or both.

(1) Create holding lanes for traffic at the approaches to a one-lane bridge with appropriate provisions for safety.

(2) Leave the historic bridge in place for one-lane traffic and move a visually compatible historic bridge to an adjacent site to carry the second lane.

(3) Leave the historic bridge in place for one-lane traffic and construct a visually compatible new bridge on an adjacent site to carry the second lane.

b) The flow of approaching traffic should be adjusted by restricting vehicles, restricting speed, or installing signs and traffic signals.

c) Provide sidewalks external to the bridge for pedestrian safety.

d) The bridge should be widened by cantilevering a new deck from either side of the existing structure, where structurally feasible and aesthetically and historically appropriate.

3. Alter the geometric configuration of the bridge to remedy geometric deficiencies.

a) To increase the vertical clearance on through bridges, the depth of the portal frames and sway frames should be reduced with minimum possible destruction of historic fabric.

b) To increase the vertical clearance on grade-separation structures, the superstructure should be raised or the roadway lowered.

c) To increase the roadway width, some types of structures can be modified (e.g., multigirder, some concrete and stone bridges). Modifications should be designed to be compatible with the original structure.

C. Materials Repair and Maintenance

1. Identify features that are important in defining the overall historic character of the bridge.

2. Historic materials should be repaired, if possible. If replacement of a feature is necessary, it should be replaced in kind or with a compatible substitute material.

a) Masonry Superstructure and Substructure

(1) Drainage and vegetation

(a) Provide proper deck drainage systems which do not damage or promote deterioration of the superstructure or substructure

(b) Remove vegetation growing on bridge superstructure or substructure.

(2) Cleaning

(a) Clean masonry only when necessary to halt deterioration or to remove heavy soiling.

(b) Clean masonry with the gentlest method possible.

(c) Use cleaning method on test patches to determine long-range detrimental effect of cleaning.

(3) Repointing

(a) Remove deteriorated mortar by carefully hand-raking the joints to avoid damaging the masonry.

(b) Duplicate old mortar in strength, composition, color, and texture.

(c) Duplicate old mortar joints in width and joint profile.

(4) Repair of deteriorated sections

(a) Replace extensively deteriorated or missing features in kind or with a compatible substitute material.

(b) Replace masonry sections that are not repairable, in kind, using the same materials or compatible substitute materials. Dismantle deteriorated sections by hand, and with care.

(c) Do not apply non-historic coatings, such as stucco, gunite, and sealants, to masonry surfaces as a substitute for repointing and masonry repairs. …

II. <u>Continued Use for Non-vehicular Purposes</u>
If it is not feasible to continue a historic bridge in service for vehicular purposes, priority shall be given to continued use for non-vehicular purposes, at an existing site or at a new site. Preference shall be given to transportation-related uses of the historic bridge. Non-vehicular uses of a historic bridge may include:

A. Transportation-Related Functions

1. Where feasible the bridge should be retained in a transportation or transportation-related function.

a) While the most feasible transportation use may be to leave the bridge in place as a bicycle or pedestrian crossing, or to move it to a public park or recreation area for the same purpose, other uses and other locations should not be precluded, including ones that involve private ownership.

2. Adaptive use in situ will often be the only alternative for masonry or concrete bridges because of their nature or size. …

B. Non-Transportation-Related Functions

1. If it is not feasible to retain the bridge in a transportation-related function, consideration should be given to non-transportation-related uses including public recreational uses, use as interpretive sites or museums, or architectural adaptations that could provide residential, commercial, or educational space.

a) In such instances, the adaptive use should not obscure or alter the essential elements of the structure that impart its identity and significance as a bridge.

b) If the bridge is to remain or be moved within a historic district, careful consideration should be given to the compatibility of the proposed use with the architectural and historical character of the historic district.

c) Items A.1 [and] A.2 … above are equally applicable to architecturally adaptive uses.

C. [Adaptive Re-Use]

If an adaptive use cannot be found, consideration should be given to retaining the bridge either in place or at an alternative location as a historical ruin or monument.

III. Replacement with Mitigation

When alternatives for continued use of a historic bridge for vehicular or non-vehicular uses have been considered and determined to be not feasible or prudent, and the historic bridge must be removed from its site, replacement with mitigation is the remaining alternative. Historic bridges which are scheduled for demolition, or alteration which destroys historic integrity, are documented to mitigate the adverse effect of demolition or alteration. Such documentation should be prepared for inclusion in the HAER collection in the Library of Congress. Additional mitigation options include storage and/or salvage of all or parts of a bridge, an alternative generally applicable to metal bridges. Mitigation options may include:

A. Documentation

The primary criterion in documenting historic bridges is whether the bridge can reveal information critical to understanding and interpreting bridge design, fabrication, engineering, and technology. Documenting bridges can contribute to understanding the development of transportation systems in the United States. Moreover, documentation provides information on the lives and works of individuals and engineers who contributed to advancing bridge technology. The following guidelines are recommended for documentation of historic bridges:

1. When a bridge has been determined to be eligible for the NRHP and all alternatives for preservation are exhausted, the federal and state agencies involved should consult with the appropriate Regional Office of the National Park Service (Western Regional Office in San Francisco) to determine the documentation level required. Generally, the levels of documentation correspond to the level of significance of the bridge as follows:

a) Documentation Level I for bridges of national significance requires:

(1) measured drawings,

(2) large-format contemporary photographs,

(3) photocopies of selected existing drawings (when available),

(4) historic photographs and illustrations, and

(5) written data.

b) Documentation Level II for bridges of state significance requires

(1) photocopies of selected existing drawings (when available),

(2) historic photographs and illustrations,

(3) large-format contemporary photographs, and

(4) written data.

c) Documentation Level III for bridges of local significance requires

(1) dimensioned sketch plans and elevations snowing bridge configuration,

(2) large-format contemporary photographs, and

(3) written data.

2. *Individuals compiling documentation should be professionally qualified with demonstrable experience in bridge history and in documenting historic bridges.*
3. *Documentation should focus on the existing bridge and should be an accurate record of existing conditions supplemented by information obtained from reliable secondary sources with documentary limitations clearly stated.*
4. *Documentation should be prepared in such a manner as to permit the independent verification of information.*
5. *Documentation should be prepared on materials that are readily reproducible, durable, and of standard sizes that meet accession and archival requirements of the Library of Congress.*
6. *Documentation should be clearly and concisely presented. …*[31]

[31] Paula A. C. Spero and Howard J. Kittell, Trial Guidelines for the Conservation of Virginia's Historic Bridges, http://www.virginiadot.org/vtrc/main/online_reports/pdf/87-r5.pdf (accessed May 2015).

iv. PRESERVATION SOLUTIONS FOLLOWING SECRETARY OF THE INTERIOR'S STANDARDS

a. Preventive & Routine Maintenance

Guidance from FHWA, AASHTO, and HDOT has increasingly been geared toward repair and maintenance activities that can preserve and extend the useful life of existing historic bridges. Beginning in 2002 FHWA announced that Highway Bridge Replacement and Rehabilitation Program (HBRRP) funds could be obligated for preventive maintenance on federal-aid highway bridges.

A 2004 memorandum on preventive maintenance eligibility states,

> *Experience has shown that when properly applied, preventive maintenance is a cost-effective way of extending the service life of highway facilities and therefore is eligible for Federal-aid funding. By using lower-cost system preservation methods, States can improve system conditions, minimize road construction impacts on the traveling public, and better manage their resources needed for long-term improvements such as reconstruction or expansion. Preventive maintenance offers State DOT's a way of increasing the return on their infrastructure investment.*[32]

The AASHTO definition of preventive maintenance is: "a planned strategy of cost-effective treatments applied to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without substantially increasing structural capacity)."[33]

Conversely, routine maintenance remains the responsibility of the State DOT and is not eligible for HBRRP or other federal-aid highway funding as noted below,[34]

> *In 2008, Congress renewed emphasis in preservation of our Nation's bridge infrastructure by changing the name from the Highway Bridge Replacement and Rehabilitation Program to the Highway Bridge Program (HBP) and adding systematic preventive maintenance (SPM) as an eligible activity.*[35]

b. FHWA Hawaii Division & HDOT "Guidelines for Bridge Preservation Program," January 2005

After years of working with the preservation of historic bridges, guidelines were established. The *FHWA Hawaii Division and Hawaii Department of Transportation Bridge Preservation Program Guidelines* issued in 2005 set the following parameters:

- *The [FHWA] Division office will also determine whether the State's Bridge Management System (BMS) uses a systematic process for preservation activities.*[36]
- *Ride improvement and preservation of serviceability are key elements of the program.*[37]
- *[Preservation maintenance] treatments include reducing the amount of water infiltrating the bridge, protecting the bridge elements, slowing the rate of deterioration, and correcting surface deficiencies or retrofit the bridge for vulnerability to seismic forces and scour.*[38]

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[32] Federal Highways Administration, United States Department of Transportation, Memorandum: "Preventive Maintenance Eligibility," HIAM-20, October 8, 2004, https://www.fhwa.dot.gov/preservation/100804.cfm (accessed May 2015).
[33] Federal Highways Administration, United States Department of Transportation, *Bridge Preservation Guide*, FHWA-HIF-11042, August 2011, 6, http://www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf (accessed May 2015).
[34] Ibid.
[35] Ibid., 3.
[36] Federal Highways Administration, United States Department of Transportation, *Hawaii Division and Hawaii Department of Transportation Bridge Preservation Program Guidelines* (Honolulu: January 2005), 2.
[37] Ibid., 3.
[38] Ibid.

- *Preventive maintenance activities should concentrate on treating bridges with fair to good NBI condition ratings and showing no more than minor distress.*[39]
- *Design repairs or treatments should allow for extending bridge service life approximately five (5) to ten (10) years.*[40]
- *Projects may be undertaken without geometric enhancements, significant reconstruction or considerable upgrades.*[41]
- *A corridor or sections of highway grouping several bridges should be considered as one project rather than individual sites.*[42]

An extensive list of maintenance activities that qualify are included as examples and further described in detail within the guidelines, with the caveat that the list is not all-inclusive. Activities that address known Hana Highway historic bridge issues include:

- Minor deck rehabilitation or repair including applying deck overlays:
  - Removing excessive asphalt overlays on concrete bridge decks is also a cost-effective measure that reduces the dead load on the existing deck and increases available load carrying capacity of the deck and superstructure.
  - Removing excessive overlays also improves the required railing height
- Installation of scour countermeasures
- Seismic retrofit
- Superstructure and substructure repairs
- Cathodic protection systems for bridge decks, superstructure and/or substructure elements
- Repair of collision damaged members

c. FHWA "Bridge Preservation Guide," August 2011

> *A successful bridge program seeks a balanced approach to preservation and replacement. Focusing only on replacing deficient bridges, while ignoring preservation needs, will be inefficient and cost-prohibitive in the long term. Adopting a "worst first" approach to managing bridge assets may also yield ineffective results that allows bridges in good condition to deteriorate into the deficient category which generally is associated with higher costs and other challenges. …A viable alternative is timely and effective bridge preservation of sound bridges to assure their structural integrity and extend their useful life before they require replacement.*[43]

Bridge actions fall under two main categories, preservation and replacement. However, "bridge replacement is not considered a preservation activity" by FHWA and many other organizations.[44] Bridge preservation includes the following categories and sub-categories (which are further defined on the following page):

- Rehabilitation

[39] Federal Highways Administration, United States Department of Transportation, *Hawaii Division and Hawaii Department of Transportation Bridge Preservation Program Guidelines* (Honolulu: January 2005), 3.
[40] Ibid.
[41] Ibid.
[42] Ibid., 8.
[43] Federal Highways Administration, United States Department of Transportation, *Bridge Preservation Guide*, FHWA-HIF-11042, August 2011, http://www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf (accessed May 2015), 2.
[44] Ibid., 9.

- Preventive Maintenance
  - Cyclical (non-condition based) Activities
  - Condition Based Activities[45]

Definitions
The following definitions from the FHWA Bridge Preservation Guide further clarify the types of preservation activities that qualify as preventive maintenance and which, as part of a bridge preservation program, would qualify for HBP funding.[46]

> *Bridge Preservation – Definition*
> *Bridge preservation is defined as actions or strategies that prevent, delay or reduce deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in good condition and extend their life. Preservation actions may be preventive or condition-driven. …*
>
> *Bridge Preservation – Commentary*
> *Effective bridge preservation actions are intended to delay the need for costly reconstruction or replacement actions by applying preservation strategies and actions on bridges while they are still in good or fair condition and before the onset of serious deterioration. …*
>
> *Preventive Maintenance – Definition*
> *Preventive maintenance is a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without substantially increasing structural capacity). …*
>
> *Bridge Maintenance – Commentary*
> *Bridge owners typically apply preventive maintenance to elements or components of structures with significant remaining useful life. As a major part of bridge preservation, preventive maintenance is a strategy of extending useful life by applying cost-effective treatments to sound bridges (good or fair condition). The concept of preventive bridge maintenance suggests that a planned strategy of cost-effective treatments should be performed to keep bridges in good condition, retard future deterioration, and avoid large expenses in bridge reconstruction or replacements. …*
>
> *Cyclical Preventive Maintenance Activities – Definition*
> *Activities performed on a pre-determined interval and aimed to preserve existing bridge element or component conditions. Bridge element or component conditions are not always directly improved as a result of these activities, but deterioration is expected to be delayed.*
>
> *Cyclical Preventive Maintenance Activities – Commentary*
> *Different performance measures and frequencies could be established for cyclical activities based on the desired level of service and program goals. …* [For example, bridge washing: 1-2 years, asphalt overlay: 10-15 years.]
>
> *Condition Based Preventive Maintenance Activities – Definition*
> *Activities that are performed on bridge elements as needed and identified through the bridge inspection process.*

[45] Federal Highways Administration, United States Department of Transportation, *Bridge Preservation Guide*, FHWA-HIF-11042, August 2011, http://www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf (accessed May 2015), 5.
[46] Ibid., 2-4.

Condition Based Preventive Maintenance Activities – Commentary
These activities are typically performed on a bridge that is in overall good to fair condition to restore bridge elements to a state of good repair. These preventive maintenance examples may also be implemented in advance of any condition-based observations. For example, installation of scour countermeasures at a substructure element that is deemed scour susceptible, but before observing any scour during the routine inspection. …[47]

[47] Federal Highways Administration, United States Department of Transportation, *Bridge Preservation Guide*, FHWA-HIF-11042, August 2011, http://www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf (accessed May 2015), 6-8.

v. BRIDGE REPAIR & REHABILITATION

Of the four distinct approaches outlined by the SOI Standards, preservation through diligent maintenance, and sensitive repair of existing historic materials and character defining features is always the ideal option for treatment of an historic property. It is generally understood that government properties have limited resources, labor, and funding that affect the level of preservation afforded to the site.

Various factors such as humid weather, landslides, daily commuter and tourist traffic at medium to high volumes, and constantly changing terrain over an extensive surface area along the Hana coastline present challenges to the ongoing preservation and maintenance of the numerous historic bridges and culverts within the project area. Additionally, it is essential that these roads, bridges, and culverts must function for public safety. Because many of these bridges are almost one hundred years old, or older, and do not meet current public safety codes, repair and rehabilitation are the next steps to consider.

Rehabilitation goes beyond preventive maintenance to address structural and safety issues. These projects typically require significant engineering resources for design, a lengthy completion schedule, and considerable costs. The below addresses a need for a more systematic approach to evaluate historic bridges for rehabilitation potential rather than assuming that the bridge needs to be replaced.

a. Guidelines for Historic Bridge Rehabilitation & Replacement, March 2007

In 2007 AASHTO's Standing Committee on the Environment commissioned a study to develop a systematic, and documentable, decision-making process for rehabilitating versus replacing historic bridges. The guidelines are intended to be used as the protocol for defining when rehabilitation of historic bridges can be considered prudent and feasible, and when it is not, based on engineering and environmental data and judgments.

> *While the National Historic Preservation Act of 1966 (amended) and Section 4(f) U.S. Department of Transportation Act of 1966 specify nationally applicable processes for considering preservation or replacement of historic bridges, there is no corresponding protocol that ensures a nationally consistent approach to determining which bridges should be rehabilitated or replaced…. Despite the federal legislation and proactive policies of many states, historic bridges continue to be lost for a variety of reasons. To ensure that rehabilitation versus replacement decision making is balanced and consistent among the states, nationally applicable guidance on historic bridge analysis is deemed by the American Association of State Highway and Transportation Officials Standing Committee on the Environment to be useful.*[48]

The protocol divides the process into 4 steps:

1. Determination of historic significance (per bridge)
2. Applying structural and functional considerations (using NBIS condition ratings)
3. Historical and environmental considerations (of the proposed work)
4. Applying the decision-making thresholds (using the information from steps 1 through 3 to define and support when rehabilitation of an historic bridge is feasible and prudent and when it is not). Refer to *Figure 4 – 1*.

The following 3 areas of adequacy are considered:

- Superstructure/Substructure Condition
- Load-Carrying Capacity
- Geometry

[48] J. Patrick Harshbarger, Mary E. McCahon, Joseph J. Pullaro, and Steven A. Shaup, *Guidelines for Historic Bridge Rehabilitation and Replacement,* AASHTO, NCHRP Project 25-25/task 19, March 2007, A-1.

Bridge elements are condition rated at a minimum of every 24 months based on a state-wide inspection process, utilizing the NBIS condition rating code. The ratings of 0 – 9 are presented below for rating structural elements 58, 59, and 60.

Code	Description
N	NOT APPLICABLE
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION - no problems noted.
7	GOOD CONDITION - some minor problems.
6	SATISFACTORY CONDITION - structural elements show some minor deterioration.
5	FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	POOR CONDITION - advanced section loss, deterioration, spalling or scour.
3	SERIOUS CONDITION - loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	FAILED CONDITION - out of service - beyond corrective action.[49]

In step 4, a matrix is used to sort the combination of adequate and inadequate possibilities.[50]

Group I.	Adequate:	Superstructure/Substructure Condition
		Load-Carrying Capacity
		Geometry
Group II.	Inadequate:	Geometry
	Adequate:	Superstructure/Substructure Condition
		Load-Carrying Capacity
Group III.	Inadequate:	Load-Carrying Capacity
	Adequate:	Superstructure/Substructure Condition
		Geometry
Group IV.	Inadequate:	Load-Carrying Capacity
		Geometry
	Adequate:	Superstructure/Substructure Condition
Group V.	Inadequate:	Load-Carrying Capacity
		Superstructure/Substructure Condition
	Adequate:	Geometry
Group VI.	Inadequate:	Load-Carrying Capacity
		Superstructure/Substructure Condition
		Geometry

Figure 4 – 1: AASHTO Rehabilitation Categories

[49] J. Patrick Harshbarger, Mary E. McCahon, Joseph J. Pullaro, and Steven A. Shaup, *Guidelines for Historic Bridge Rehabilitation and Replacement,* AASHTO, NCHRP Project 25-25/task 19, March 2007, A-17.
[50] Ibid., A-30 – A-31.

Additional considerations include:

> *From the engineering perspective, the threshold for defining when rehabilitation is the appropriate decision is a structural condition code value of 4. A condition code value of 4 (poor) will require further study to determine if there are feasible and prudent options for rehabilitation. [The structural capacity of the bridge is affected by this value.] Bridges with a code value of 5 (fair) or greater generally have rehabilitation potential.*
>
> *A condition code value of 3 (serious) is unacceptable when and if the controlling member(s) cannot be sufficiently improved. If the controlling member(s) can be improved, then the bridge is considered to have rehabilitation potential despite its 3 or below rating.*
> *Bridges with high and exceptional historical significance should be considered for rehabilitation based on a greater level of effort (level of engineering required, cost, etc.) because of their overriding historical significance. Even with more effort, some may not have rehabilitation potential.*[51]

b. Flexible Design

AASHTO has become a national leader in encouraging flexible design in highway design that is responsive to local transportation needs and has been a strong advocate for *context sensitive solutions* – a new approach to highway design that embraces local community values and concerns as a part of the design process. Through flexible design and context sensitive solutions, many of the historic preservation issues for historic roads can be addressed.

In their publication, *A Guide to Achieving Flexibility in Highway Design*, AASHTO states:

> *Many states and localities have adopted the AASHTO Green Book for use as the basis of their state guidelines with no change. However the intent of the AASHTO Green Book is that* ***individual states, cities, and counties have the freedom to develop their own design guidelines*** *and processes based on sound engineering principles that reflect local conditions and needs as well as the needs of the highway users. For such agencies, the design criteria in the AASHTO Green Book can be a starting point or benchmark. Other published design criteria, such as that published by the Institute of Transportation Engineers, may also be referenced by an agency. The AASHTO Green Book is thus a guide, a reference, and a basis for the development of an agency's guidelines. Terrain, climate,* ***culture and values****, and driving habits differ across the nation; what is good and acceptable in one location may not be satisfactory or practical in another [emphasis added].*[52]

c. Context Sensitive Solutions

Act 70 of the Session Laws of Hawaii (2006) directs the Hawaii director of transportation to "…establish Flexible Highway Design Guidelines to govern new construction, reconstruction, preservation, resurfacing (except for maintenance surfacing), restoration, or rehabilitation of bridges, principal and minor arterial roads, collector and local roads, and streets. …The guidelines shall also provide for documentation of the facts, circumstances, and considerations involved in the flexible design decision, including an explanation of the process and the reasoning that led to the decision."[53]

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[51] J. Patrick Harshbarger, Mary E. McCahon, Joseph J. Pullaro, and Steven A. Shaup, *Guidelines for Historic Bridge Rehabilitation and Replacement,* AASHTO, NCHRP Project 25-25/task 19, March 2007, A-31.

[52] American Association of State Highway and Transportation Officials (AASHTO), *A Guide to Achieving Flexibility in Highway Design* (American Association of State Highway and Transportation Officials, 2004), 9.

[53] State of Hawaii, "Highways; Flexible Design; Liability Immunity," House of Representatives, Twenty-Third Legislature, 2006, State of Hawaii, H.B. No. 1947 S.D. 1, Act 70 of the Session Laws of Hawaii, 2006, http://www.capitol.hawaii.gov/session2006/bills/HB1947_sd1_.htm (accessed May 2015).

Context sensitive solutions (also known as *context sensitive design*) is one of the newest movements in transportation policy and planning. As its name suggests, the movement encourages transportation design solutions that are sensitive to the natural and built environment – the contextual setting of a community or locale. Transportation projects, under this theory, should not merely function efficiently and effectively, but also contribute to and enhance the historic, cultural, and environmental characteristics of the community; thus, public involvement is crucial to this process. Developed in response to Act 70, Hawaii's 2006 adaptation of a context sensitive solutions policy is based on procedures by the State of New York Department of Transportation.

> *The [context sensitive solutions] philosophy and public involvement procedures may be applied to any roadway, highway or freeway project and shall be considered on the following:*
>
> A. *Projects on routes designated as Scenic Byways;*
> B. *Projects that fall, entirely or in part, within any of the following corridors (subject to amendment by the Legislature):*
>   1. *Hana Highway, east Maui;*
>   2. *Hanalei Road, north Kauai;*
>   3. *Hamakua-Honokaa Heritage corridor, Island of Hawaii;*
>   4. *Upper Kona Road, Island of Hawaii; and*
>   5. *Ka Iwi Coastal Highway, eastern Oahu.*[54]

AASHTO and FHWA have been encouraging all states to adopt context sensitive solutions as an overarching philosophy directing all transportation projects.

> *In the view of AASHTO, established processes and design guidance are not in conflict with the movement [(Context Sensitive Design)]. Furthermore, a well-designed context-sensitive design solution need not increase the risk of tort lawsuit to an agency. AASHTO supports the concepts and principles of flexibility in highway design and feels that all professionals responsible for highway and transportation projects should understand how to accomplish a flexible design solution within current design processes and approaches.*[55]

[54] Department of Transportation, State of Hawaii, *Report to the Twenty-Fourth Legislature State of Hawaii 2007: Pursuant to Act 70, SLH 2006, Relating to Liability, The Director of Transportation,* http://files.hawaii.gov/dotadmin/library/legislature/pursuant-to-act70-slh2006.pdf (accessed May 2015), 5.
[55] American Association of State Highway and Transportation Officials (AASHTO), *A Guide to Achieving Flexibility in Highway Design* (American Association of State Highway and Transportation Officials, 2004), xv.

vi. BRIDGE REPLACEMENT / NEW STRUCTURES

As with any preservation plan, replacement of historic structures is the last resort in efforts to ensure that these structures function safely for the community. If the bridge cannot be rehabilitated without compromising public safety, the option for replacement should be exercised judiciously and new structures should be designed with consideration of Hana Highway's unique historic character. All new bridges must meet the minimum design standards in AASHTO LRFD Bridge Design, HDOT Bridge Design & Criteria, and applicable FHWA standards for load capacity and safety features to ensure the safety of the general public traveling over the bridge. In addition, due to landslides, storms, and/or road damage resulting from earth settlement, it may be warranted to add new culverts and/or hillside bridges in order to protect the users of Hana Highway.

When a bridge is determined to be beyond repair and replacement is required, or in the event that an historic bridge structure is damaged and rendered unsafe and unusable due to an unforeseen natural disaster, it is strongly recommended that future bridge designers should follow the *SOI Standards for Rehabilitation* with attention to guidelines for new construction within an historic district, as noted in the following excerpt from *Sense of Place: Design Guidelines for New Construction in Historic Districts,*

> *A designer or preservationist contemplating new construction in a historic setting may adopt one of four strategies based on four possible attitudes toward the existing setting or resource: 1) literal replication, 2) invention within the same or a related style, 3) abstract reference, and 4) intentional opposition. These options represent a range of responses to the call for 'differentiated' yet 'compatible' designs for additions or infill construction in historic settings found in the SOI Standards.*[56]

The SOI Standard notes that all new construction should be differentiated from the older, original construction and shall be "compatible with the massing, size, scale, color, and architectural features"[57] of the property and the district. An itemized breakdown of the SOI Standards for "New Construction within the Boundaries of Historic Properties" is presented below, with notes on each item's specific relevance to the Hana Highway Historic Bridge District detailed after each guideline.

a. New Construction within the Boundaries of Historic Properties

> *It is possible to add new construction within the boundaries of historic properties if site conditions allow and if the design, density, and placement of the new construction respect the overall character of the site. According to the Secretary of the Interior's Standards for Rehabilitation – Standard 9 in particular – and the Guidelines for Rehabilitating Historic Buildings, new construction needs to be built in a manner that protects the integrity of the historic building(s) and the property's setting.*[58]
>
> *In addition, the following must be considered:*
>
> 1. *Related new construction – including buildings, driveways, parking lots, landscape improvements and other new features – must not alter the historic character of a property. A property's historic function must be evident even if there is a change of use.*[59]

[56] Preservation Alliance for Greater Philadelphia, *Sense of Place: Design Guidelines for New Construction in Historic Districts,* supported by a grant from the William Penn Foundation, 2007, http://www.preservationalliance.com/publications/SenseofPlace_final.pdf (May 2015), 5.
[57] "Standards: The Secretary o the Interior's Standards for Rehabilitation, Introduction to the Standards," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/rehabilitation/rehab/stand.htm (July 2014).
[58] "New Construction within the Boundaries of Historic Properties," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab/new-construction.htm (accessed July 2014).
[59] Ibid.

Relevance to Hana Highway: When necessary, related new construction, such as hillside bridges or culverts, may be added within the boundaries of the Hana Belt Road Historic District, provided that the new structures a) do not exhibit features incompatible with the character-defining features of the district, b) do not perceptively widen or straighten the road, and/or c) do not otherwise alter the road's existing configuration. Related new construction should appear to be fully integrated into the road, and should not alter the character of the historic district. The height of new bridge or culvert railings, which are the most visible and identifiable portion of the bridge to the general public and road users, should be kept as close as possible to the original height, scale, and proportions of historic railings while complying with code, to ensure that natural views are protected.

2. *The location of new construction should be considered carefully in order to follow the setbacks of historic buildings and to avoid blocking their primary elevations. New construction should be placed away from or at the side or rear of historic buildings and must avoid obscuring, damaging, or destroying character-defining features of these buildings or the site.*[60]

   Relevance to Hana Highway: In order to retain the historic road configuration and character-defining features of the Hana Highway, construction of new hillside bridges or culverts should be located within the highway ROW and should avoid straightening or widening the existing road wherever possible. In the event that an existing, historic bridge requires full replacement, the new bridge should be constructed at the same location of the historic bridge structure, without altering or adversely affecting its neighboring rock formations. New construction should not adversely impact the view of existing, adjacent natural features, such as waterfalls and pools, which contribute to the character-defining setting of Hana Highway.

3. *Protecting the historic setting and context of a property, including the degree of open space and building density, must always be considered when planning new construction on an historic site. This entails identifying the formal or informal arrangements of buildings on the site, and whether they have a distinctive urban, suburban, or rural character. For example, a historic building traditionally surrounded by open space must not be crowded with dense development.*[61]

   Relevance to Hana Highway: "Relevance to Hana Highway" in Items 1. and 2., above, apply to this guideline.

4. *In properties with multiple historic buildings, the historic relationship between buildings must also be protected. Contributing buildings must not be isolated from one another by the insertion of new construction.*[62]

   Relevance to Hana Highway: Within the Hana Belt Road Historic District, the visual and spatial relationships between multiple historic structures and the road itself should be preserved. Construction of new structures within the historic district and rehabilitation of existing structures should be completed in such a manner that the continuous, rural road that defines the historic Hana Highway, Route 360 corridor is not significantly altered.

[60] "New Construction within the Boundaries of Historic Properties," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab/new-construction.htm (accessed July 2014).
[61] Ibid.
[62] Ibid.

5. *As with new additions, the massing, size, scale, and architectural features of new construction on the site of a historic [bridge] must be compatible with those of the historic [bridge]. When visible and in close proximity to historic [bridges], the new construction must be subordinate to these [bridges]. New construction should also be distinct from the old and must not attempt to replicate historic [bridges] elsewhere on site and to avoid creating a false sense of historic development.*[63]

   Relevance to Hana Highway: The design of new structures within the historic district should be compatible with and sensitive to that of the existing historic structures, yet the new design should also be "distinguishable from the historic fabric by informed observers or trained professionals."[64]

   The most visible character-defining features of the Hana Highway bridges, as identified in this report, consist of the parapets/railings, piers, abutments, and dramatic structural engineering of these early bridges. It is crucial that these historic features be retained, and recommended that they be used as a general guideline for the massing, size, scale and architectural features of new construction within the historic district to maintain a sense of place.

   It is important that the design of new bridge railings be visually compatible with historic bridge parapets/railings, because parapets/railings are the most visible portion of the bridge and seen together, these elements provide a continuous visual linkage along the Road to Hana. Other elements, such as piers and abutments, which are often visible on the *makai* side of hairpin turns, should also be given careful consideration for design compatibility with their respective historic components, in the case of new construction.

   Additionally, the three arched bridges along the state-owned portion of Hana Highway, Route 360 are set in dramatic, easily visible locations; maintaining this visibility is important in defining the overall character of the historic district.

   Due to the necessity of contemporary design to meet modern day safety codes that address both crash-tested railings and a significantly higher load capacity, the aesthetics of any new structures built along the Hana Highway will be somewhat different from that of historic bridges, by default; this satisfies an acceptable degree of differentiation to avoid creating a false sense of history. The construction and structural design of bridge decks are generally much less visible to passers-by and it is understood that this crucial structural component may need to be strengthened or adapted to meet applicable safety codes; thus, there may be increased flexibility in design of the deck that would not adversely impact the character of the historic district.

   Historic districts and structures naturally grow and change over time. A new bridge, or any new construction within the historic district, should exude a sense of place and sensitive compatibility to its historic surroundings, even though it may be completed in a different style appropriate to the time that it is built. Such construction protects historic resources, reflects the sense of place, and creates a continuity of character.

[63] "New Construction within the Boundaries of Historic Properties," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab/new-construction.htm (accessed July 2014).
[64] Preservation Alliance for Greater Philadelphia, *Sense of Place: Design Guidelines for New Construction in Historic Districts*, 2007, http://www.preservationalliance.com/publications/SenseofPlace_final.pdf (accessed May 2015), 9.

6. *The limitations on the size, scale, and design of new construction may be less critical the farther it is located from historic buildings [or districts].*[65]

   Relevance to Hana Highway: The existing road and ROW of Hana Highway, Route 360 is considered a contributing site to, and even defines, the historic district. Bridges located outside of the Hana Belt Road Historic District, say in nearby Kahului, may be subject to separate design guidelines appropriate for that area; thus, the limitations on the size, scale, and design associated with new construction in the historic district would not apply in another location.

7. *As with additions, maximizing the advantage of existing site conditions, such as wooded areas or drops in grade, that limit visibility is highly recommended.*[66]

   Relevance to Hana Highway: Future design teams should consider designs that aesthetically maximize and enhance the natural setting of rural Hana, the site-specific conditions at each structure location, and the unique character of adjacent natural geographic and rock features. It should be noted that all bridges along Hana Highway, Route 360 are sited in a context-sensitive manner.

8. *Historic landscapes and significant view sheds must be preserved. Also, significant archeological resources should be taken into account when evaluating the placement of new construction, and, as appropriate, mitigation measures should be implemented if the archeological resources will be disturbed.*[67]

   Relevance to Hana Highway: This guideline relates to the protection of cultural resources, as well as the natural setting, which is a character-defining feature of the Hana Belt Road Historic District. All activities related to repair, rehabilitation, and new construction should be completed in accordance with best management practices. Future design and construction teams should take extra precaution to avoid damaging or adversely impacting archaeological resources, surrounding lands, geographic features, and waterways, all of which may affect downstream communities and was a key concern identified during the course of community and stakeholder meetings.

[65] "New Construction within the Boundaries of Historic Properties," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab/new-construction.htm (accessed July 2014).
[66] "New Construction within the Boundaries of Historic Properties," U.S. Department of the Interior, National Park Service, http://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab/new-construction.htm (accessed July 2014).
[67] Ibid.

vii. HIGHWAY REFERENCES & DESIGN SPECIFICATIONS

The following reference manuals, websites, guides, and design specifications were used to provide treatment recommendations, based on current safety standards and conditions, and additional background information:

- AASHTO Guide for Commonly Recognized (CoRe) Structural Elements with 2002 Interim Revisions
- AASHTO Guide Specifications for Design and Bonded FRP Systems for Repair and Strengthening of Concrete Bridge Elements, First Edition, 2012
- AASHTO Guidelines for Historic Bridge Rehabilitation and Replacement, March 2007
- AASHTO LRFD Bridge Design Specifications, Seventh Edition, 2014
- AASHTO Manual for Assessing Safety Hardware (MASH), First Edition
- AASHTO Manual for Bridge Element Inspection, First Edition, 2013 with 2015 Interim Revisions
- AASHTO, The Manual for Bridge Evaluation, Second Edition, 2011 with 2011, 2013, 2014, and 2015 Interim Revisions
- AASHTO, Roadside Design Guide, Third Edition, 2002
- AASHTO, Roadway Lighting Design Guide, October 2005
- AASHTO, Standard Specifications for Structural Supports for Highways Signs, Luminaries, and Traffic Signals, Sixth Edition, 2013 with 2015 Interim Revisions
- AASHTO-AGC-ARTBA, Inspectors' Guide for Shotcrete Repair of Bridge, Task Force 37 Report, December 1999
- AASHTO, A Policy on Geometric Design of Highway and Streets, Sixth Edition, 2011
- American Concrete Institute (ACI) 318-05 and 318R-05, Building Code Requirements for Structural Concrete and Commentary
- Federal Highway Administration (FHWA), 25 CFR 625, Design Standards for Highways, October 1997
- FHWA Hawaii Division, Bridge Preservation Program Guidelines, January 2005
- Harshbarger, J. Patrick, Mary E. McCahon, Joseph J. Pullaro, and Steven A. Shaup, Guidelines for Historic Bridge Rehabilitation and Replacement, March 2007
- Hawaii Statewide Uniform Design Manual for Streets and Highways, 1980
- HAER No. HI-75, Hana Belt Road, Between Haiku and Kaipahulu, Hana, Maui County, HI, (compiled after) 1968
- Institute of Electrical and Electronic Engineers (IEEE), National Electrical Safety Code (NESC), 2012
- International Code Council (ICC), International Building Code (IBC), 2006
- Michigan Transportation Asset Management Council, Developing a Bridge Asset Management Guide and Sample Preservation Bridge Plan for Local Agencies, May 2011, http://michiganltap.org/sites/ltap/files/workshops/materials/Developing_a_Bridge_Asset_Management_Guide_for_Local_Agenices.pdf
- Montana Department of Transportation, Bridge Design Standards, http://www.mdt.mt.gov/other/bridge/external/design-stds-manual/design_stds_manual.pdf
- National Association of Cement Users (NACU), Standard Building Regulations for the Use of Reinforced Concrete, February 1910
- National Cooperative Highway Research Program (NCHRP), NCHRP 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features, 1993
- NCHRP, NCHRP Synthesis 398, Cathodic Protection for Life Extension of Existing Reinforced Concrete Bridge Elements, 2009
- National Fire Protection Agency (NFPA), NFPA 70: National Electrical Code (NEC), 2014

- Oregon Department of Transportation, Rebecca Burrow, Chris Bell, and Chris Leedham, Oregon's Historic Bridge Field Guide 2013
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- Ray, Malcolm H. and Christine E. Carrigan, Final Report: Recommended Guidelines for the Selection of Test Levels 2 through 5 Bridge Railings, NCHRP 22-12(30), February 2014
- Reid, John D. and Ronald K. Faller, A New TL-2 Rough Stone Masonry Guardwall, November 2009
- The Secretary of Interior's (SOI) Standards for the Treatment of Historic Properties
- State of Hawaii, Historic Bridge Inventory and Evaluation, November 2013
- State of Hawaii, Pursuant To Act 70, SLH 2006, Relating to Liability, December 2006
- State of Hawaii, Department of Transportation, Highways Division. "Bike Plan Hawaii Master Plan." http://hidot.hawaii.gov/highways/bike-plan-hawaii-master-plan/
- State of Hawaii, Department of Transportation, Highways Division, Design Criteria for Bridges and Structures, 8 August 2014
- State of Hawaii, Department of Transportation, Highways Division, Design Criteria for Highway Drainage, 1 October 2010
- State of Hawaii, Department of Transportation, Highways Division, Design Guidelines for Rehabilitation, Restoration, and Resurfacing (RRR) Projects, September 2010
- State of Hawaii, Department of Transportation, Highways Division, Federal-Aid Highways 2035 Transportation Plan for the District of Maui, July 2014
- State of Hawaii, Department of Transportation, Highways Division, Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai, September 1990
- State of Hawaii, Department of Transportation, Highways Division, State of Hawai'i Historic Bridge Inventory and Evaluation, May 2008
- Texas Department of Transportation, Bridge Railing Manual, May 2013
- Texas Department of Transportation, Historic Bridge Manual, March 2014
- U.S. Department of Transportation (USDOT), Federal Highway Administration, Bridge Inspector's Reference Manual, Volumes 1 and 2, December 2012
- USDOT, FHWA, Bridge Preservation Guide, August 2011
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CHAPTER 5

APPLICATION OF DESIGN STANDARDS & GUIDELINES

i. PROJECT DESIGN PARAMETERS

The National Register of Historic Places nomination form[1] and the Historic American Engineering Record Report HI-75[2] cited a total of 43 historic bridges and 12 identified culverts between mile markers 5.09 and 34.0 along the historic Hana Highway, Route 360. These structures are listed as "contributing" structures in the National Register nomination of the Hana Belt Road as an Historic District. In addition to the 43 bridges and 12 culverts identified as historic structures, there are seven hillside bridges and 45 culverts along this stretch of highway built between the early 1900's and 2004.

The main objective of the *Hana Highway Bridge Preservation Plan* (2015) is to preserve the original appearance and character of the historic bridges in the Hana Belt Road Historic District while addressing current safety standards. Proper signage meeting current standards must also be addressed, as it provides direction and information to drivers. The *Manual on Uniform Traffic Control Devices* published by FHWA establishes standards used nationwide in the design and maintenance of all public streets, highways, bikeways, and private roads open to traffic. State and local policies are also based on design guidelines set forth by AASHTO in the publication, *A Policy on Geometric Design of Highways and Streets* (also known as the "Green Book").

The 43 historic bridges and 12 identified culverts along the Hana Highway, Route 360 were analyzed for public safety, ability to repair or rehabilitate in a safe manner, and ability to maintain traffic flow during construction. The majority of signage at bridges along the Hana Highway, Route 360 need replacement, repair, or cleaning. Each bridge has different visibility conditions and thus, unique signage requirements. Most bridges are wide enough for only one vehicle lane with no sidewalks. Many of the bridges are also located on hairpin turns, which may present additional challenges for those requiring widening or major structural repair. Bridge railings vary in height and condition and do not meet current acceptable standards.

Based on highway design standards mentioned above and in Section A, Chapter 4. vii. *Highway References & Design Specifications*, it is recommended that bridges and culverts along the Hana Highway, Route 360 conform to the following:

- For a two-lane bridge, a minimum width of 24-feet (curb-to-curb), or
- For a one-lane bridge with two-way traffic, a minimum width of 16-feet (curb-to-curb),
- Eliminate blunt ends with guardrails and end treatments at bridge approaches,
- Design of approaches that provide safe sight distance from both ends of the bridge,
- Provide adequate signage including visible striping and reflectors,
- Hydraulic capacity to safely pass storm runoff without overtopping the bridge deck,
- Provide railings/parapets that meet the criteria for a Test Level 2 (TL-2) Bridge Railing,
- Rehabilitate structurally deficient bridge elements, and
- Upgrade bridges to support a load capacity of 40 tons.

Since the seven hillside bridges were recently constructed and meet the design standards listed above, there are no rehabilitation recommendations for these bridges.

The 45 additional culverts not included in the HAER report are smaller than the minimum 20-foot bridge length to be considered in the NBI. Design recommendations for these culverts will be limited to their visible portions from the highway and should be rehabilitated or replaced to meet current safety standards.

[1] *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001).
[2] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005).

a. Structural Design Criteria & Assumptions for Evaluation

Assumed Existing Material Strengths (If none provided or could be determined from record drawings and/or sampling and testing of existing material.)[3]

A. Concrete Strength	f'_c = 2,000 pounds per square inch
B. Reinforcing Steel	f_y = 33,000 pounds per square inch

AASHTO Design Forces for Test Level 2 (TL-2) Traffic Railing[4]

A. Transverse vehicle impact force	F_t = 27,000 pounds
B. Longitudinal friction force	F_L = 9,000 pounds
C. Vertical (Down) force of vehicle laying on top of rail	F_v = 4,500 pounds
D. Longitudinal length of distribution of F_t at a height of H_e	L_t = 4.0 feet
E. Longitudinal length of distribution of F_L	L_L = 4.0 feet
F. Longitudinal length of distribution of F_v on top of railing	L_v = 18.0 feet
G. Height between impact force F_t and bridge deck	H_e = 20.0 inches
H. Minimum height of rail	H = 27.0 inches

Seismic Criteria based on FHWA Seismic Retrofitting Manual for Highway Structures Part 1 – Bridges[5]

A. Earthquake Ground Motion: Lower Level (LL)

B. Bridge Importance: Essential

C1. Anticipated Service Life 2 (ASL 2), 16 – 50 yrs, for the condition of repair/rehabilitation of a bridge or

C2. Anticipated Service Life 3 (ASL 3), > 50 yrs, for the condition of replacement of a bridge

D. Performance level 3 (PL3): Fully Operational

New Construction Material Strength (minimum)

A. Concrete Strength	f'_c = 4,000 pounds per square inch
B. Reinforcing Steel	f_y = 60,000 pounds per square inch

b. Discussion of Recommended Minimum Bridge Width

The *Preservation Plan for the County of Maui Bridges within the Hana Highway Historic District,* completed in December 2001, specified the minimum clear width for a one-lane bridge for the Hana Belt Road Historic District as 16 feet. This provided for a 12-foot wide traffic lane in the center of the bridge with 2-foot shoulders on each side. This allowed for two cars to cautiously pass each other safely.

Hana Highway, is classified as a major collector with an average daily traffic (ADT) amount varying from 1,000 to 1,800 vehicles. Maximum posted speed limit is 35 miles per hour (mph). The accident data from 2006 to 2010 does not indicate whether one-lane bridges were a major factor in the reported accidents. Out of the 245 accidents reported, only eight were in the vicinity of one-lane bridges. There were no indications in the reports that the bridges contributed to the accidents. Although the ADT is much higher than other States that allow rehabilitated

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[3] National Association of Cement Users (NACU), *Standard Building Regulations for the Use of Reinforced Concrete* (Philadelphia: The Association, 1910).

[4] American Association of State Highway and Transportation Officials, *AASHTO LRFD Bridge Design Specifications*, 7th ed. (Washington, D.C.: American Association of State Highway and Transportation Officials, 2014).

[5] U.S. Department of Transportation, Federal Highway Administration, *FHWA Seismic Retrofitting Manual for Highway Structures Part 1 – Bridges*, publication no. FHWA-HRT-06-032 (McLean: Research, Development, and Technology Turner-Fairbank Highway Research Center, 2006).

and replacement one-lane bridges, the HDOT recommends that a minimum clear width of 16 feet be used for one-lane bridges on the historic Hana Highway. This is based on the accident history, the posted highway speed limit, maintaining the ambiance of the highway, sensitivity to the wishes of the community, and for consistency with the County of Maui's portion of the highway. Appropriate signage shall also be provided at the approaches to these bridges warning drivers to slow down or stop as needed.

c. Additional Items of Consideration for Future Design Teams

- Retain a geotechnical engineering consultant to provide site-specific geotechnical information including, but not limited to, foundation, seismic design, and slope stability recommendations.
- Retain a qualified historic architect to ensure projects meet SOI Standards and comply with requirements of the proposed programmatic agreement.
- Utilize detour routes and bypass bridges that minimize the effect on local communities.
- An EIS/EA may be necessary to determine the implications the construction and temporary bypass bridge will have on the surrounding agriculture and communities.
- Determine stream flow information and conduct a scour analysis.
- Retain an environmental engineering consultant to determine if there are hazardous materials at the bridge locations.
- Landscaping shall be restored to match original conditions or per an approved landscape plan once work has been completed at the bridges.
- See also discussion of preservation design criteria in Section A, Chapter 1. *General*, Chapter 3. *Summary of Identification Guidelines & Evaluation Methods*, Chapter 4. *Design Standards & Guidelines*, & Chapter 7. *Hana Belt Road Historic Bridge District: State Bridges*.
- See also discussion in Section A, Chapter 6. *Related Issues Along the Hana Highway* for additional concerns identified beyond the scope of this report.

ii. BEST MANAGEMENT PRACTICES

The Area of Potential Effect (APE) for future construction projects at all bridge locations shall include the overall area that contains, but is not limited to, the following:

- The bridge itself and stream below,
- Staging areas, as necessary,
- Temporary bypass bridge and stream below,
- Any utilities that may need to be moved or added for construction, and
- De-watering areas, if any.

The location of the bypass should be included in the APE and an intensive level archaeological inventory survey should be completed within the APE.

A construction management plan with information on best management practices to include on-site quality control and containment of construction debris is essential to the follow-through of a well-designed project.

iii. REPAIR, REHABILITATION & REPLACEMENT RECOMMENDATIONS

This section provides overall recommendations for the future design teams to consider when preparing construction documents for the repair, rehabilitation, or replacement of the historic bridges. Preference should be given to repair and rehabilitation first, with replacement considered a last resort. Given that Hana Highway, Route 360 cannot be closed without considerable hardship on the communities that the highway serves, a temporary detour bridge may be necessary to keep the highway open when applying these options.

a. Approach Walls & Safety Features at the Approaches

Existing bridge approaches typically consist of the following elements: a metal guardrail that transitions to a low rock wall, which continues to the end of the bridge parapet/railing. To provide a safe approach to the bridges a guardrail end treatment and approach guardrail should be present. Following current codes, these should be installed to protect vehicles from end impacts, snagging points, and for the redirection of vehicles back onto the bridge if they go astray.

Approach Walls

Currently, there are low CRM approach walls at the end of most bridge railings (refer to *Figure 5 – 1*). The existing CRM approach walls do not meet the TL-2 criteria (refer to *Figure 5 – 2*).[6] Local Hana community members have expressed concern about replacing these CRM walls with metal guardrails; many prefer to keep the CRM walls.

Figure 5 – 1, Figure 5 – 2: Kupukoi Stream Bridge downstream Hana approach in 2012 (left) with and 2014 (right) without CRM approach wall, Courtesy of NOEI

The majority of guardrails at the approaches are not attached to the bridge railing in accordance with current traffic standards (refer to *Figure 5 – 3*). Most of the CRM approach walls are not continuous and have openings several feet wide in them (refer to *Figure 5 – 4*). These openings create a snagging hazard for vehicles and are a safety issue.

[6] Refer to Section A, Chapter 5. i. a. *Structural Design Criteria & Assumptions for Evaluation: AASHTO Design Forces for Test Level 2 (TL-2) Traffic Rating*

Figure 5 – 3: Metal guardrail, guardrail end treatment, and CRM wall, Courtesy of NOEI

Figure 5 – 4: Gap in CRM approach wall Courtesy of NOEI

Approach Wall Design Criteria

Recommend that approach wall designs and construction meet the following criteria:

- Crash-tested TL-2 walls (or solid parapets) that are FHWA approved and accepted. Deviations from the FHWA accepted construction design of the walls must be approved by FHWA, HDOT, and SHPD prior to design.
- If no approach wall exists at the bridge, then a crash-tested approach wall will be designed and constructed.
- Natural rock or CRM façade to be removed, retained, and incorporated into the new crash-tested TL-2 approach wall façade design.
- Existing openings in the CRM approach walls should be eliminated and a drainage system designed to remove water from the bridge (i.e., providing PVC pipes through the new approach wall).
- Guardrail transitions should be compatible with the new approach wall and conform to current acceptable standards.
- Appearance of new or reconstructed facades shall closely match that of the original historic masonry work, including materials, scale, details, and color.

Approach Wall Type Recommendations

Three types of approach walls to consider are as follows:

- Baltimore Washington Parkway Stone Rail
- Low Profile Concrete Bridge Railing
- Stone Masonry Guardwall – Recommended

Of the three types, the Stone Masonry Guardwall (refer to *Figure 5 – 5*) is recommended as the best option because it has a crash-test rating of TL-3, does not have a top rail, has a natural rock appearance that closely matches existing lava rock walls, and has a relatively flat surface.

Figure 5 – 5: Example of the stone masonry guardwall
Courtesy of FHWA

Concrete Bridge Name Panel
The approach walls shall contain a concrete bridge name panel. Refer to *Figures 5 – 6, 5 – 7,* and *5 – 8* for design details of the panels.

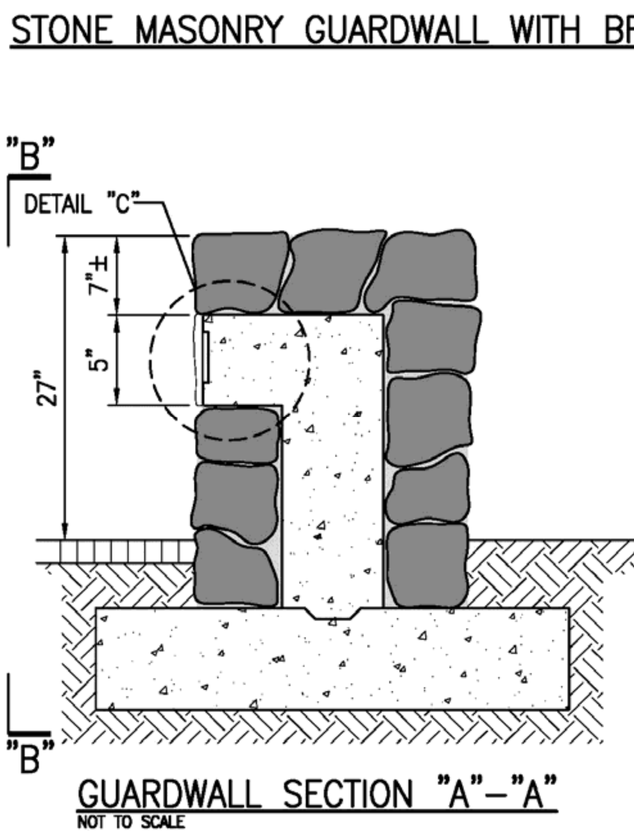

Figure 5 – 6: Section of guardwall
Courtesy of NOEI

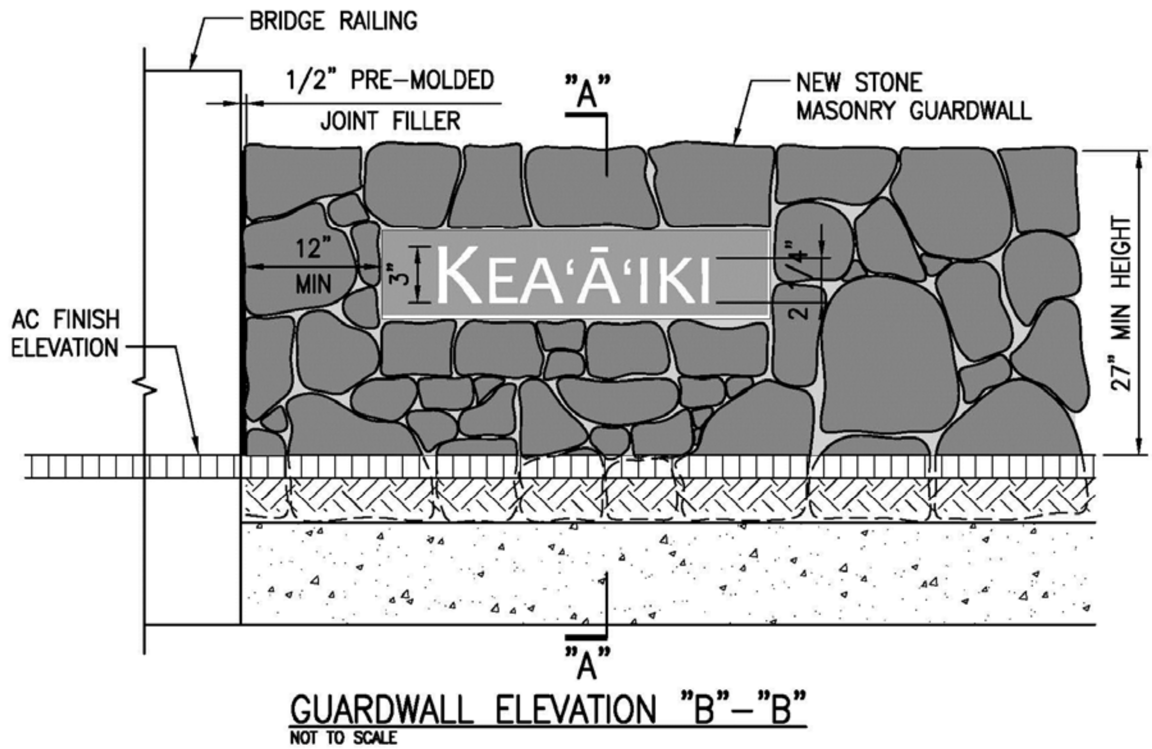

Figure 5 – 7: Guardwall elevation with size of inscribed letters
Courtesy of NOEI

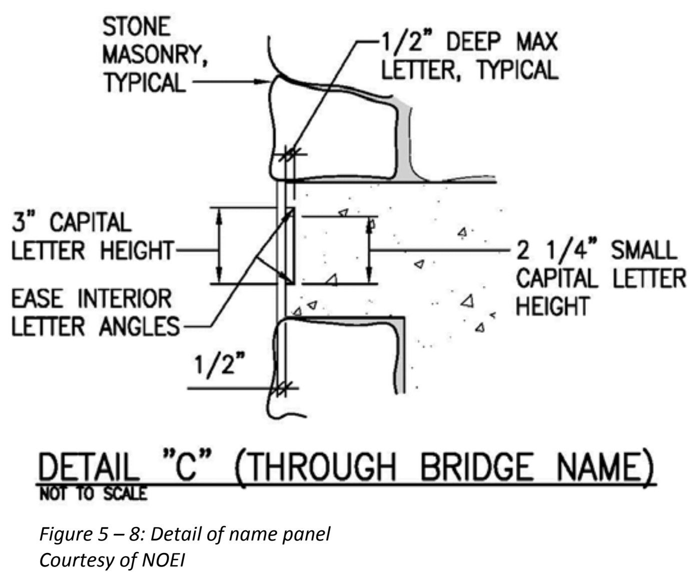

Figure 5 – 8: Detail of name panel
Courtesy of NOEI

Safety Features
Traffic safety features at the bridges are appraised based on "current national standards set by regulation, so that an evaluation of their adequacy can be made."[7] The safety features at the approaches to the bridge include approach guardrail ends, approach guardrail, and transitions.

Most of the safety features at bridges are missing. Bridges with a guardrail next to an approach wall do not have a transition. In these cases, the guardrails abruptly stop or have an obsolete, curled end treatment at the start of the approach wall. Currently, there are no approved methods for connecting the guardrail to the CRM approach walls. Also, most of the existing approach walls are not tall enough to accommodate the installation of a transition. However, some bridges have constructed a separate reinforced concrete approach wall to connect the transition for this purpose. Based on traffic accident reports between 2006 and 2010[8] for Hana Highway, Route 360, there have not been any accidents at the approaches due to the lack of safety features or a transition.

b. Railings

According to Hawaii DOT *Design Criteria*, "all traffic railings on bridges and highways structures shall conform to TL-2 – For design speed of 45 mph or less, or for posted speed of 35 mph or less."[9] There are five distinct types of bridge railings along the Hana Highway, Route 360. These include the following:

1. Concrete open vertical with Greek cross decorative panels,
2. Concrete open vertical without Greek cross decorative panels,
3. Concrete solid with cap,
4. Concrete solid without cap, and
5. Concrete open horizontal railing.

Refer to Section A, Chapter 3. iv. *Bridge Identification* for detailed descriptions, figures, and examples. All of the bridge railings along the Hana Highway, Route 360 in the historic district do not meet the TL-2 crash-test strength requirements. The TL-2 design allows for the containment and redirection of vehicles hitting bridge railings. Also, due to the addition of multiple asphalt cement (AC) pavement overlays on the bridge, some of the existing bridge railings do not meet the minimum required 27 inches height requirement. Removal of multiple layers of AC pavement overlays is addressed in Section B. *Bridges* of this report (noted in the "Recommendations" section for individual bridges as necessary).

A future state-implemented master plan for bicyclists exists, called *Bike Plan Hawaii*. AASHTO requires a minimum railing height of 42 inches for cyclists and pedestrians.[11] However, the recommendations in this report are limited to the bridges and do not include the entire Hana Belt Road Historic District (refer to Section A, Chapter 6. iii., b. *Alternative Transportation Concerns*). The Hana Highway, Route 360 is neither a pedestrian nor a cyclist route. Therefore, recommendations for increasing the height of the existing railings and parapets for pedestrians and bicyclists will not be considered for this project.

Railing/Parapet Design Criteria
Recommend that bridge railings/parapets meet the following criteria:

- Railings/Parapets replaced with crash-tested TL-2 railing/parapet or upgraded with a detached crash-tested guardrail in front of the existing historic railing/parapet.

[7] U.S. Department of Transportation, Federal Highway Administration, Bridge Inspector's Reference Manual, BIRM vol. 1-2, publication no. FHWA-NHI-12-049 (Moon Township: Michael Baker, Jr., Inc., 2002, 2006, 2012).
[8] Accident data, memo dated June 26, 2014, State of Hawaii, Department of Transportation, HWY-T (Honolulu: 2014).
[9] Design Criteria for Bridges and Structures, State of Hawaii, Department of Transportation, Highways Division (Honolulu: 2014).
[11] American Association of State Highway and Transportation Officials, *AASHTO LRFD Bridge Design Specifications*, 7th ed. (Washington, D.C.: American Association of State Highway and Transportation Officials, 2014).

- Crash-tested TL-2 railings/parapets shall be FHWA approved and accepted. Deviations from the FHWA accepted construction design of the railings/parapets must be approved prior to use.
- Railings/Parapets selected shall also be approved by SHPD.
- Appearance of the new railing/parapet, used to replace the existing railing/parapet, shall closely match the replaced railing/parapet in texture, color, and finish of a cleaned historic parapet.
- Existing bridge deck to which a new railing/parapet is attached, shall be analyzed for a continuous load path to accommodate the new crash-tested railing/parapet/guardrail (refer to *Figures 5 – 9* to *5 – 13*).

Railing/Parapet Type Recommendations

For the concrete open vertical type of railing, the following railings were considered:

- Texas C411 – *Recommended*
- Texas T411
- Texas F411
- Aesthetic Balustrade Bridge Railing

Figure 5 – 9: Example of the Texas C411 railing
Courtesy of guides.roadsafellc.com/

The different types of railings and parapets considered were narrowed down to one or two preferable options most compatible with the historic bridges in each category. The Texas C411 railing is recommended for the open vertical type railing (refer to *Figure 5 – 9*). Texas C411 is a 42 inches high reinforced concrete railing with an open design and is crash-test rated for TL-2. The height of the existing railing shall be considered from the top of the railing to the top of the bare deck slab, without the asphalt cement and fill if it is present.

For the concrete solid type of parapet, the following railings were considered:

- Vertical Concrete Wall, 32 inches and 42 inches high – *Recommended*
- Vertical Concrete Barrier Rail, 42 inches high – *Recommended*

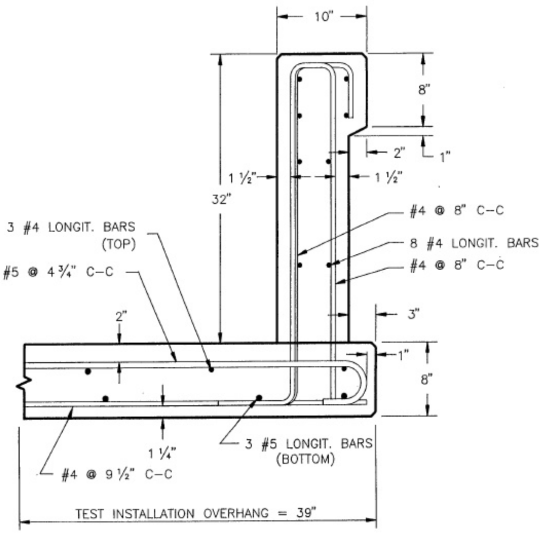

Figure 5 – 10: Example of the 32-inch high Vertical Concrete Wall
Courtesy of safety.fhwa.dot.gov/

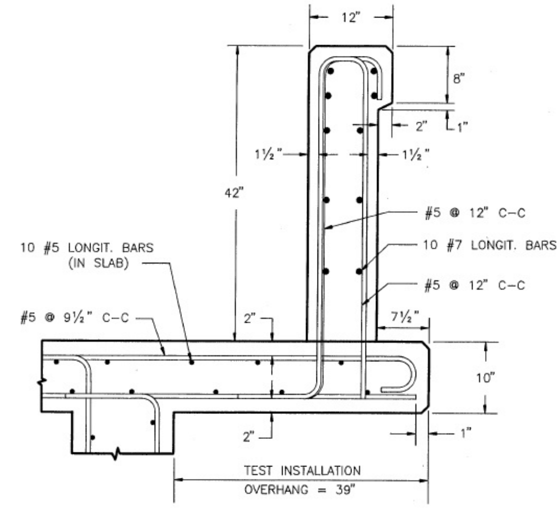

Figure 5 – 11: Example of the 42-inch high Vertical Concrete Wall
Courtesy of safety.fhwa.dot.gov/

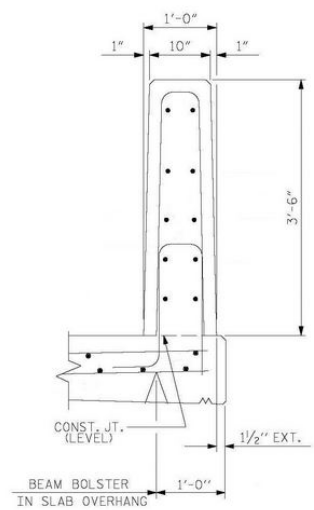

Figure 5 – 12: Example of the 42-inch high Vertical Concrete Barrier Rail
Courtesy of guides.roadsafellc.com/

The "Vertical Concrete Wall" is recommended to be used when the existing solid type of parapet with a cap is recommended to be replaced (refer to *Figure 5 – 10* and *Figure 5 – 11*). This parapet has an exterior appearance of a top cap and is crash-test rated for a TL-2. The top cap appearance closely resembles the existing solid parapets they would replace. Also, this type of parapet is most favorable when replacing a parapet with an exterior decorative panel.

The "Vertical Concrete Barrier Rail" will be recommended in conditions where a parapet without a cap is to be replaced (refer to *Figure 5 – 12*). This parapet is crash-test rated for a TL-4.

For crash-tested interior railings, the following railings were considered:

- Wyoming 740 Bridge Railing – *Recommended*
- Aluminum True Beam (or Tru-Beam Aluminum) Bridge Railing
- CA ST-10 Rail
- Delaware Thrie-Beam Retrofit Railing
- Foothills Parkway Aluminum Bridge Railing
- Michigan Railing 2 Tube
- Washington DC Tube Rail

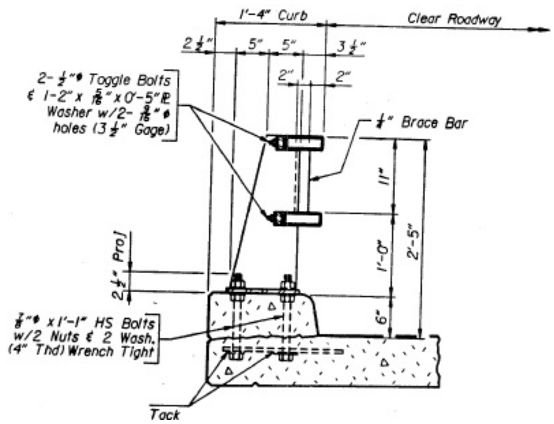

Figure 5 – 13: Example of Wyoming 740 Bridge Railing
Courtesy of guides.roadsafellc.com/

The recommended crash-tested interior rail is the Wyoming 740 bridge railing (refer to *Figure 5 – 13*). This railing would be constructed in front of an existing railing or parapet acting as the crash barrier. This railing consists of rectangular steel tubes, which provide the least obstructed view, and it is crash-test rated to meet TL-3 standards. This bridge railing is constructed with a concrete curb and will require corrosion protection through regular maintenance.

Refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options* for more information on these recommended railing options.

c. Deck & Superstructure

Most bridges along the Hana Highway, have multiple layers of AC overlay due to previous repaving projects that did not remove the previous layers of AC before applying new AC overlay on the bridge. During the months of October 2014, January 2015, and February 2015, the build-up of AC was removed from the deck surface of the following 11 bridges:

- #14 Palauhulu Stream Bridge
- #15 Waiokamilo Stream Bridge
- #16 Waikani Stream Bridge
- #17 West Wailuaiki Stream Bridge
- #18 East Wailuaiki Stream Bridge
- #19 Kopiliula Stream Bridge
- #20 Puaakaa Stream Bridge
- #21 Waiohue Stream Bridge
- #22 Unnamed Bridge No. 1 (Waiohuolua)
- #23 Unnamed Bridge No. 2
- #24 Unnamed Bridge No. 3

The majority of bridges on the Hana Highway, Route 360 have an 8 inch average concrete deck thickness. New crash-tested railings/parapets constructed along the sides of the bridge where the concrete deck is cantilevered from the exterior girders may require strengthening to provide a continuous load path.

Deck and Superstructure Design Criteria

It is recommended that the deck and superstructure meet the following criteria:

- Bridges will be widened to meet the minimum 16 feet curb-to-curb criteria (for a single-lane two-way traffic) or 24 feet curb-to-curb criteria (for a two lane two-way traffic), unless otherwise specified, including considerations for the external appearance of the bridge (i.e., retaining certain character-defining features).
- Deck and superstructure will be upgraded to support a live load capacity of 40-tons.
- Additional superstructure support will be required to accommodate the loading requirements of the new crash-tested railing. A new reinforced concrete beam can be added to provide the additional support (refer *to Figure 5 – 14*).
- Superstructure and substructure will be investigated to determine whether strengthening is necessary to support construction activities for the bridge.

  Considerations for adjacent properties, historic and cultural areas, and/or native endangered flora affected by widening of the bridge and temporary detour bridge construction will be addressed on a case-by-case basis.

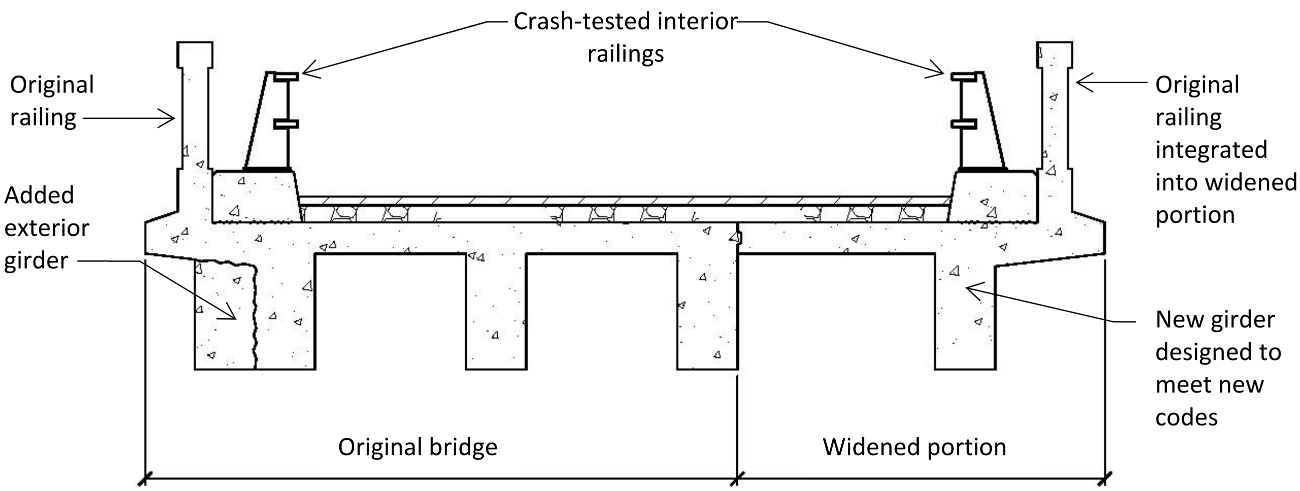

Figure 5 – 14: Section view through widened deck with new crash-tested railings and added exterior girder for strengthening
Courtesy of NOEI

Partial rehabilitation or replacement of a portion of the bridge which is structurally deficient and/or unable to support a 40-ton live load capacity

The deck and superstructure are required to be able to support a live load of 40-tons. Many of the bridges are deficient in their ability to carry this load and are posted with a load limit signs. In order for this criterion to be satisfied the following shall be considered:

1. Rehabilitation of the bridge shall include a life cycle cost analysis as well as initial cost of all improvements (refer to *Figure 5 – 15*).

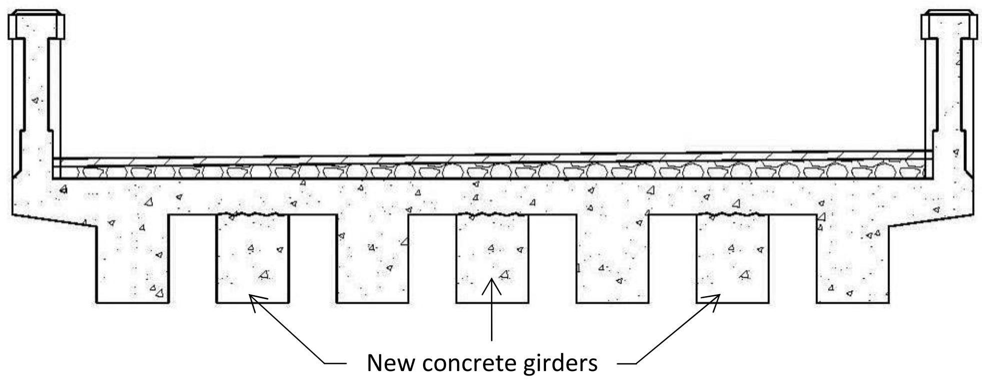

Figure 5 – 15: Section view through deck with new girders between existing girders, which were structurally deficient
Courtesy of NOEI

2. If rehabilitation is not feasible, then replacement of the bridge or bridge element(s) shall be considered, along with other improvements (refer to *Figure 5 – 16*). Bridge elements that are replaced shall be designed to meet current standards.

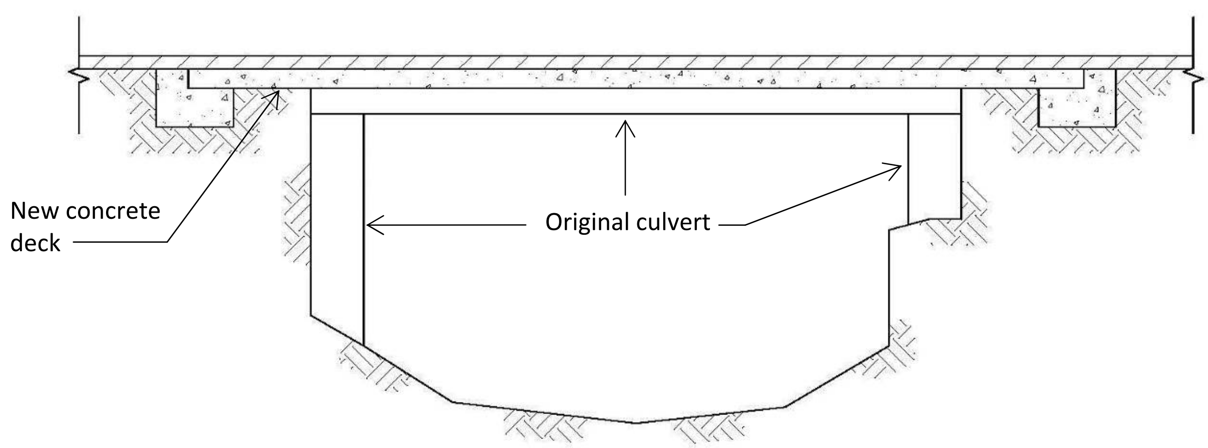

Figure 5 – 16: Section view through culvert with new deck placed above existing structure
Courtesy of NOEI

d. Substructure

According to record drawings, the substructures for the bridges consisted of concrete rubble masonry, rubble concrete, or cast-in-place reinforced concrete abutments and piers. Piers for the bridges vary between pier walls (refer to *Figure 5 – 17*), columns (refer to *Figure 5 – 18*), or a combination of both (refer to *Figure 5 – 19*).

Figure 5 – 17: Example of pier wall (#11 Honomanu)
Courtesy of NOEI

Figure 5 – 18: Example of pier columns (#9 Haipuaena)
Courtesy of NOEI

Figure 5 – 19: Example of combination pier wall and columns (#39 Ulaino)
Courtesy of NOEI

Substructure Design Criteria:

Recommend that the substructure meets the following criteria:

- Substructure shall support a 40-ton live load.
- Upgrade bridge, as required, to conform to seismic code (refer to following Section A, Chapter 5. iii**.** e. *Repair & Rehabilitation Considerations*, subsection "Seismic upgrade of bridge elements").
- Rehabilitation/replacement of elements with evidence of historic craftsmanship shall have their appearance maintained and restored upon completion of the rehabilitation/replacement (refer to *Figure 5 – 20*).

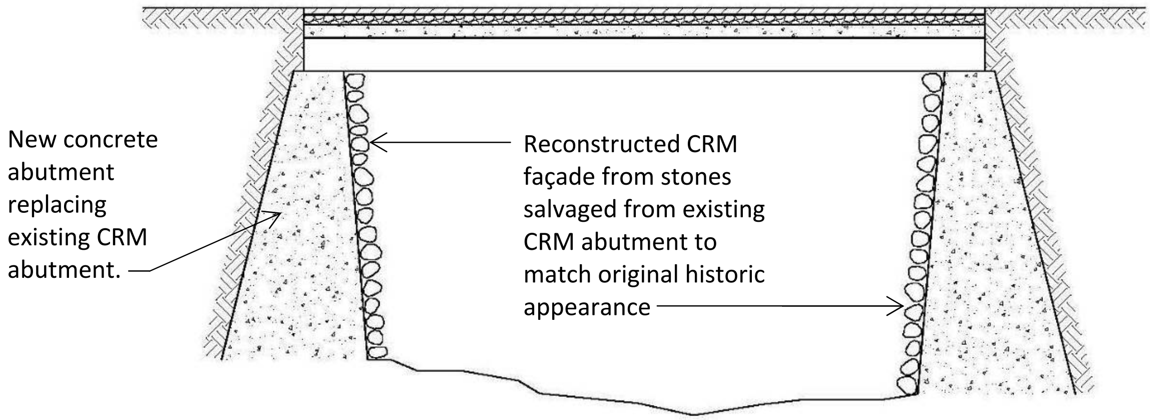

Figure 5 – 20: Section view through bridge with new concrete abutments and reconstructed façade
Courtesy of NOEI

e. Repair & Rehabilitation Considerations

Repairing a bridge element in deteriorated condition or structurally deficient

Rehabilitation or repair shall be considered before replacement, along with the life cycle cost and other improvements being performed on the bridge. Bridge repairs include, but are not limited to the following defects: wide cracks, spalls with/without exposed rebar (refer to *Figure 5 – 21*), delamination, and undermined foundations.

Figure 5 – 21: View of spall with exposed rebar at bottom of concrete girder (#33 Kahawaihapapa)
Courtesy of NOEI

Shotcrete may be used as a repair option only for existing cast concrete surfaces, but the surface finish shall be made smooth to match the existing structure.

Fiber Reinforced Polymer (FRP) strengthening of bridge elements

Per HDOT directive, FRP shall not be used as the primary strengthening method. During construction, it may be feasible and economical to use FRP to support adequately strong bridge elements for the additional loads they may encounter.

Seismic upgrade of bridge elements

CRM abutments and piers shall to be replaced with reinforced concrete construction unless it can be shown that the existing CRM substructure is stable under design vertical and seismic loads. CRM rock façade will be retained and incorporated into the new concrete abutment and pier design to meet historic restoration requirements (refer to *Figure 5 – 20*).

Bridges without record drawings or that are constructed of concrete will require further investigation to determine their structural adequacy. This includes, but is not limited to, reviewing record drawings of similar bridges, sampling and testing of existing materials, and scanning to determine reinforcing. Also, a geotechnical investigation will be required to determine design parameters and the integrity of the natural rock formations under the bridge foundations. Information from the investigation may include the following recommendations based on existing conditions:

- The type of material behind concrete abutments to determine if rock or soil anchors or thickening of the abutment may be considered to seismically upgrade the concrete abutments (refer to *Figures 5 – 22* and *5 – 23*).
- If the natural rock material under the current bridge abutments and/or piers is found to be insufficient to support the bridge with the new design criteria, then the inadequate material is to be removed and replaced with material recommended by the geotechnical engineer.
- If a void is encountered beneath the abutment and/or piers, then the void is to be filled with material recommended by the geotechnical engineer.

The natural rock formation shall be maintained and preserved during the investigation.

Chloride concentration analysis shall be performed on all retained concrete elements of the bridge. The integrity of the concrete may warrant that the bridge element be considered for cathodic protection (refer to following Section A, Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge* for more information) or replacement.

If the abutments and piers are found to be seismically inadequate per current standards, then they shall be rehabilitated or replaced. Replacement will be considered only if rehabilitation is found to be infeasible, uneconomical, or the improvements to the bridge would dictate the replacement of the bridge elements.

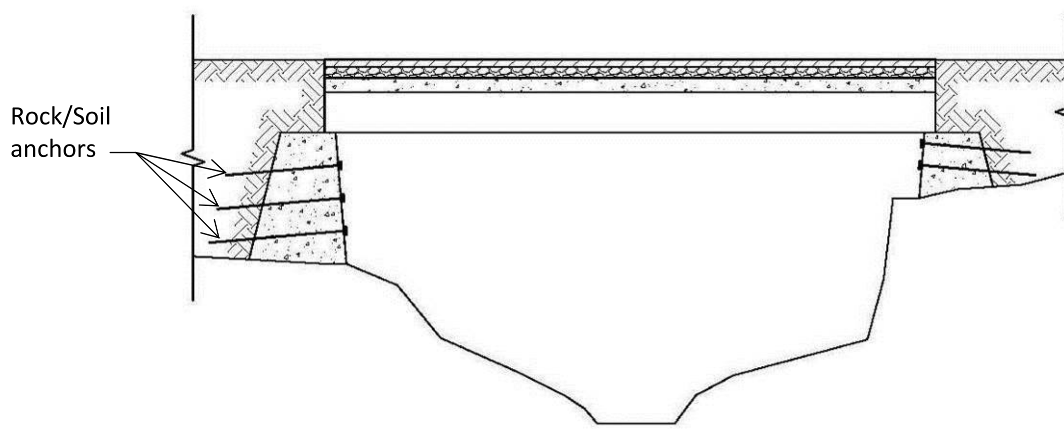

Figure 5 – 22: Section view through bridge with rock/soil anchors in the concrete abutments
Courtesy of NOEI

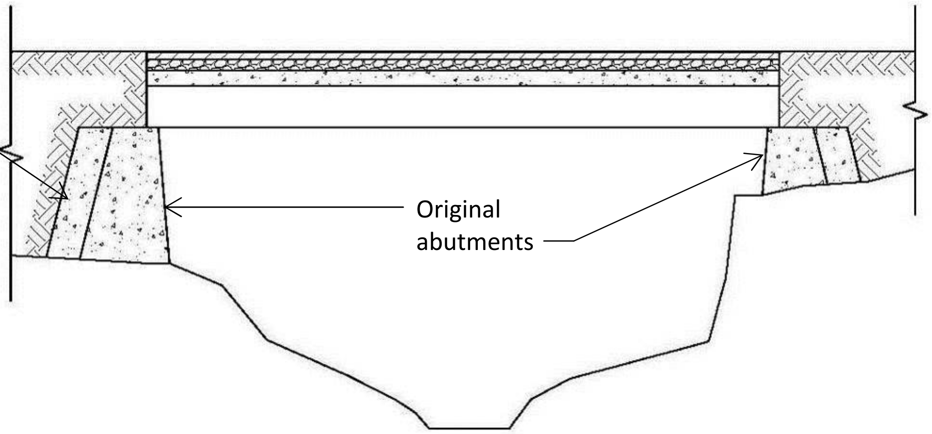

Figure 5 – 23: Section view through bridge with thickened concrete abutments
Courtesy of NOEI

Address scour critical bridges (3 bridges total as of January 2015)
Scour critical bridges are bridges "with a foundation element that has been determined to be unstable for the observed or evaluated scour condition."[12] Bridges included in this report, which are identified as scour critical, are #04 Oopuloa Stream Bridge, #08 Puohokamoa Stream Bridge, and #18 East Wailuaiki Stream Bridge. A Plan of Action (POA) has been created for these bridges and is on file with the HDOT.[13, 14, 15]

If at the time of design additional bridges are found to be scour critical and a POA report is available, which recommends countermeasure actions to be taken, then the future design team will approach the HDOT to determine if this can be added to the scope of work.

If there is no POA report and the bridge is scour critical, then the future design team will discuss with the DOT who will be responsible for preparing the POA report, which will require at a minimum:

- A hydraulic analysis to evaluate stream flow and scour potential
- Mitigative recommendations. If recommendations adversely affect the characteristic of the stream channel and may affect downstream communities (i.e., taro farms), then recommendations are to be adjusted to be compliant with this report. This may also require further discussions with HDOT, SHPD, and the local communities.

f. Activities to Prolong the Life of the Bridge

Additional activities that may prolong the life of the bridge may also be considered, as follows:

- Routine bridge inspections and repairs.
- Cathodic protection of the preserved historic bridge.

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[12] U.S. Department of Transportation, Federal Highway Administration, Bridge Inspector's Reference Manual, BIRM vol. 1-2, publication no. FHWA-NHI-12-049 (Moon Township: Michael Baker, Jr., Inc., 2002, 2006, 2012).
[13] State of Hawaii, Department of Transportation, "Scour Critical Bridge: Plan of Action (POA), Oopuloa Stream Bridge" (January 14, 2011).
[14] State of Hawaii, Department of Transportation "Scour Critical Bridge: Plan of Action (POA), Puohokamoa Stream Bridge" (January 14, 2011).
[15] State of Hawaii, Department of Transportation, "Scour Critical Bridge: Plan of Action (POA), East Wailuaiki Stream Bridge" (January 14, 2011).

    - Condition survey of the bridge shall be performed which includes, delamination/spall survey, reinforcing mapping and cover measurements, electrical (half-cell) potential, and chloride and carbonation testing. Chloride concentration analysis shall follow the most recent publication of AASHTO T-260 "Standard Method of Test for Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials."
    - The results of the condition survey shall be used as the basis for selecting a protection strategy to prolong the life of the bridge. If it is determined that cathodic protection is a viable rehabilitation option, then the bridge shall be assess for electrical continuity, concrete resistivity, and quality of concrete.
    - A cathodic protection consultant shall be retained by the future design team if this is pursued.
    - Rehabilitation and repairs to the bridge will need to coordinate activities with the installation of the cathodic protection.
    - Cost to implement cathodic protection may be comparable to total bridge replacement if the condition of the bridge is severe.
    - Along with the cathodic protection consultant, the future design team shall develop a maintenance program for the cathodic protection equipment.
- Future asphalt repaving work will remove the existing overlay before applying new overlay.
- Create a bridge washing program, which will include acquiring a National Pollutant Discharge Elimination System (NPDES) permit.[16]
- Implement a periodic maintenance program per FHWA and HDOT policy (refer to Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*).
- Use an organic, non-toxic weed killer instead of chemical herbicides when removing vegetation growing on bridges.

The recommendations presented are not limited to those listed within this chapter. New techniques to preserve and rehabilitate bridges may be developed in the future. In the case that future techniques are to be considered as an alternative, these techniques will require review from HDOT, SHPD, and possibly the communities prior to implementation.

g. Bridge Replacement if Necessary

Replacement of an historic bridge should be the last option, after repair and rehabilitation options have been explored and exhausted, and the bridge has been properly documented. If an historic bridge is determined to be beyond repair/rehabilitation and replacement is required, or in the event that an historic bridge structure is damaged and rendered unsafe and unusable due to an unforeseen natural disaster, the replacement bridge should be designed to meet current standards in a manner that is both context-appropriate and sensitive to the character of the historic district. Such an action requires consultation with the SHPD and local communities, in addition to review by and concurrence with HDOT (refer to Section A, Chapter 4. vi. *Bridge Replacement/New Structures*).

[16] Washington State DOT obtained an NPDES permit for the purpose of washing and pressure washing of bridges and ferry terminals.

iv. ROADWAY SIGNAGE

Signage along the Hana Highway, Route 360 plays a very important role in public safety because it provides warnings and guidance for drivers. There are many blind turns, narrow one-lane roads and bridges, and various safety hazards such as falling rocks or trees; many of these conditions constantly change depending on the season, weather, growth of vegetation, and other variables. Signage should be designed and maintained as set forth by the MUTCD and "Green Book" guidelines for safe roadway design. General community plans suggest a site-specific Hana Belt Road signage design that does not detract from the region's rural character (refer to Section A, Chapter 1. v. *County General Plans & Community Plans* for more information). While the majority of signage along Hana Highway, Route 360 appears to be in adequate condition, there are areas in which signs and striping need cleaning, repair, and/or replacement. There may also be a need for new signs and striping depending on individual conditions at each bridge. Please refer to Section B. *Bridges* and Section C. *Culverts* for individual signage and striping conditions at each bridge and culvert approach.

For additional information regarding Hawaiian bridge names and appropriate identifying signage, please refer to Section A, Chapter 6. viii. *Signage: Hawaiian Bridge Names*.

v. TRANSPORTATION MANAGEMENT PLAN SUMMARY

Hana Highway, Route 360 provides regional connectivity between Kahului and Kaupo and access to the following: Residences of Hana Town, agricultural land, Hana High School & Elementary School, Travaasa Hana Resort, and the Hana Airport. A draft of the TMP was prepared in accordance with AASHTO, FHWA, and HDOT guidelines, all of which provide recommendations to reduce and minimize traffic impacts resulting from proposed construction activities for the preservation and rehabilitation of bridges and culverts along Hana Highway. Refer to Section G, Appendix 2. *Transportation Management Plan – Hana Highway Bridge Preservation Plan* for detailed information.

a. Early Planning & Coordination

Plan and coordinate all construction activity, traffic management strategies and any lane closure operations at the earliest possible stage prior to start of construction with the following agencies, businesses and organizations:

- Hana residents,
- Hana businesses, churches, and government agencies,
- State Department of Education,
- Hana Airport,
- Maui Police/Fire Department, and
- Maui County Emergency Services.

b. Construction Constraints

Each bridge and culvert location has varying degrees of challenges and site-specific constraints that will affect construction activities and result in impacts to traffic. These construction constraints include, but are not limited to the following:

- Limitation of construction funds,
- Lack of feasible detour route,
- Narrow or confined bridge repair work areas,
- Right-of-Way Issues
    - Temporary bridge structures
    - Construction work area
    - Construction staging area
    - Proximity to private property,
- Height and weight restrictions ,
- Roadway alignment and sight distance issues, and
- Topography of embankments, hillside cliffs, and overgrown foliage.

c. Temporary Bridge Structures & Construction Staging Area

Alternative routing scenarios are a key component of any project that takes place or addresses a temporary natural disaster along the narrow, occasionally one-lane Hana Highway thoroughfare. Alternative routes are also a main concern for Hana residents, many of whom traverse Hana Highway on their daily commute to work into the greater Kahului/Wailuku region. The intent of recommendations made within the *Hana Highway Bridge Preservation Plan (2015)* is to minimize the amount of disruption to daily and visitor traffic. Thus, temporary bypass bridges have been recommended for the majority of bridge rehabilitation scenarios in a manner that will allow repairs to take place on the historic bridge *in situ*, while traffic flow may continue slower but relatively unimpeded adjacent to the historic bridge.

Specific routing options have not been developed as part of the *Hana Highway Bridge Preservation Plan* (2015), because the study is limited in scope to address preservation and rehabilitation issues pertaining to Hana Highway's historic bridges. However, the information contained in this report is intended to help inform future projects by providing bridge-specific data and community input about important cultural sites that may affect HDOT's project planning for alternative routing scenarios at selected bridges. As such, conceptual detour locations are shown with temporary bypass bridges for each of the 43 historic bridges in Section B and 12 culverts in Section C. It is recommended that bridge-specific approach locations to the temporary bridges be re-evaluated and confirmed at the time of future project development.

During the design phase, the engineer, contractor, and supplier of temporary bridge structure should work together to determine the most feasible and best method to provide for temporary bridges and construction staging areas, as needed, at specified bridge and culvert locations. It is necessary to consider constraints related to the following, which shall not be limited to:

- Construction constraints listed above,
- Lane Closures (partial single-lane closure vs. full two-way lane closure), and
- Duration and time-of-day for lane closure implementation.

d. Lane Closures

While it is preferred that at least a single lane of travel remain open along Hana Highway during construction, it is possible that full two-way lane closures will be required. It is recommended that if possible, full two-way lane closures be limited to the hours between 9:00 PM and 5:00 AM, when traffic volumes are minimal.

Partial Single-Lane Closure

- Advanced warning signs should caution drivers of impending construction work and/or delays related to single-lane closures.
- Police officers or flaggers should be stationed on either end of the work area to coordinate the start and stop of traffic through the single through-lane and facilitate safe and continuous travel for emergency vehicles during construction. Traffic control should place police officers at safe locations along the road, due to limited visibility and sight distance issues.
- Appropriate speed limits and delineation should be provided along the roadway to negotiate travel through construction area.
- Proper lighting should be provided for travel through the construction area.
- Single-lane closures at each bridge location along Hana Highway should be allowed during any hour of the day.
- The public needs to be notified well in advance of any road closures.

Full Two-Way Lane Closure

- Full two-way lane closures should be avoided if at all possible.
- With no feasible detour routes available for vehicles traveling between the project's study limits, both local and regional travelers may experience lengthy detour routes in excess of 3 hours greater than their normal route.
- If it is determined that full two-way road closures are unavoidable, each full two-way road closure will be reviewed in accordance to HDOT's standards that may require supplemental information, analyses, and evaluations specific to each full two-way road closure. Final approval on any full two-way road closure would need to be vetted to the HDOT Traffic Branch and obtain final approval by the HDOT Director or its designated representative.

- In order to minimize impacts of full two-way road closures, the following strategy should be employed, where feasible:
  - Full two-way road closures should be administered on an interval-basis to avoid delaying a vehicle longer than 30 minutes.
  - Full two-way road closures should be restricted to nighttime hours between 9:00 PM to 5:00 AM.
  - If full two-way road closures are necessary outside of the hours specified above, the closures should be implemented when public schools are not in session, to minimize impacts to students, parents, and teachers.
  - Any full two-way road closure at a specific bridge location should be coordinated and scheduled concurrently with other nearby bridge locations to reduce the overall impact of implemented full two-way road closure, provided that the road closure maintains a detour route for any residence or neighborhood and does not confine them between two full two-way road closures.
  - Any full two-way road closure should be coordinated and scheduled with other HDOT or County of Maui projects to determine the best strategy to employ full two-way roadway closures.
  - Special provisions should be made prior to any full two-way road closures to provide for emergency services or major government agencies.
  - The public needs to be notified well in advance of any road closures.

vi. TORT LIABILITY ISSUES

It should be noted that the information in this report is not to be construed as legal analysis or a legal opinion.

The State generally has a duty to provide safe transportation facilities for public use. If individuals are injured or killed due to an accident caused by an unsafe transportation facility, then tort liability may attach to the repair, rehabilitation, or replacement of the transportation facility. Monetary damages may be assessed to those who have failed to safely construct and maintain the transportation facility. The court awards in the State of Hawaii against the State for alleged highway design defects are reported to be in the millions of dollars. The size of the court awards indicates that the possibility of even a single accident resulting in a fatality or serious injury over the life of a replacement or rehabilitated bridge should be a significant consideration in highway design.

Complying with design standards can help reduce the risk of tort liability. Design standards change over time. In the event of a tortious liability dispute, keeping up with contemporaneous standards will help prove that the transportation facility was constructed and maintained in a safe manner. Although it is not mandatory that a transportation facility be updated with each design standard change, it is incumbent upon the entity conducting the upgrade to comply with the design standards that are in effect at the time of the upgrade. To the extent that preservation of historic bridges is one of the goals of the State, the State should take into account the safety considerations with the preservation considerations in its decision making.

CHAPTER 6

RELATED ISSUES ALONG THE HANA HIGHWAY

i. GENERAL

The Hana Highway, Route 360 presents a variety of challenges for the HDOT, residents, and visitors alike. While the *Hana Highway Bridge Preservation Plan* (2015) aims to create preservation and safety-guided strategies for bridges along the Hana Highway in as comprehensive a manner as possible, it should be noted that there are several factors that were brought up during the course of developing this preservation plan and which the team took into consideration while making recommendations. However, some of these factors may not have been directly addressed within this preservation plan, due to project scope limitations. The following sections in this chapter provide a brief overview of additional issues, available programs in place that reflect these related concerns, and general recommendations regarding possible future exploration and implementation.

ii. PROGRAMMATIC AGREEMENT

The *Hana Highway Bridge Preservation Plan* (2015) may be used as a foundational document in the development of a Programmatic Agreement between managing state and federal agencies for projects related to the 43 state-owned bridges identified within this plan. Development of the *Hana Highway Bridge Preservation Plan* (2015) included consultation between HDOT, FHWA, and SHPD throughout the course of the project. All parties involved have provided review and comment on all aspects of the preservation plan, including individual assessments for each structure as detailed in Section B. *Bridges* and Section C. *Culverts*, and through ongoing consultation, these parties have been integral in helping to shape and refine team recommendations that address preferred preservation and safety solutions for each structure.

Concurrence with this plan may form the basis of the PA, which will streamline the consultation process in the future. The PA would likely identify all projects that would have no effect on the historic character of the bridges and thus, no further consultation would be necessary. It could further note that, provided future projects follow recommendations in the *Hana Highway Bridge Preservation Plan* (2015), no further consultation will be necessary.

The PA may also specify, but is not limited to, the following conditions:

- Additional research and verification of Hawaiian place names to be applied at each bridge or culvert, with a process to address the issue of Hawaiian name discrepancies,
- Identification of possible staging areas, based on archaeological information provided and cultural sites identified within this report,
- A vegetative management plan, since roadside edging and adjacent boundary environments may also be affected during future construction projects,
- A "lessons learned" review period at 10 years, after which existing stipulations in the PA may be re-evaluated based on identified metrics of success for completed projects, and
- A process to address variations from the *Hana Highway Bridge Preservation Plan* (2015).

iii. SAFETY & TRANSPORTATION CONCERNS

The charm of the Hana Highway, Route 360 along the Hana coast lies in its rural, winding road, and rustic characteristic with scenic views. The Hana Belt Road was built using late 19th and early 20th century construction methods, and builders were limited by accessibility of the unique geographical features of the Hana coastline. Currently, this results in a number of present-day road hazards that include continuously winding roads over steep grade changes, blind turns for drivers traveling in either direction, limited or no shoulder areas on narrow roads adjacent to steep cliffs, and weather and moisture conditions that often lead to flooding and landslides along the only road from East Maui to Central Maui. These factors exacerbate driving conditions along the many narrow bridges and culverts along the Road to Hana. Since the time of original construction of the Hana Belt Road, the daily volume of modern vehicular traffic has significantly increased. Consequently, HDOT has identified safety as a primary concern for users traveling along this route. After receiving a great deal of community feedback on this issue, the following items are suggested for consideration.

a. Driving Etiquette Literature

Visitors to the area are often unfamiliar with the environmental hazards, and often present unintentional hazards themselves by impeding the flow of regular traffic. With an ever-increasing number of annual visitors on the Road to Hana, tourist driving etiquette is cited as one of the most common issues faced by East Maui residents. A brochure or literature detailing visitor etiquette may include the following tips intended to improve the Road to Hana experience for everyone:

- Avoid walking and/or standing on bridges, which affects vehicular traffic flow and endangers pedestrians,
- Extra care should be taken when negotiating the curves and narrow one lane bridges,
- Pay attention to yield signs along the one-lane bridges and take turns appropriately,
- Be aware of other cars around you; pull over and let residents pass where appropriate,
- No matter how scenic the view is, do not park at shoulder locations with limited space and areas with “No Parking” signs,
- Do not trespass on private property, which is often immediately adjacent to many of the bridges, and
- Share the road with bicyclists.

It is recommended that HDOT collaborate with rental car companies, airlines, travel experience companies, and the Hawaii Tourism Authority to develop and provide travel literature educating visitors on driving etiquette along the Hana Highway. It may also prove helpful to note where available parking and pull-outs are located near selected bridges that have proven to be popular photographic opportunities and experience a greater degree of congestion; providing this crucial information for visitors will likely minimize vehicular congestion immediately at/on these narrow bridges and encourages individual safety and awareness.

It is possible that funding for this endeavor may be obtained from the following organizations, though additional funding sources for outreach and development should also be explored, coordinated, and confirmed at the time that such a project is initiated.

- Hawaii State Department of Transportation
- Hawaii Tourism Authority
- Hawaii Scenic Byways
- Maui Certified Local Government (CLG) Office

b. Alternative Transportation Concerns

In addition to daily commuters and travel tour buses, non-vehicular users along Hana Highway, Route 360 include bicyclists and pedestrians. Cycling enthusiasts regularly traverse the route, and local travel companies provide bike adventure tours along the Road to Hana. Pedestrians are sometimes seen hitchhiking along the road, along which there are intervals with no shoulder, and are also often stopped at bridges.

Additionally, some of the bridges are used as popular recreation stops where a small group of people gather and sometimes hinder driving. While this behavior should not necessarily be discouraged, traffic concerns on these bridges must be acutely considered.

Signs are located at a few of the bridges indicating that it is inappropriate to stop or stand on the bridges for personal safety reasons. Due to sharp changes in terrain and elevation, sight distance visibility is often hindered, which can make it challenging to accommodate non-vehicular users on the road.

Bike Plan Hawaii, a master plan prepared for the State of Hawaii, provides strategies for accommodating and integrating bicyclists on the roads in order to help develop and encourage livable communities. The plan promotes the creation of a statewide bicycle network. As noted in Section A, Chapter 5. iii. b. *Railings*, AASHTO requirements state a minimum height of 42 inches should be provided for cyclists; this required height dimension would impact the existing historic bridge railings and exceed the current applicable minimum height requirement of 27 inches for TL-2 crash-tested railings. However, it is noted that the Hana Highway, Route 360 is not a cyclist route, nor is it a pedestrian route; thus, recommendations in the *Hana Highway Bridge Preservation Plan* (2015) are made with the project scope in mind and consider safety standards to address vehicular traffic along the Hana Highway. The terrain and road right-of-way constraints along this route present many challenges not conducive to typical urban traffic engineering. However, bicyclists follow the same rules as drivers and “Share the Road” signage and low speed limits, especially at narrow bridges, should be incorporated in the overall road plan.

While these strategies may encourage individual awareness of dangers on the road and an element of risk they may encounter as they travel, it is also important to note that it is incumbent upon all users journeying along the Road to Hana to look out for one another, and to be aware of their surroundings and others at all times. In creating the previously-mentioned brochure, it may be helpful to include a note detailing this element of road safety concerns.

c. Comprehensive Transportation Plan for East Maui

A closer look at how different facets of the transportation system can work comprehensively may be helpful, since a separate bicycle route, air transport, emergency vehicle needs, and a ferry system (not currently extant) may be better utilized to handle increased loads and to address transportation needs. The community expressed concerns regarding these alternatives during the development of the *Hana Highway Bridge Preservation Plan* (2015) (refer to Section G, Appendix 7. *1st Cycle of Community Meetings – Project Initiation Stage (May to August 2014)*, Appendix 8. *2nd Cycle of Community Meetings – Preliminary Plan Stage (February to March 2015)*, and Appendix 9. *3rd Cycle of Community Meetings – Final Plan Stage (July to August 2015)* for further information). Community members also expressed a desire to incorporate a separate bicycle route if possible to accommodate and encourage the safety of all Hana Highway, Route 360 users. Ideas such as signage to inform drivers where upcoming turnouts are located, toll charges, and weigh stations were discussed and noted in Section G, Appendices 7., 8., and 9. Some of these solutions may require legislative efforts and a system of enforcement. If concerns for these alternatives can be addressed properly, alternative transportation options can help maintain longevity of the historic bridges and highway. For additional discussion, refer to Section A, Chapter 1. v. c. *Hana Community Plan* (1994).

iv. ROCKFALL MITIGATION PLAN

East Maui's weather and moisture conditions lead to landslides and treacherous road conditions at times throughout the year. The HDOT's rockfall mitigation program, managed by the HDOT Materials Testing and Research Branch, addresses these conditions through various state-funded and federally-funded projects, which includes the removal of unstable and protruding rocks above the roadway, installing restraining mesh and anchors, and slope cutting and re-vegetation of the adjacent hillside slopes. The intent of the HDOT's capital improvement projects is to increase safety for all users and to improve transportation infrastructure within the state.[1]

Although the team acknowledges the importance of this concern, voiced throughout the community, and its impact on HDOT's highway maintenance program, the scope of the *Hana Highway Bridge Preservation Plan* (2015) is limited to providing recommendations for the rehabilitation of historic bridges along the highway. Maui HDOT's rockfall mitigation plan, which is publicly available and accessible, may address many of the community's concerns.

[1] Wendy Osher, "$500,000 Released for Hana Highway Rockfall Mitigation," *Maui News*, May 5, 2014. http://mauinow.com/2014/05/05/500000-released-for-hana-highway-rockfall-mitigation/ (accessed August 15, 2014).

v. ALTERNATIVE FUNDING OPTIONS

a. MAP-21

P.L. 112-141, the Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law on July 6, 2012. This surface transportation authorization bill is the first of its kind to span multiple years since 2005. The bill governs the funding and authorization for federal surface transportation expenditure within the United States of America.[2]

> *MAP-21 is a milestone for the U.S. economy and the Nation's surface transportation program. By transforming the policy and programmatic framework for investments to guide the system's growth and development, MAP-21 creates a streamlined and performance-based surface transportation program and builds on many of the highway, transit, bike, and pedestrian programs and policies established in 1991.*[3]

MAP-21 expands on established policies and addresses previous challenges to better the infrastructure of the U.S. transportation system.[4]

> *MAP-21 creates a streamlined, performance-based, and multimodal program to address the many challenges facing the U.S. transportation system. These challenges include improving safety, maintaining infrastructure condition, reducing traffic congestion, improving efficiency of the system and freight movement, protecting the environment, and reducing delays in project delivery.*
>
> *MAP-21 builds on and refines many of the highway, transit, bike, and pedestrian programs and policies established in 1991. This summary reviews the policies and programs administered by the Federal Highway Administration. The Department will continue to make progress on transportation options, which it has focused on in the past three years, working closely with stakeholders to ensure that local communities are able to build multimodal, sustainable projects ranging from passenger rail and transit to bicycle and pedestrian paths.*[5]

Several programs established in the past such as the Highway Bridge Replacement and Rehabilitation Program under the Surface Transportation Act of 1978 and the Transportation Enhancement Program under the Intermodal Surface Transportation Efficiency Act (ISTEA), which previously addressed federal funding of transportation projects, have been reestablished within programs under MAP-21. A range of highway and transportation authorizations and programs fall under MAP-21. The five core programs within MAP-21 "provide[s] the majority of Federal-aid highway funds to the states."[6]

Among the many resource programs available under the umbrella of MAP-21, the most pertinent programs related to federal funding for the Hana Belt Road Historic District are:

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[2] Transportation.gov, "Moving Ahead for Progress in the 21st Century Act (MAP-21)," U.S. Department of Transportation, http://www.dot.gov/map21 (accessed June 2014).

[3] U.S. Department of Transportation, Federal Highway Administration, "MAP-21 – Moving Ahead for Progress in the 21st Century," Federal Highway Administration, http://www.fhwa.dot.gov/map21/ (accessed June 2014).

[4] U.S. Department of Transportation, Federal Highway Administration, "Moving Ahead for Progress in the 21st Century Act (MAP-21): A Summary of Highway Provisions," Federal Highway Administration, http://www.fhwa.dot.gov/map21/summaryinfo.cfm (accessed June 2014).

[5] Ibid.

[6] "Summary of Moving Ahead for Progress in the 21st Century (MAP-21)," U.S. Senate Committee on Environment & Public Works, U.S. Senate, http://www.epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=6d1e2690-6bc7-4e13-9169-0e7bc2ca0098 (accessed June 2014).

- ***National Highway Performance Program*** *(Core) – This section consolidates existing programs (the Interstate Maintenance, National Highway System, and Highway Bridge programs) to create a single new program, which will provide increased flexibility, while guiding state and local investments to maintain and improve the conditions and performance of the National Highway System. This program will eliminate the barriers between existing programs that limit states' flexibility to address the most vital needs for highways and bridges and holds states accountable for improving outcomes and using tax dollars efficiently.* Note: Hana Highway, Route 360 is not included in the National Highway System.
- ***Transportation Mobility Program*** *(Core) – This program replaces the current Surface Transportation Program, but retains the same structure, goals and flexibility to allow states and metropolitan areas to invest in the projects that fit their unique needs and priorities. It also gives a broad eligibility of surface transportation projects that can be constructed. Activities that previously received dedicated funding in the Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users, but are being consolidated under MAP-21, will be retained as eligible activities under the Transportation Mobility Program.*
- ***Highway Safety Improvement Program*** *(Core) – MAP-21 builds on the successful Highway Safety Improvement Program. MAP-21 substantially increases the amount of funding for this program because of the strong results it has achieved in reducing fatalities. Under the Highway Safety Improvement Program, states must develop and implement a safety plan that identifies highway safety programs and a strategy to address them.*
- ***Transportation Infrastructure Finance and Innovation Program (TIFIA)*** *– The TIFIA program provides direct loans, loan guarantees, and lines of credit to surface transportation projects at favorable terms. TIFIA will leverage private and other non-federal investment in transportation improvements. Included in the "America Fast Forward" title of MAP-21 will be provisions that build upon the success of the TIFIA program. MAP-21 modifies the TIFIA program by increasing funding for the program to $1 billion per year, by increasing the maximum share of project costs from 33 percent to 49 percent, by allowing TIFIA to be used to support a related set of projects, and by setting aside funding for projects in rural areas at more favorable terms.*
- ***Projects of National and Regional Significance Program*** *– This bill authorizes a program to fund major projects of national and regional significance which meet rigorous criteria and eligibility requirements. This program authorizes for appropriation $1 billion in Fiscal Year 2013.*
- ***Federal Lands and Tribal Transportation Highways Programs*** *– MAP-21 consolidates the existing program structure by creating a new Federal lands and tribal transportation program. The bill maintains funding for maintenance and construction of roads and bridges that are vital to the federal lands of this country.*
- ***Administrative Expenses*** *– Funds the general administrative operations of the Federal Highway Administration.*
- ***Emergency Relief*** *– Provides funds to states to repair highways and bridges damaged by natural disasters.*

- ***Highway Bridge and Tunnel Inventory and Inspection Standards*** *– Improves the existing highway bridge inspection program and authorizes a national tunnel inspection program to ensure the safety of our nation's bridges and tunnels.*[7]

[7] "Summary of Moving Ahead for Progress in the 21st Century (MAP-21)," U.S. Senate Committee on Environment & Public Works, U.S. Senate, http://www.epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=6d1e2690-6bc7-4e13-9169-0e7bc2ca0098 (accessed June 2014).

vi. NATIONAL SCENIC BYWAYS PROGRAM

The National Scenic Byways Program, established in 1991 under the directive of the Intermodal Surface Transportation Efficiency Act, encourages the development of scenic byways throughout the state, in recognition of the importance of their archaeological, cultural, historical, natural, recreational and/or scenic qualities. The Hawaii Scenic Byways program began in 2008 and currently includes byways on the islands of Kauai, Hawaii, and Oahu. There are currently 150 byways in 46 different states.[8]

The Road to Hana is already a popular tourist destination and an economic foundation to the rural East Maui community, many of whom also worry that the long-term impacts these visits hold may be currently underestimated regarding the longevity of the community. The Scenic Byways Program "[is] intended to create unique travel experiences and enhance local quality of life through preserving, protecting, interpreting, and promoting the intrinsic qualities of designated byways," and also promote economic vitality for livable communities through recognizing and analyzing important economic impact benchmarks.[9]

Although it was not undertaken through the scope of the *Hana Highway Bridge Preservation Plan* (2015) at this time, it is strongly recommended that the State and local community consider sponsoring the recognition of the Hana Belt Road Historic District in its Hawaii Scenic Byways program. The *Maui Island Plan* likewise recommended establishing a Scenic Roadway Corridor Overlay District to help ensure a greater level of protection for the unique resources that comprise Maui's scenic landscape, particularly along the Hana Highway, Route 360 (refer to Section A, Chapter 1. v. b. *Maui Island Plan – General Plan 2030*, *"Scenic Resources"*). Hawaii Scenic Byways may also be an important source of information and may be able to provide additional funding for applicable projects.[10]

[8] Gary Jensen, "America's Byways Pay Off in Authentic Experiences, But How About Dollars?" Federal Highway Administration, U.S. Department of Transportation, http://www.fhwa.dot.gov/publications/publicroads/13janfeb/05.cfm (accessed August 2014).
[9] Ibid.
[10] ScenicByways.org, "Hawaii Scenic Byways: Program Introduction 2013," State of Hawaii Department of Transportation, http://scenicbyways.ehclients.com/files/Program_Information_2013.pdf (accessed August 2014).

vii. HAWAII STATEWIDE HIGHWAY SYSTEM SUSTAINABLE LANDSCAPE MASTER PLAN (2014)

The *Hawaii Statewide Highway System Sustainable Landscape Master Plan* (2014) was prepared by consultants, Jones & Jones Architects + Landscape Architects and KI Concepts, LLC, "to help meet… challenges by addressing the environmental, social, and economic pressures confronting the state's highway system."[11]

Hawaii's highways, viewed as "historic linkages," are resources that provide community identity, economic vitality, and accommodate ever-changing social dynamics. The tenets described in this document are based on a deeply comprehensive view of sustainability and how it is supported not only in terms of environmental renewal but also the renewal of community cultural practices and traditions. It provides a framework for identifying the challenges faced by Hawaii's state highway system and provides recommendations for effectively managing the diverse landscape settings in a sustainable manner. The guiding principles of the sustainable landscape plan are:

- *No ke ola pono i ke Kaiaulu* (For the good health of the community)
- *Malama Pono i ka Aina* (To righteously care for the land)
- *Na Mea Maamau a Mau* (Perpetuation of culture and traditions)
- *He Kuleana ko Kakou* (We have a shared responsibility)
- *Pehea La, ua pono anei* (Is it right or excellent?)

As preservation and sustainability are intricately and inherently linked, the *Hana Highway Bridge Preservation Plan* (2015) is closely tied to and shares goals with the *Hawaii Statewide Highway System Sustainable Landscape Master Plan* (2014), for the area that encompasses East Maui. Preserving the unique transportation infrastructure of the Hana Belt Road Historic District and maintaining its integrity, while performing upgrades to address modern day safety standards, provides a link to the nation's collective past, while ensuring that the regional values and way of life in East Maui will be respected, maintained, and supported for generations to come. The *Hawaii Statewide Highway System Sustainable Landscape Master Plan* (2014) is a valuable resource that should be used in future conjunction with the *Hana Highway Bridge Preservation Plan* (2015).

[11] Charles Scott, Brad Kurokawa, Jones & Jones Architects + Landscape Architects, and KI Concepts, LLC, *Hawaii Statewide Highway System Sustainable Landscape Master Plan* (2014), 3.

viii. SIGNAGE: HAWAIIAN BRIDGE NAMES

General community plans suggest a site-specific Hana Belt Road signage design that does not detract from the region's rural character (refer to Section A, Chapter 1. v. *County General Plans & Community Plans* for more information).

During the course of several rounds of community outreach and discussion in preparing the *Hana Highway Bridge Preservation Plan* (2015), it was evident to the project team that identifying the correct Hawaiian place names for bridges and streams was an important concern to many stakeholders, including local community members, residents, and organizations associated with Hana. Many people requested that signage identifying the traditional Hawaiian names be placed at each bridge.

The project team identified the following concerns regarding the possibility of adding Hawaiian name signage for bridges along the Road to Hana:

- Proper identification of traditional place names,
- Use of diacritical markings and Hawaiian punctuation, and
- Application of proposed signage (refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approache*s, *"Concrete Bridge Name Panel"*).

a. Identification of Traditional Place Names

Research and identification of Hawaiian names were primarily conducted through discussion with local residents and long-time community members familiar with the Hana area and stream names, including Ms. Melody Cosma and Ms. Kaui Kanakaole, a Hawaiian language specialist, and through use of the following printed or digital resources:

- Pukui, Mary Kawena, Samuel H. Elbert, and Esther. T. Mookini. *Place Names of Hawaii*. Honolulu: University of Hawaii Press, 1974, 1976 editions.
- Pukui, Mary Kawena, and Samuel H. Elbert. *Hawaiian Dictionary; Hawaiian-English, English-Hawaiian*. Honolulu: University of Hawaii Press, 1971, 1986 editions.
- Hawaii Heritage Center. *Historic Bridge Inventory and Evaluation: Islands of Maui and Molokai*. Prepared for the State of Hawaii Department of Transportation Highways Division in cooperation with the U.S. Department of Transportation Federal Highway Administration. Honolulu: September 1990.
- Ahupuaa maps, USGS maps, and geographical data.

It should be noted that State Bill SB895, introduced during the 2015 legislative session, but which failed to pass at this time, cited the following references for appropriate identification and spelling of Hawaiian names:

- Pukui, Mary Kawena, Samuel H. Elbert, and Esther. T. Mookini. *Place Names of Hawaii*. Honolulu: University of Hawaii Press, 1974 edition.
- Pukui, Mary Kawena, and Samuel H. Elbert. *Hawaiian Dictionary; Hawaiian-English, English-Hawaiian*. Honolulu: University of Hawaii Press, 1986 edition.
- Huaolelo, Komike. *Mamaka Kaiao: A Modern Hawaiian Vocabulary*. Honolulu: University of Hawaii Press, 2003.

Despite intensive background research and community outreach through as many avenues as known and available to the team, definitive identification of Hawaiian names at each bridge is not included in the scope of this preservation plan and these names should be confirmed by project teams prior to future work. (Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further information.)

b. Use of Hawaiian Punctuation for Bridge Names

The project team requested feedback from community members regarding whether Hawaiian punctuation and diacritical markings should be included or omitted from bridge names. No conclusion was reached on the matter during the course of discussion and community outreach; however, options are listed in Section G, Appendix 10. *Hawaiian Place Names Research.*

c. Application of Proposed Signage

Although local community members were generally in favor of including signage and identification at bridge and culvert locations, additional concerns were expressed by the community regarding the signage format and permanence, due to vandalism and past experiences where tourists removed existing signage to obtain travel souvenirs.

Existing Signage & Identification
A recent widening and improvement project at Culvert #9, located near the County of Maui baseyard in Hana, provides an example of a simple, inscribed name and date plaque inset within the concrete parapet. The Hawaiian place name associated with this culvert and the date of original construction are both inscribed in the exterior face of the original upstream parapet; as such, the name plaque is not immediately visible from the road.[12]

In general, if there is already existing signage at bridges, it is recommended that the signage be maintained.

Future Signage & Identification
For future projects, it is suggested that a concrete name plaque with inscription be used as an inset on approach walls to identify the historic bridges and culverts where possible, and once the name and use (or omission) of Hawaiian punctuation can be confirmed with the community and Hawaiian language scholars. Name plaques should face the highway side so that the information is readily visible to those on the road, and it is recommended that the edges be rounded or eased, with a maximum ½" incision from the parapet face to avoid the possibility of a "snag" hazard to drivers.

Figures 5 – 6, 5 – 7, and 5 – 8 shown in Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approache*s, *"Concrete Bridge Name Panel"* provides a readily visible Hawaiian name marker to identify each bridge or culvert structure, and provides a consistent aesthetic compatible with the Hana Belt Road Historic District.

[12] The existing plaque added to the original upstream parapet of Culvert #9 during a recent bridge renovation project in 2014 provides the identification as "Holoinā wā wae Gulch 1951." However, according to HDOT plan drawings dated December 2011, the intended date to reflect the correct, original date of construction should be 1915.

ix. EAST MAUI IRRIGATION SYSTEM

The five Hana Belt Road Historic District bridges listed below are adjacent to the EMI System, a National Historic Civil Engineering Landmark constructed during the latter half of the 19th century:

- #03 Nailiilihaele Stream Bridge,
- #04 Oopuola Stream Bridge,
- #05 Makanali Stream Bridge,
- #06 Kaaiea Stream Bridge, and
- #19 Kopiliula Stream Bridge.

The EMI system, which spans more than 60 miles and provides water for approximately 30,000 acres of sugarcane plantations,[13] is significant because its construction dramatically influenced the agricultural and economic landscape of East Maui, was technologically advanced for its time, was a forerunner of major aqueduct construction in the United States, and has been in continuous operation for almost a century-and-a-half. Today, the complex EMI system still provides necessary water collection, diversion, and transportation for irrigation of lands in the central isthmus area of Maui.[14] As such, it is an intact and unique historic engineering resource that should be maintained and preserved, preferably as much as possible in tandem with the aforementioned adjacent bridges.

The *Hana Highway Bridge Preservation Plan* (2015) provides related recommendations that attempt to address the presence of adjacent EMI components in a context sensitive manner to the greatest extent possible. However, the scope of the preservation plan is limited to the historic bridges and does not address preservation or operational concerns of the vast EMI system and its complex components.

The #19 Kopiliula Stream Bridge is the bridge most visibly connected to the EMI system, with EMI equipment attached directly to the bridge railing itself and an EMI dam fully integrated into the foundations of the bridge. For detailed information and team recommendations for #19 Kopiliula Stream Bridge and the four additional bridges in close proximity to the EMI system, refer to Section B. *Bridges* individual bridge chapters.

[13] Chui Ling Cheng, *Measurements of Seepage Losses and Gains, East Maui Irrigation Diversion System, Maui, Hawaiʻi*, Open-File Report 2012-2015, U.S. Geological Survey, U.S. Department of the Interior, prepared in cooperation with the State of Hawaii Commission on Water Resource Management (Reston: U.S. Geological Survey, 2012), 1.
[14] Ibid.

CHAPTER 7

HANA BELT ROAD HISTORIC DISTRICT: STATE BRIDGES

i. G E O G R A P H Y

a. Maui Island & Hana Belt Road Historic District

The Hana Belt Road Historic District was created in 2001 through listing on the Hawaii State Register and the National Register of Historic Places. The boundary justification is as follows:

> *The boundaries are coterminous with the Hāna Belt Road's historic right-of-way. The beginning and end points were selected to encompass the portion of the Hāna Belt Road that retains the greatest historic integrity and character. This section of roadway is relatively unaltered and is the most spectacular portion of Maui's historic belt road system, both in its scenery and its historic character. The boundaries include the highest concentration of stylistically consistent historic bridges in the State of Hawa'i.*[1]

Ownership of the road is divided into two segments between the State and the County. The state-owned Hana Highway portion of Route 360, begins 0.2 miles west of mile marker 3 and ends in Hana town at mile marker 34. This section of the district contains 43 historic bridges and 12 historic culverts, which are the subject of the *Hana Highway Bridge Preservation Plan* (2015).[2]

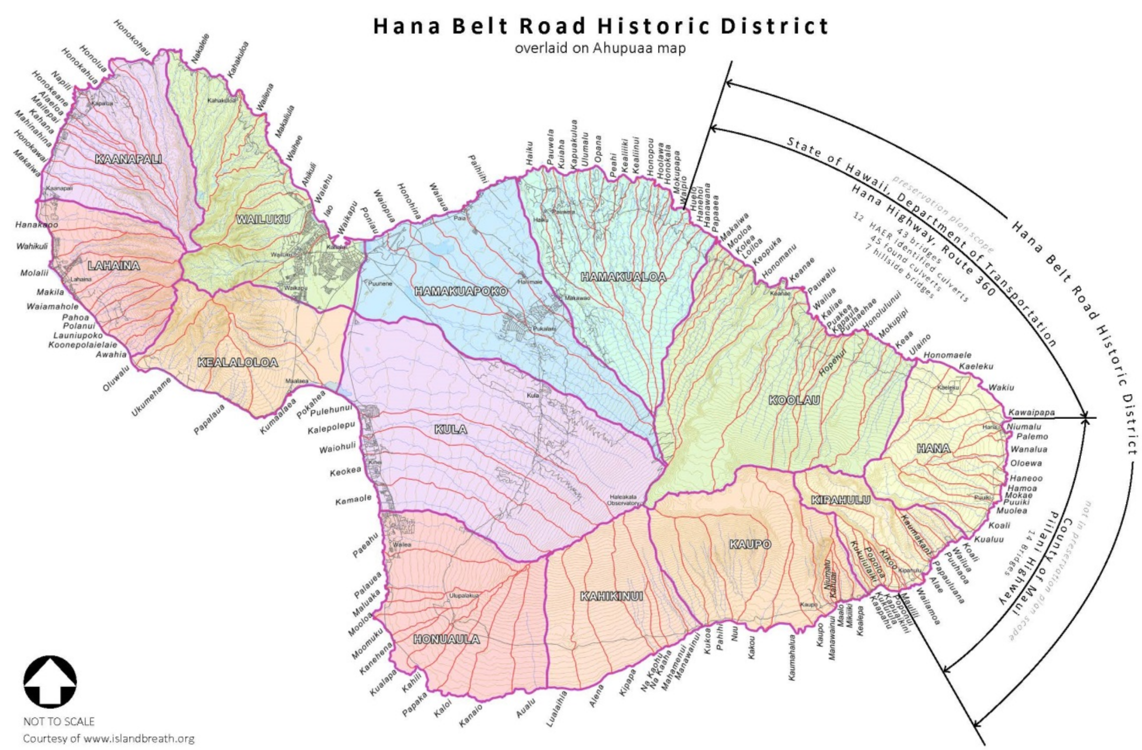

Figure 7 - 1: Overview of the Hana Belt Road Historic District, showing HDOT and County of Maui jurisdictions[3]
Courtesy of www.islandbreath.org

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[1] *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 6.

[2] Ibid. The term "mile marker" is used in this sole context per measurement data provided in the National Register Nomination. Throughout the remainder of this report, the term "mile point" or "MP" is used to indicate accuracy in bridge and culvert locations consistent with measurements in the HDOT bridge database.

[3] For a larger image of this map, refer to Section A, Chapter 1. *Figure 1 – 1*.

The second segment of the highway that falls within the Hana Belt Road Historic District is a portion of Piilani Highway, Route 31, which starts from mile marker 34 in the town of Hana and continues to the south end of Koukouai Bridge near Kipahulu. There are 14 bridges and two culverts along this corridor that are under the jurisdiction of the County of Maui; these structures were previously addressed in the *Preservation Plan for County of Maui Bridges within the Hana Highway Historic District* (2001) and are not included in the scope of this preservation plan. Two additional bridges along Piilani Highway — Pualuu Bridge and Oheo Bridge — lie within Haleakala National Park and fall under the jurisdiction of the Federal Government; these two structures are also not included in this preservation plan report.

In 2005, the historic bridges and culverts of the Hana Belt Road Historic District were documented in *HAER Report HI-75*, filed with The Library of Congress.

b. Hawaiian Land Divisions: East Maui Moku & Ahupuaa[4]

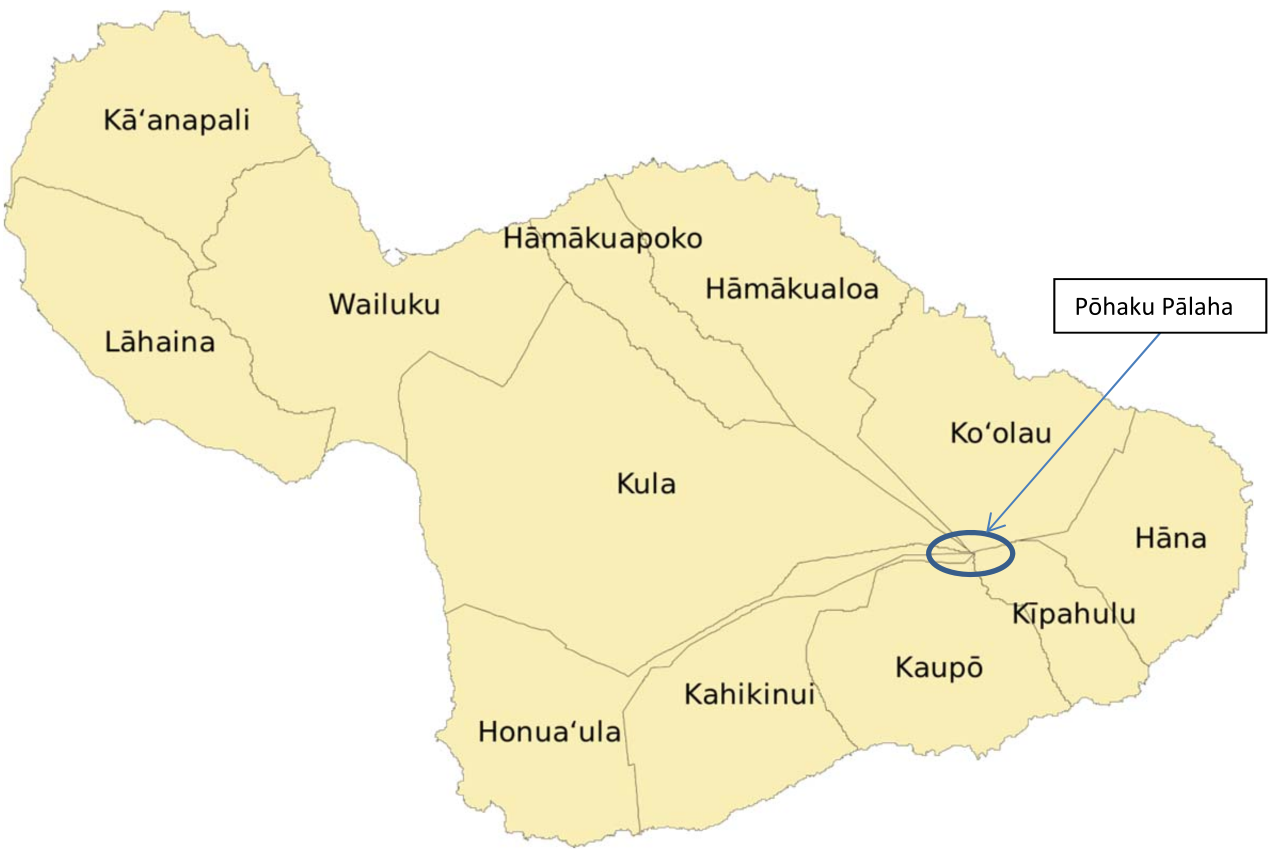

Figure 7 - 2: Island of Maui with the twelve traditional moku land divisions[5]
Courtesy of Wikipedia

[4] Please note that Hawaiian punctuation is used extensively throughout this and the following section (Section A, Chapters 7. i. *Geography*, 7. ii. *History*, and 7. iii. *Hana Highway History*) due to its use in original texts that are referenced through direct quotation.
[5] Wikipedia.com, "History of Maui, Early Settlement," Wikimedia Foundation, Inc., http://en.wikipedia.org/wiki/History_of_Maui (accessed April 29, 2015).

Moku & Ahupuaa System

Prior to the arrival of foreigners in the Hawaiian Islands during the 18th century, the Native Hawaiians categorized their land with a unique land division system, with each area representing distinct political and geographical regions. The Native Hawaiian land division system still in effect today is a unique approach to establishing boundaries based on a traditional cultural lifestyle that enabled people within each community to utilize the wide variety of resources available to them.

> *On each of the four larger islands, Kaua`i, O`ahu, Maui, and Hawai`i, lands [are] divided into wedge-shaped districts called moku.*
>
> *The moku [are] further divided into land sections called ahupua`a. Ahupua`a [are] often bounded by ridgelines and typically [encompass] an entire valley from mountain summit to the outer reef. This type of land division allowed for each ahupua`a to contain nearly all of the resources that its [original, native] inhabitants required for survival.*
>
> *The island of Maui is divided into twelve moku, eight of which intersect within Haleakalā National Park. On the northeast edge of Haleakalā Crater the upper ends of the moku converge into one point, called Pōhaku Pālaha.*
>
> *Pōhaku Pālaha can be understood in the literal sense as meaning a smooth or flattened rock, but it may also be described as the center from which eight districts of East Maui originate and "spread out" from.*
>
> *For some Native Hawaiians, the Pōhaku Pālaha is also a representation of the concept of the piko. The piko, or belly-button, is a very sacred part of a person's body for Native Hawaiian's, and the Pōhaku Pālaha is considered by some to be the piko for the island of Maui.* [6, 7]

For a further detailed discussion of traditional Hawaiian lifestyle and cultural historical background of this region, please refer to Section G, Appendix 1. *Archaeological Literature Review for the Hana Highway*, Section 3.1 "Traditional and Historical Background."

[6] Pacific Island Ranger, "Native Hawaiian Land Division," The National Parks of the Pacific Islands, http://pacificislandparks.com/2010/10/22/native-hawaiian-land-division-2/ (accessed March 23, 2014).

[7] "Native Hawaiian Land Division," Haleakala National Park, Hawaii, National Park Service, U.S. Department of the Interior, http://www.nps.gov/hale/learn/historyculture/moku.htm (accessed April 29, 2015).

ii. H I S T O R Y

a. Introduction

From the Hawaiian language, the name Hana poetically translates as "rainy land, low-lying sky." The name is not restricted only to the small East Maui village and bay, but is also applied to one of four geographic districts on the island of Maui. The [Hana Belt Road Historic District] covers nearly half of East Maui, which is comprised of Haleakala, a dormant volcano [that rises] more than 10,000' in elevation. In ancient times, lava flows poured from rifts in Haleakala to create the jagged northeast coast of Maui. Centuries of stream erosion from the wet, northeasterly tradewinds on Haleakala's windward (northeast) slope helped create a rugged terrain of high sea cliffs and v-shaped valleys. The wet climate resulted in dense forests that, together with the rough terrain, made the Hana [region] one of Hawaii's most isolated and inaccessible areas.[8]

b. Maui Island History

Despite its isolation, Hana played an important role in Hawaiian legend and history. According to lore, the demigod Maui lived at Kauiki at Hana Bay. Maui used his great hook to raise the Hawaiian Islands out of the sea. He also lassoed the sun to slow it down and lengthen the day, which allowed his mother Hina to dry her kapa (barkcloth).[9]

Hawaiian Kingdom(s)

Prior to 1450 A.D., Maui was divided into two separate kingdoms, one with a court at Lahaina, the other with a court in Hana. The East Maui coastal area was well populated in ancient times, but had little contact with the rest of Maui due to its isolated location. Traditionally, Hawaiians preferred to rely on their highly-developed navigational skills and traveled by canoe. As a result, Hana was often politically tied to the more accessible communities across the channel on the island of Hawaii. In the sixteenth century, Maui's King Pi'ilani conquered East Maui and pulled Hana into his political sphere. Pi'ilani was notable for his public works projects, including the Alaloa, or main road, which began in West Maui.[10]

In 1777, Queen Kaahumanu, the favorite wife of King Kamehameha I (the ruler who united the Hawaiian Islands), was born at Kauiki.[11] *A strong-willed woman, Kaahumanu ruled as regent after Kamehameha's death in 1819 and convinced the king's successor to break the traditional kapu (taboo) system. Her actions inadvertently opened the door to Christian missionaries, who arrived in Hawaii the year after Kamehameha's death in 1820. The establishment of Christian missions and the subsequent American presence in Hawaii changed the course of Hawaiian history.*[12]

Settlements

The Hawaiians' connection to their aina (land) is perhaps the most essential component of their cultural existence. As such, the Hana Coast was and remains culturally significant to Native Hawaiians. Evidence indicates that the numerous deep gulches and streams along the Hana Coast allowed a sizeable Hawaiian population to flourish in ancient times. The wet tradewinds provided the area with ample rain to grow awa, bananas, sweet potatoes, breadfruit, and perhaps most

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[8] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 5.
[9] Ibid.
[10] *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 11.
[11] It is important to note that "*Kauiki Point is the southern point that encloses Kapueokahi Bay. It is the birthplace of the demigod Maui and birthplace of the future wife of Kamehameha; Kaahumanu."* See Section G, Appendix 1. *Archaeological Literature Review for the Hana Highway*, Section 3.1.3.3.1.9. "Kapueokahi Harbor" and "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 5.
[12] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 5.

importantly, kalo (taro). The small coastal bays were favorable fishing grounds. Ancient agricultural terraces found in Oopuola, Waikamoi, Puohokamoa, Haipuaena, and Honomanu Gulches demonstrate that Hawaiians lived throughout the coast, not just in the communities of Keanae, Wailua, Nahiku, Hana, and Kipahulu.[13]

See also Section G, Appendix 1. *Archaeological Literature Review for the Hana Highway*, Section 3.1 "Traditional and Historical Background" for detailed description of settlements along the northeastern coast of Maui from Huelo to Hana.

Culture & Lifestyle

The Hawaiian economy centered upon agricultural production, and land-use was linked to a tiered system of land divisions. Whole islands or parts of large islands constitute moku, independent chiefdoms, which were divided into a large number of radial land sections, ahupua'a. These generally ran from the forested uplands, across the agricultural lands, and out to the coast and sea, encompassing the resources of both land and ocean. Each ahupua'a was controlled by a lesser chief, who in turn appointed one or more stewards to oversee production, organize work parties, collect tribute, and in other ways represent the chief. Ahupua'a were economically self-sufficient to some degree, although differences in the local resource base (agricultural land, water resources, stone for tools, and so on) resulted in differences in the production patterns of individual land sections. Within ahupua'a there were yet smaller sections and divisions, especially the 'ili and mo'o, which were held and worked by the extended households or groups of commoners.[14]

Although Polynesians brought domestic pigs, dogs, and fowl with them to the islands, and raised large numbers of these animals for food, it was the sea that yielded the greatest variety and abundance of animal food. A plethora of techniques, and such varied equipment as bone and shell fishhooks, spears, traps, and many kinds of net, nooses, sweeps, and weirs, enabled Hawaiin fishermen to exploit all ecological zones, from inshore reefs to the deeper benthic waters. Women gathered mollusks, sea urchins, and seaweed from rocky headlands and bays. No other Polynesians exceeded the Hawaiians in their marine production, for only in Hawai'i was true aquaculture developed, with the construction of large fishponds to impound and raise several species such as mullet (Mugil cephalis) and milkfish (Chanos chanos). These ponds, of which there were several hundred, were under control of the chiefly class.[15]

The Hawaiian economy also displayed considerable craft specialization, with such experts as canoe-makers, adz-makers, bird-catchers, wood-carvers, and tattooing experts. Many of these specialists received support from the more important chiefs, whose households were graced and distinguished by the fine bowls and containers, feather garments, and other products of these craftsmen.[16]

Post Contact

In 1832, American missionaries reported that the Hana [region] was well populated. They counted 3,816 souls in Hana and 1,553 in nearby Kipahulu. By the end of the 1800s, diseases introduced by the influx of foreigners had drastically reduced the native population. In 1878, only 2,067 people were estimated to reside in the entire Hana District. Despite the decline, the village

[13] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 5.
[14] Patrick V. Kirch, *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory* (Honolulu: University of Hawaii Press, 1985), 1-3.
[15] Ibid.
[16] Ibid.

of Hana seemed to prosper. By 1880, the community boasted a school, courthouse and two stores.[17]

Agriculture

The impact of foreigners on Hawaiian culture is best illustrated in the great changes to agricultural production. Although some Hawaiians continued to live a subsistence lifestyle, by the late 1800s industrial agriculture had been established along the Hana Coast. Sugar plantations became the dominant economic enterprise, but there were also failed attempts in pineapple and rubber. These industrial plantations required more laborers than Hawaiians could supply, so immigrants were employed. To better serve the increasing plantation population, communities in the Hana [region] supported small general stores, schools, post offices, and churches. Asian influence on the Hana Coast was most apparent in Keanae where more than half of the kalo loi (taro fields) were used as rice paddies from the 1880s to the 1930s. Chinese fraternal societies were established in Keanae and Kipahulu in the early 1900s.[18]

Transportation

Although the calls for an improved belt road along the Hana Coast probably dated to the mid-1890s, the first written evidence of such demands were probably Maui News *editorials in 1900. A writer opined that there was a serious need for a good wagon road not just to Hana, but through to Kipahulu. He argued that a decent wagon road would increase property values in East Maui by making it possible for hundreds of small farms to be established and grow marketable crops. Another editorial that year called for a 16 [foot]-wide road and suggested that revenues from government leases of the East Maui watershed could be used to pay for the project. The writer believed that the ditch trail could easily be converted into a government belt road "without the outlay of one cent of money."*[19]

[17] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 5.
[18] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 6.
[19] Ibid., 31.

iii. HANA HIGHWAY HISTORY

a. Overview

In Hawaii, we find comprehensive highway construction programs as early as the sixteenth century as various kings attempted to control individual islands prior to the consolidation of the Hawaiian Islands under King Kamehameha I in 1810. On the island of Maui, for example, King Piilani (d. 1527), known for a long peaceful and prosperous reign, began construction of the "Alaloa or long road" [in West Maui].[20]

The road had no bridges, and beaches were often used to cross gulches. Hawaiian travelers reportedly swung themselves over East Maui's rushing streams with ropes made of vines. Rather than travel over rough footpaths, they probably swam around points that jutted out into the ocean.[21]

b. Early Roads

Kings Belt Road

The predecessor trail to the Hana Belt Road was built by Piilani's son, Kihapiilani, in the 16th century.

Paved with hand-fitted basalt (lava) rocks, rounded stones and coral, the four to six foot wide road was also referred to as the "Kipapa (pavement) of Kihapi'ilani." With its completion, [the road become known as the King's Highway and] Maui became the first island in the Hawaiian chain with a paved road around the entire island. The 138-mile road facilitated rapid movement for the King's frequent military campaigns; it also helped with the efficient collection of taxes and enhanced intra-island communication via runners known as "kukini."[22]

EMI Ditch Road

[The modern history of the Hana Belt Road began in the 1870s, when] 15 miles of unpaved road was built from Central Maui into East Maui's rain forest to facilitate the construction of the Hamakua Ditch, which was completed in 1878. The ditch was an extraordinary nineteenth century engineering marvel built to ensure the economic success of the sugar industry by bringing water from rainy East Maui to Central Maui's arid plantations.[24]

After the completion of the Hamakua Ditch, the trail adjacent to the waterway, which had facilitated its construction and maintenance, became useful as a horse trail for residents traveling along the coast. What came to be called the "Ditch Trail" was also popular with tourists. While Haleakala Crater was a "must see" for most tourists visiting Hawaii, by the end of the nineteenth century, a typical journey also included the beautiful Hana Coast as seen along the "Ditch Trail." Guided tours on horseback traveled to the summit of Haleakala, through the volcano's massive crater, and down via Kaupo Gap to the small community of Kaupo near sea level. From Kaupo, travelers continued on a rough trail to Kipahulu, on to Hana and Nahiku, and then followed the Ditch Trail through the rain forest back to Kailua.[25]

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[20] Paul Daniel Marriott, "The Preservation Office Guide to Historic Roads: Clarifying Preservation Goals for State Historic Preservation Offices, Establishing Preservation Expectations for State Transportation Departments" (Washington, D.C., 2010), 27.

[21] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 27.

[22] Paul Daniel Marriott, "The Preservation Office Guide to Historic Roads: Clarifying Preservation Goals for State Historic Preservation Offices, Establishing Preservation Expectations for State Transportation Departments" (Washington, D.C., 2010), 27.

[24] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 28.

[25] Ibid.

In 1900, [Maui residents] began considering the necessity of extending a good wagon road through to Hana, which would be part of the island's "belt" (around-the-island) road system. That year, a rudimentary road was built from Ke'anae to Nāhiku to service the Nāhiku Rubber Company. Construction through this country was difficult due to the terrain and climate. The road was surfaced with cinder, but was not adequate for automobile traffic. In 1905, the Superintendent of Public Works reported that the road in East Maui traversed through very rough country and as a result, was built "as narrow as possible in order to construct, with the money available, the maximum length of road."[26]

c. Need & Support

Transportation & Commerce

Belt road projects are a significant element in the transportation history of Maui. This road building program was concurrent with the strategy of all the major Hawaiian Islands to develop belt road systems. By 1900, [local Maui residents] were concentrating on the Hāna section of the belt road, calling for a good wagon road to connect Central Maui and Hāna… A road to Hāna was believed necessary for the economic development of East Maui and its success in sugar, minor industries, and small-scale farming. Prior to the completion of a road from Central Maui to Hāna, travel to East Maui villages was by steamship or an unpaved wagon and horse trail. The route along the Hāna Coast was often impassable due to heavy rain.[27]

Tourism

Another significant commercial aspect of the Hāna Belt Road was tourism. By the 1920s, Maui's businessmen and civic leaders recognized the importance of scenic roads and considered them to be commercial enterprises, without which Maui could not develop its tourism industry. As early as 1912, the Hāna Belt Road, as well as a proposed route to the summit of Haleakalā, were planned as the centerpieces of Maui's road-building projects. [Maui residents] realized that building a road to Hāna would open up some of the finest scenery in the Hawaiian Islands and put Maui "on the tourist map."[28]

Community Support

The Hāna Belt Road was part of this great, early twentieth century public works movement. First suggested in 1895, the Maui Board of Supervisors sought funding for the road as early as 1900. Although numerous bridges were constructed on the Hāna Belt Road starting in 1908, little money was available for road construction or improvement. Local Maui residents lobbied Hawaii's governors and legislators for decades before receiving funding to build the dream of an automobile road to Hāna.[29]

d. Community Leaders, Designers & Builders

Community Leaders

Although many civic-minded individuals contributed to the Hana Belt Road's completion, William Pogue and Samuel Kalama were the driving forces behind the project. Both men were well-known public figures in the Maui community. Between them, the two men chaired the Maui County Board of Supervisors for nearly the entire time that [Maui residents] worked to get funding and build their road.[30]

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[26] *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 12.
[27] Ibid., 37.
[28] Ibid., 38.
[29] Ibid., 40.
[30] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 56.

- **William Fawcett Pogue**
  - *Pogue chaired both the Maui County Board of Supervisors from 1908 until 1912, and for several years after 1911, the Maui Loan Fund Commission, which funded the Hana bridges and road. He also had experience in the territorial legislature*.[31]

- **Samuel Enoka Kalama**
  - *Sam Kalama served on the Board of Supervisors from 1912 to 1932, chairing the board his entire tenure. Kalama also had ten years [of] experience in the territorial legislature, and served in numerous other government posts*.[32]

County Engineers

Although the Territory of Hawaii reviewed and approved project and funding plans for the construction of the Hana Belt Road, the County of Maui was responsible for [the majority of design and engineering] work. This included arranging financing, design and engineering, and building.[33]

- **Hugh Howell**
  - *Hugh Howell, who was appointed Maui's first County Engineer in 1906, served again in 1914, and also worked as a secretary/engineer with the Maui Loan Fund Commission. Howell was educated at the University of California and came to Hawaii in 1894 to work as a hydraulic engineer. Together with other Loan Fund Commission engineers who were less well known, Howell completed the early survey work for the Hana Belt Road. As the county engineer, he also designed several bridges, including [#07] Waikamoi and [#09] Haipuaena*.[34]
  - *During his tenure, Howell "concentrated on replacing failing, high maintenance truss bridges with simpler, more cost-effective structures built on durable concrete or rock masonry piers. East Maui had forty-seven bridges in 1908 and documents show that the wood structures demanded constant attention."*[35]
  - *Howell later [founded] his own engineering company. In the 1930s he conducted federal water surveys and planned irrigation projects on Molokai. Howell was also appointed as civil engineer for the Hawaiian Homes Commission. He, like Pogue and Kalama, was involved with numerous civic clubs*.[36]

- **Apau Paul (A. P.) Low**
  - *Paul Low, who was born in Honolulu [in 1891] and received a B.S. in Civil Engineering from Stanford [in 1914], also did post graduate work at the University of Illinois. As Maui County Engineer from 1918 until 1928, Low prepared the project specifications and managed the two major phases of Hana Belt Road construction between 1923 and 1926. His name appears on many of the Hana Belt Road bridge plans. During his tenure as county engineer, Low supervised a number of Maui's other public works projects, including the County Office Building in 1924. He was elected to the Territorial Senate in 1928*.[37, 38]

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[31] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 56.
[32] Ibid., 56.
[33] "Haneoo Bridge," Historic American Engineering Record, HAER HI-98 (2012), 5.
[34] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 56-57.
[35] "Haneoo Bridge," Historic American Engineering Record, HAER HI-98 (2012), 5.
[36] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 57.
[37] Ibid., 57.
[38] Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

- **A. H. Wong**
    - *A. H. Wong succeeded Low as county engineer in 1928. Wong was born in Honolulu and received a degree in civil engineering from Purdue University. Wong had been Low's assistant engineer while the Hana Belt Road was under construction. He designed… [#17] West Wailuaiki Bridge, and his name also appears on the plans for [#16 Waikani Bridge with William D'Esmond, and #29] Kuhiwa Bridge. Wong later worked on the construction of Haleakala Highway and became an engineering supervisor of the Works Progress Administration project that built Maui Airport during the 1930s*.[39]

- **Charles Bailey**
    - *Charles Bailey was born in Vermont and earned a civil engineering degree at the University of Vermont. Bailey went to Hana in 1912 to supervise the first macadamizing project in the Hana [region]… Kalama praised Bailey as the county's best bridge and road builder, which was why he was chosen to manage the county team that built [#29] Kuhiwa Bridge. After serving as an engineer with the county, Bailey was appointed to the Territory of Hawaii Commission on Public Lands*.[40]

- **Joseph Matson, Jr.**
    - County Engineer during the latter half of the 1930's, when several bridges were widened including #12 Nuaailua and #15 Waiokamilo Bridges.[41, 42]

Designers

- **William D'Esmond, Architect**
    - *One notable architect/civil engineer who also made an important civic contribution to the Hana Belt Road was William D'Esmond. With Wong, D'Esmond designed [#16] Wailuanui (Waikani) Bridge. D'Esmond was educated at the British Army Engineering School and the University of Maine. Born in San Francisco, California he came to Hawaii with the U.S. Army in 1912 and relocated to Wailuku in 1920, where he established a successful architectural practice. D'Esmond designed Maui's County Office Building in 1927; Paia School, 1926; St. Anthony's School, 1925; and numerous residences on Maui*.[43]

- **David K. Kapohakimohewa**
    - Born in Keakea Maui, circa 1900 to Hawaiian parents, D. K. was responsible for the design of the unique Greek Cross railings of the #15 Waiokamilo Bridge, widened in 1937. [44, 45] He later went on to serve in the House of Representatives from the 3rd District.[46]

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[39] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 57.
[40] Ibid.
[41] County Engineer's Department, "Waiokamilo Stream," Hana Belt Road, Job No. 215, Historic Drawings, November 1937.
[42] County Engineer's Department, "Nuaailua Section," Hana Belt Road, Job No. 215-B, Historic Drawings, April 1939 and July 1940.
[43] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 58.
[44] "Record of Issue of License to Marry," David K. Kapohakimohewa to Eva A. Newton, June 24, 1925, District of Makawao, County of Maui, Vital Statistics Collection, Department of Accounting and General Services, Hawaii, http://archives1.dags.hawaii.gov/gsdl/collect/vitalsta/index/assoc/HASH011c/0db7b421.dir/doc.pdf (accessed May 25, 2015).
[45] County Engineer's Department, "Waiokamilo Stream," Hana Belt Road, Job No. 215, Historic Drawings, November 1937.
[46] "Kapohakimohewa, D.K.," Hawaii State Archives Digital Collection, *Government Office Holders Collection, 1843-1959*, http://archives1.dags.hawaii.gov/gsdl/collect/governme/index/assoc/HASH01d7/86ead767.dir/Kapohakimohewa,%20D%20K.jpg (accessed May 25, 2015).

Builders

Builders were often a combination of county employees, prison labor, and private contractors. Many of these individuals who may have participated in building the Hana Belt Road are not well known, or are unidentified; however, two individual local contractors, John Wilson and Moses Akiona, who worked on the Hana Belt Road and other notable freeway construction projects were listed in a reference titled the *Pan Pacific Who's Who*, during the middle of the 20th century.[47]

- **John Henry Wilson**
    - o *Wilson was born in Honolulu and educated at Stanford University. He made a name for himself as the builder of the serpentine Pali Road on Oahu and worked on many other engineering projects. He became the Superintendent of Highways on Maui in 1907 and Honolulu City Engineer in 1919. Wilson was well known for his years as the mayor of Honolulu*.[48]

- **Moses Akiona**
    - o *Moses Akiona was born in Keanae and established his contracting firm, Moses Akiona, Ltd., in 1920. In addition to [#16] Waikani bridge, Akiona's firm worked on other Maui projects, including Malulani Hospital, Kula Sanitarium, and the Lahaina Courthouse. His business eventually grew to become one of the largest contracting firms in the territory. In the 1960s, Akiona and his sons built a section of the H-l freeway on Oahu*.[49]

- **Lincoln "Link" Loy McCandless**
    - o Born in Pennsylvania, September 18, 1859, he was the youngest of 3 brothers (John A. & James B.) who came to Hawaii in 1882.[50] They applied their oil drilling and mining skills to form McCandless Brothers, drilling artesian wells. Their success in guaranteeing irrigation water enabled the vast rice and sugar plantations by landowners such as Benjamin Franklin Dillingham.[51]
    - o The first political office McCandless held was as a member of the Republic of Hawaii House of Representatives, 5th district (1898-1900).[52] After the United States annexed the islands to form the Territory of Hawaii, McCandless was elected to the territorial legislature as a senator from 1902 to 1906. McCandless also served one term as Delegate to U.S. House of Representatives from the Territory of Hawaii's at-large district from March 4, 1933 to January 3, 1935.[53]

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[47] "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 57.
[48] Ibid., 57-58.
[49] Ibid., 58.
[50] John William Siddall, "Men of Hawaii: Being a Biographical Reference Library, Complete and Authentic, of the Men of Note and Substantial Achievement in the Hawaiian Islands," *Honolulu Star Bulletin*, vol. 2 rev. (Territory of Hawaii: Honolulu Star Bulletin, Limited, 1921), 277.
[51] Daniel Harrington, "McCandless, Lincoln Loy," Biographies, Hawaiian Encyclopedia.com, Mutual Publishing, LLC, www.hawaiianencyclopedia.com/Part-2-glossary-m-s.asp (accessed May 7, 2015).
[52] "McCandless, Lincoln L.," Hawaii State Archives Digital Collection, *Government Office Holders Collection, 1843-1959*, http://archives1.dags.hawaii.gov/gsdl/collect/governme/index/assoc/HASH01f2/acc557b7.dir/McCandless,%20Lincoln%20L.jpg (accessed May 18, 2015).
[53] Ibid.

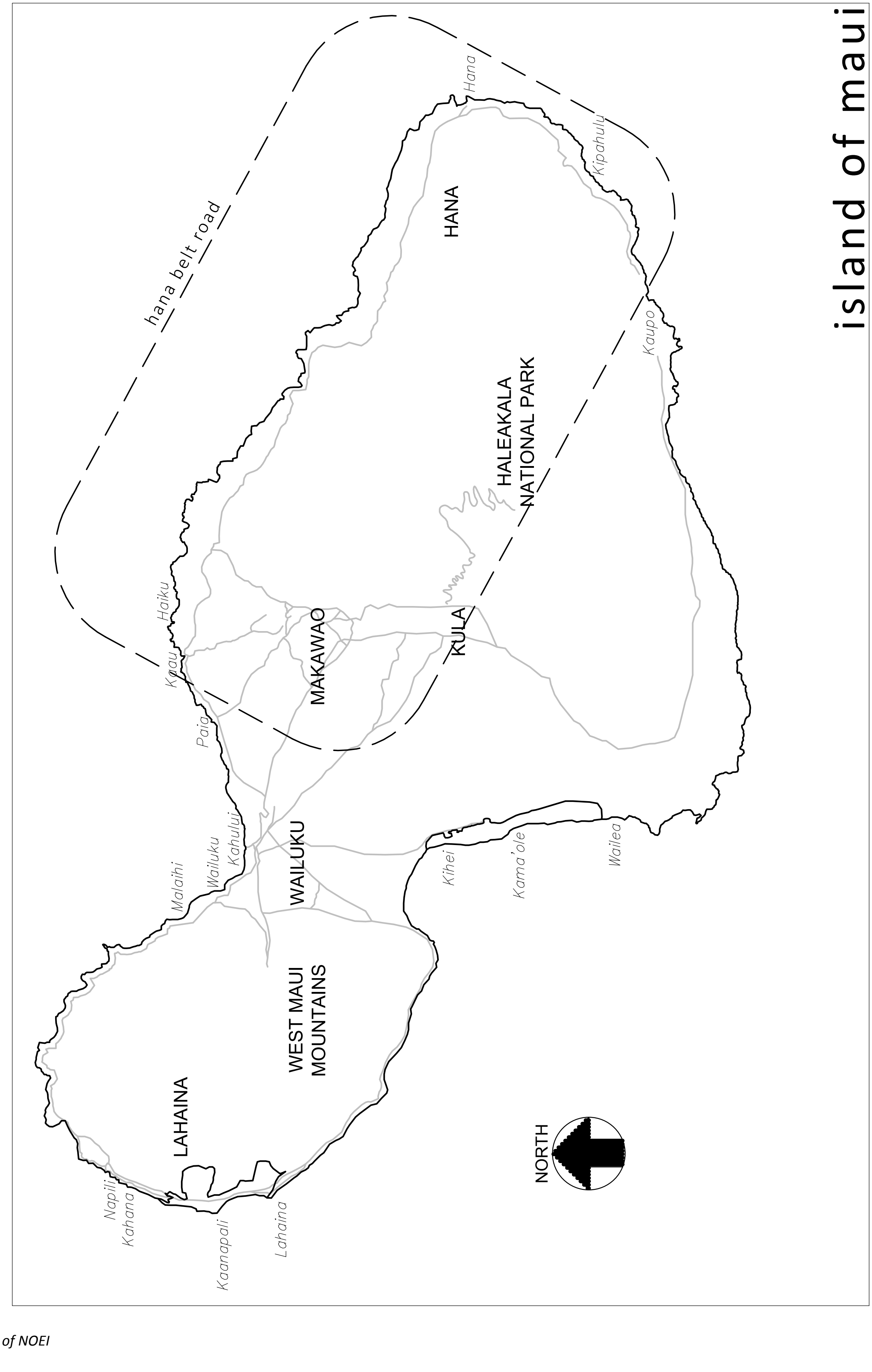
iv. DESIGN & CONSTRUCTION OF BRIDGES ON THE ROAD TO HANA

Beginning in the late 19th and early 20th centuries, the Road to Hana was designed and constructed in several phases. These phases resulted from a number of challenges presented by the weather, varying topography of the area, political opposition to building the road, and limited funds appropriated to the young Territorial government. As such, it appears that some of the bridges may have been designed several years prior to their actual construction and this may be one of the reasons for the string of different bridge types and small groupings of similar bridge types seen along the picturesque drive to the town of Hana.

Based on research found within the NRHP nomination forms and the HAER HI-75 report, the information and graphics on the following pages have been compiled in order to identify key aspects of the design and construction sequence of the Hana Highway, with its associated bridges, and to further illustrate the early development of the road.

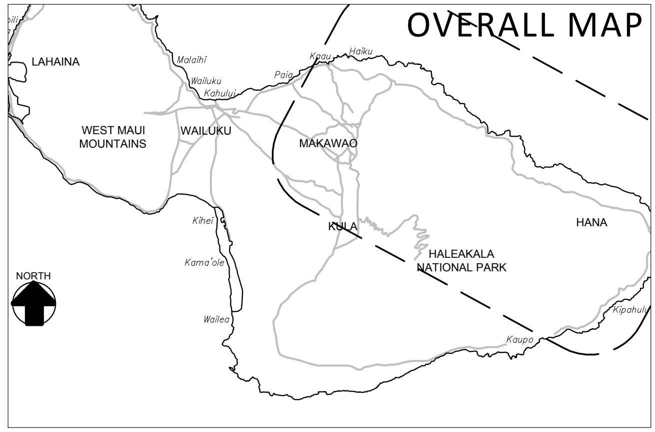
Many of the original drawings and public documents recording the history of the Hana Belt Road have survived, while it is assumed that some have not. As identified previously in Section A, Chapter 7. iii. d. *Community Leaders, Designers & Builders*, several key people were involved in the construction of the Road to Hana during various stages of development and construction; others remain unnamed and unidentified within the historic record. Where possible, pertinent information inferred from the historic record has been noted in relation to the design and construction of particular bridges.

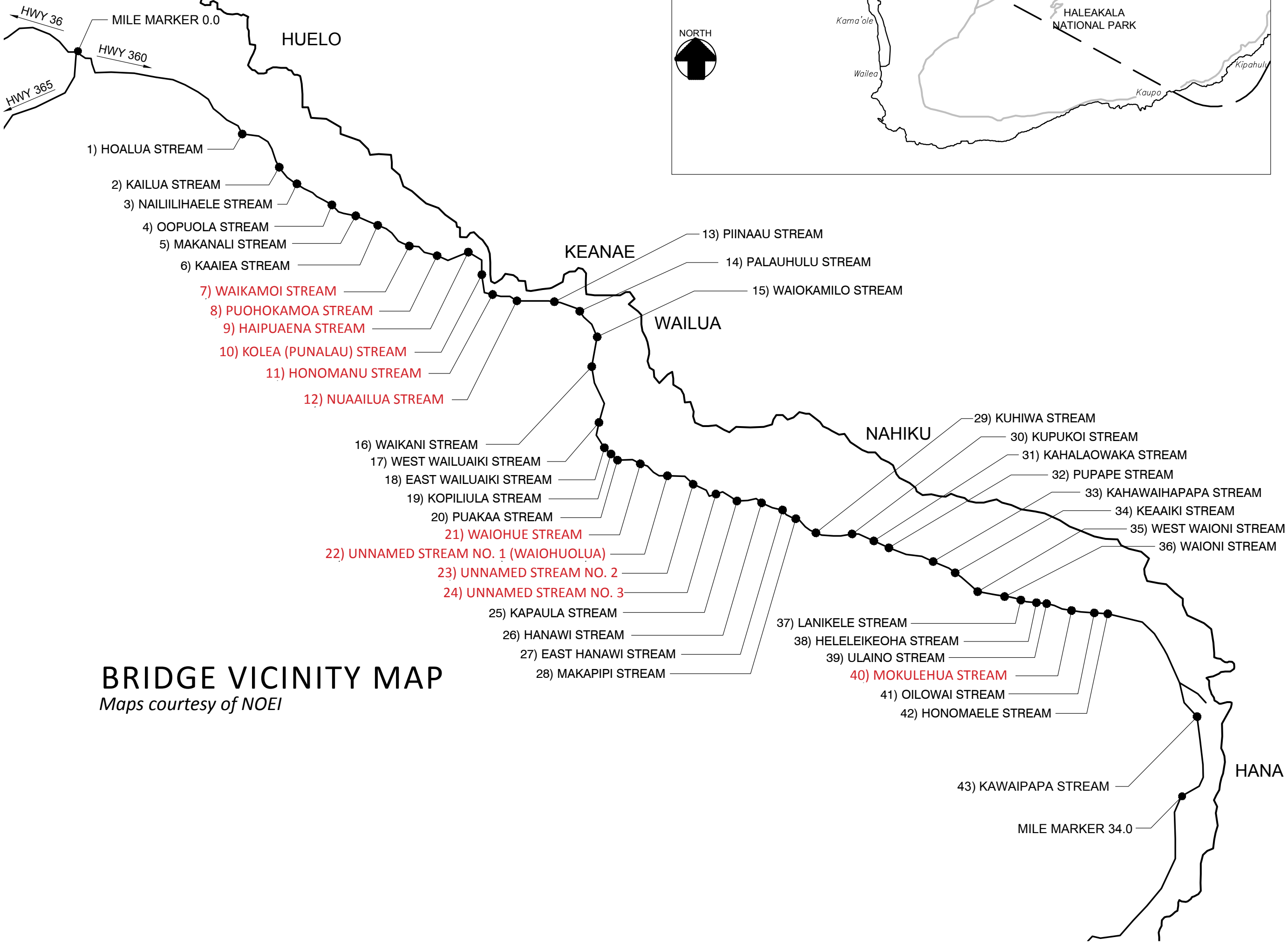
For further detail, references include Section G, Appendix 1. *Archaeological Literature Review for the Hana Highway*, Section 3.1.4 “Construction of the Hana Belt Road”; Section G, Appendix 4. *National Register Forms*; and the HAER HI-75 report document, which is not included in the *Hana Highway Bridge Preservation Plan* (2015) due to size, but the document can be accessed online at:
http://lcweb2.loc.gov/master/pnp/habshaer/hi/hi0800/hi0808/data/hi0808data.pdf



Courtesy of NOEI

1908 - 1912





BRIDGE VICINITY MAP

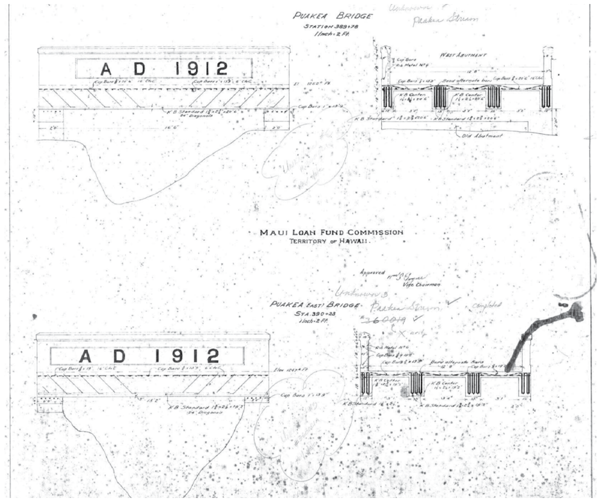
Maps courtesy of NOEI

#40 Mokulehua Stream Bridge, oldest concrete bridge along Hana Highway, Route 360
Courtesy of NOEI

#10 Kolea (Punalau Stream) Bridge with a date inscribed parapet (exceptional date panel)
Courtesy of NOEI

1908 - 1912

#8 Puohokamoa Stream Bridge with a date inscribed parapet (exceptional date panel)
Courtesy of NOEI



#23 Unnamed Stream Bridge No. 2 (top) and #24 Unnamed Stream Bridge No. 3 (bottom)
Courtesy of State of Hawaii Department of Transportation

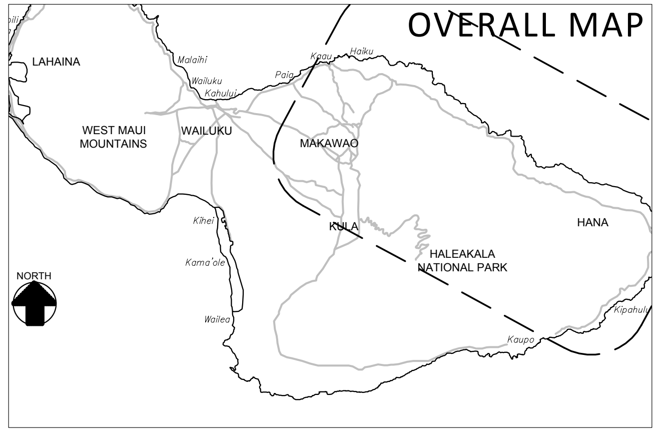
Prior to 1909 most bridges were high maintenance wood truss structures. However, in 1906 to 1909 bridges along the Hana Belt Road began to be constructed with permanent (concrete/rock) piers and foundations. Characteristic of these first concrete bridges were the solid parapet walls. These bridges were often designed with the date inscribed in a panel on the outside downstream face of the parapet. However as some structures were constructed at a much later date than they were designed, they were constructed with panels but without a date. The bridge's clear widths are narrow (originally for a wagon road), varying between 12.5 and 15 feet. The spans vary from single to triple span, with bridge lengths reaching up to 60 feet long.

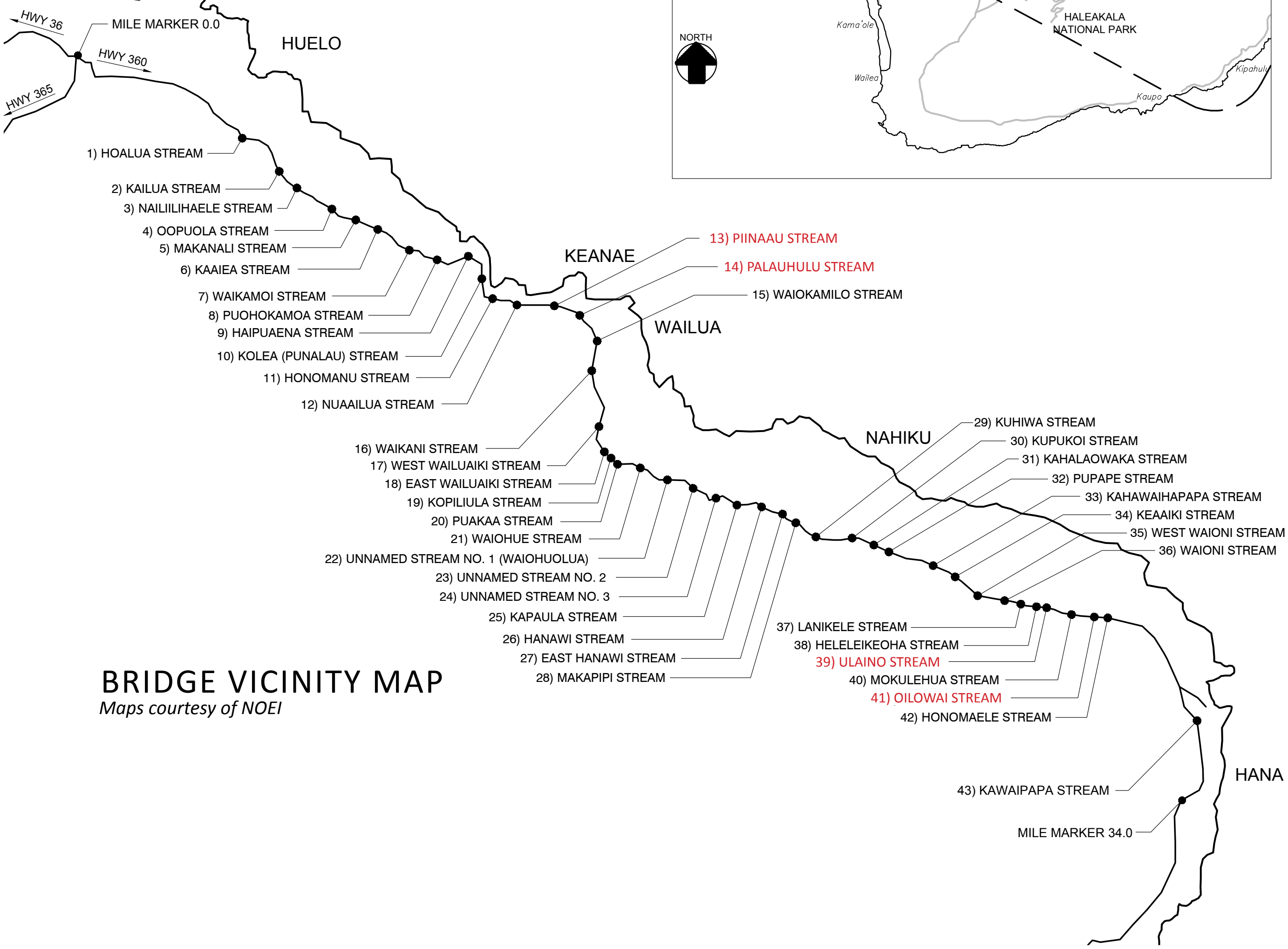
- First Hana Road concrete bridge (#40 Mokulehua) was constructed in 1908
- Bridges and structures between #07 Waikamoi and #12 Nuaailua were designed and constructed between 1911 and 1912
- Similarly bridges #22 Unnamed No. 1, #23 Unnamed No. 2, #24 Unnamed No. 3, and #21 Waiohue were designed in 1912 but were not built until later (1920, 1920, 1920, and 1926, respectively)

DESIGNED DATE	BUILT DATE	BRIDGE # & STREAM NAME	DESIGNER	NOTES
1908	1908	40 Mokulehua	Unknown	
1911 / 1912	1911 / 1912	07 Waikamoi	Hugh Howell	
		08 Puohokamoa		
		09 Haipuaena		
		10 Kolea (Punalau)		
		11 Honomanu		
		12 Nuaailua	County Engineer's Office, "Y. T."	
1912	1920	*22 Unnamed No. 1 (Waiohuolua)	Unknown	Designed in 1912; however, it was not built until 1920.
		*23 Unnamed No. 2		
		*24 Unnamed No. 3		
1912	1926	21 Waiohue		**Designed in 1912; however, it was not built until 1926.

*For a discussion of the possible historic names see Section B, Chapter 22 - 24 and Section G, Appendix 10.
** Possible 1912 design date from historic drawings, see Section B, 21 Waiohue Stream Bridge.

1913 - 1916





BRIDGE VICINITY MAP
Maps courtesy of NOEI

#19 Kopiliula Stream Bridge
Courtesy of FAI

#39 Ulaino Stream Bridge with an open square baluster railing
Courtesy of HAER HI-75

ROAD TO NOWHERE

1913 - 1916

The unfinished stretch of belt road between Nahiku and Keanae, which had been lengthened by a territorial contract in 1903, was funded for additional work in 1912. ... John H. Wilson of Honolulu submitted the lowest bid... Wilson was well known in Hawaii as the builder of the serpentine Pali Road through the Ko`olau Mountains on Oahu.[1]

In 1914, two bridges #39 Ulaino and #41 Oilowai were constructed at the Hana end of the Hana Belt Road. With these bridges, the open railing became the predominant parapet design along the Hana Belt Road.

DESIGNED DATE	BUILT DATE	BRIDGE # & STREAM NAME	DESIGNER	NOTES
1914	1914	39 Ulaino	Unknown	
		41 Oilowai		Possibly built by Wilson & McCandless.
1916	1916	13 Piinaau		
		14 Palauhulu		

[By 1914, a]fter several months of [the community] attempting to convince the governor [Lucius E. Pinkham] that the new section of road between Keanae and Nahiku would be useless without additional funding needed to carry the road into Keanae, Pinkham announced that he would not approve the project. He reportedly expressed 'ardent disapproval' for a road between Keanae and Hana.[2] ...

The Wilson and McCandless firm completed several miles of road in November 1914. The work was a "fine piece of road" that cost about $85,000, but benefited no one since it ended miles from any habitation at the bottom of a gulch in the Ko`olau Forest Reserve. The Maui News noted that the roadway ran through some of Hawaii's most spectacular scenery as it traversed along the mountainside a few thousand feet above sea level and close below the ditch trail. The section of "useless" road included a fine bridge at the West Kopili`ula gulch. Wilson's firm most likely built Kopili`ula Bridge [(#19 Kopiliula Stream Bridge)].[3, 4]

The MLFC [Maui Loan Fund Comission] continued to build bridges in the Hana District, with at least five bridges constructed in 1915 [south of Hana] and three in 1916 [#13 Piinaau Stream Bridge and #14 Palauhulu Stream Bridge near Keanae].[5]

1 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 33.

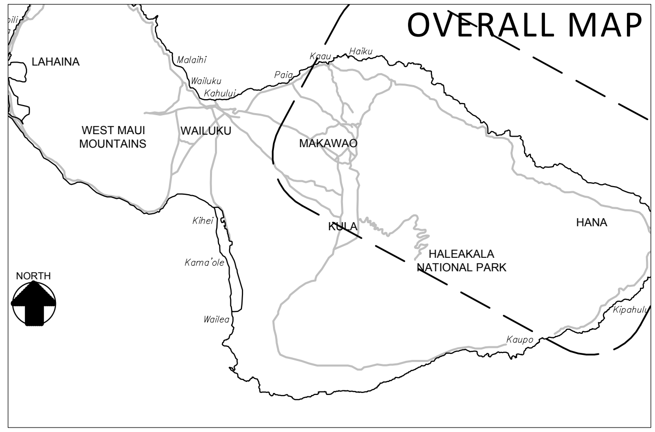
2 Ibid., 34.

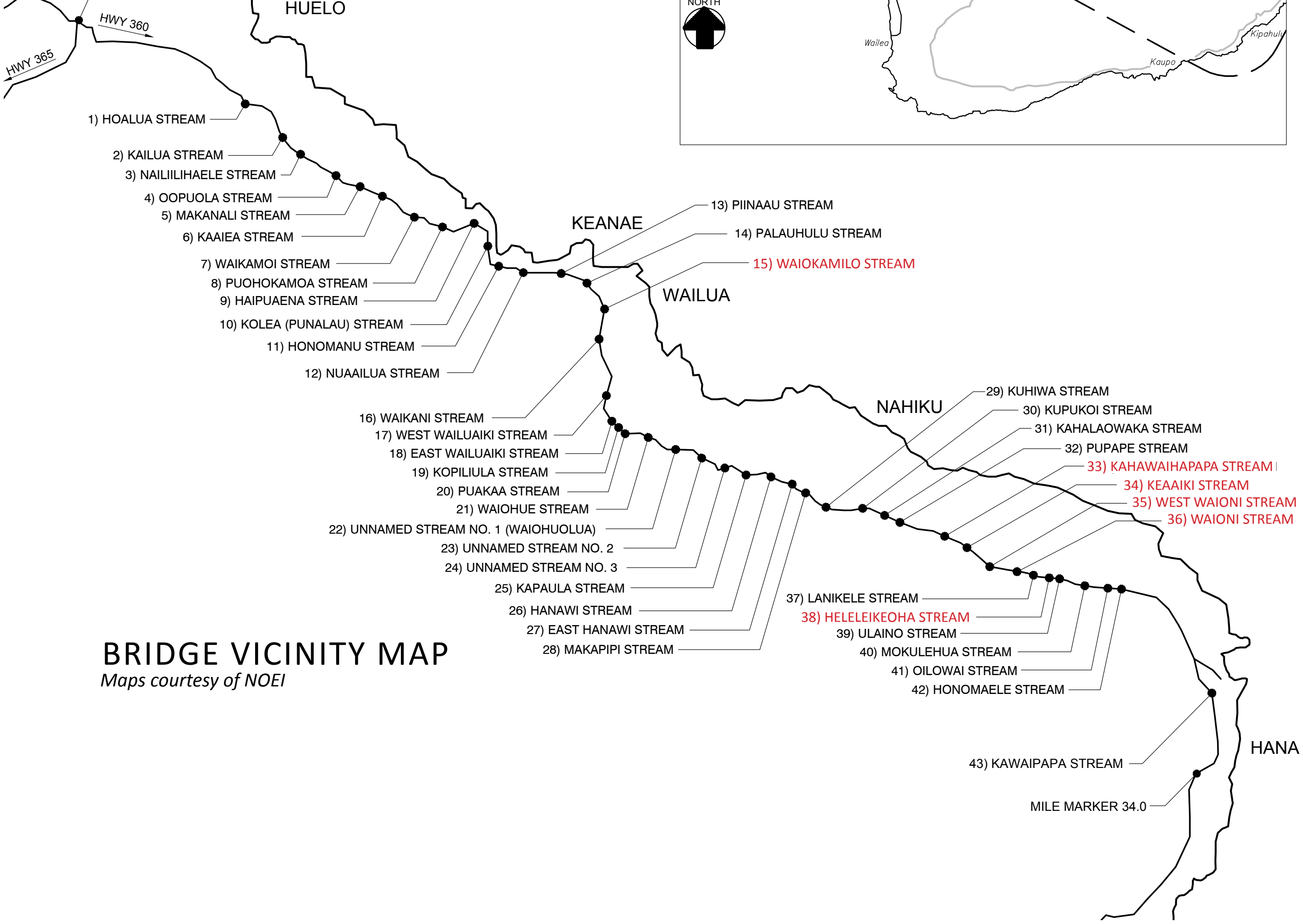
3 Two articles in *The Maui News* refer to a bridge in the western portion of Kopiliula Gulch that was built in 1914 with a length of 70 feet. However, the articles do not refer to a specific bridge and #19 Kopiliula Stream Bridge is similar in design to a Paihi Bridge constructed in 1911. Concrete open vertical railing designs are characteristic of bridges built after 1914, while several solid parapet bridges were built during the early construction years of the Hana Belt Road. #19 Kopiliula Stream Bridge has a solid parapet thus, HAER-HI-75 surmises that the inspection reports for #19 Kopiliula Stream Bridge may have the wrong construction date of 1926 and may have been built in 1914 by Wilson. See "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 34.

4 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 34.

5 Ibid., 34.

1917 - 1922





BRIDGE VICINITY MAP

Maps courtesy of NOEI

#23 Unnamed No. 2 Bridge designed in 1912, built in 1920
Courtesy of NOEI

#33 Kahawaihapapa Stream Bridge designed with typical open picket railings
Courtesy of NOEI

WAR YEARS
1917 - 1922

#34 Keaaiki Stream Bridge
Courtesy of NOEI

#35 West Waioni Stream Bridge
Courtesy of FAI

In 1920, [Maui residents] *learned that no money would be appropriated for the belt road for another two years. By that time, the focus of belt road work had shifted to the need for macadamizing* [(paving)] *the section that ran through the pineapple district west of Kailua towards Central Maui. ...*

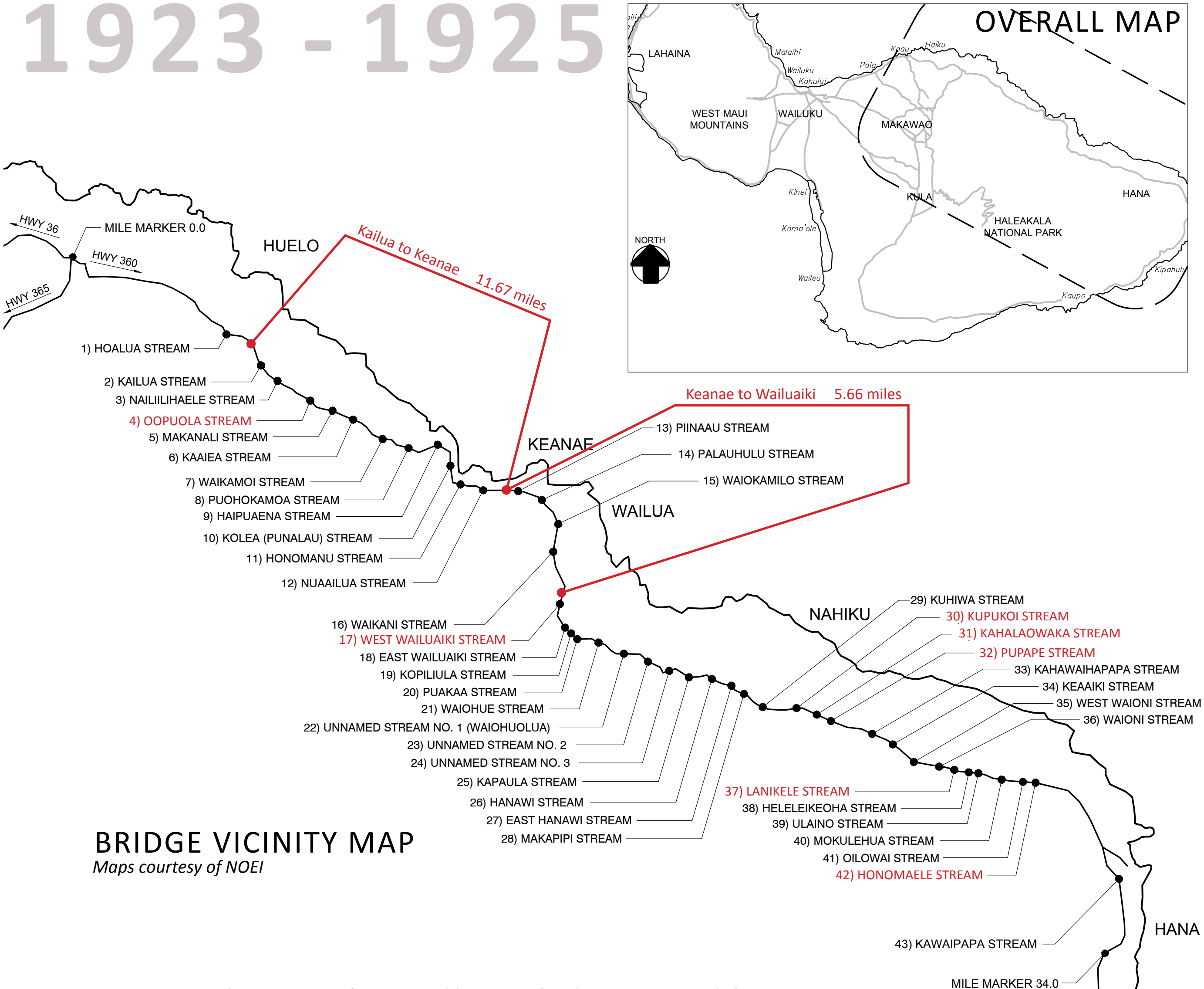
Although no progress was made on completing the belt road to Hana, work on the bridges along the Hana Coast continued, both west and south of Hana. Records indicate that two bridges were built in 1917, five in 1920, two in 1921, and one in 1922.[6]

DESIGNED DATE	BUILT DATE	BRIDGE # & STREAM NAME	DESIGNER	NOTES
1917	1917	38 Heleleikeoha	Unknown	
1920	1920	35 West Waioni		
		36 Waioni		
1921	1921	15 Waiokamilo	D. K. Kapohakimohewa	Railing replaced in 1937 with Greek cross design, see *1930s Onward*.
		34 Keaaiki	County Engineer's Office	
1922	1922	33 Kahawaihapapa	County Engineer's Office	

*For #22 Unnamed No. 1 (Waiohualoa), #23 Unnamed No. 2, and #24 Unnamed No. 3 which were built in 1920, see *The Early Years 1908-1912*.

6 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 35.

1923 - 1925



BRIDGE VICINITY MAP

Maps courtesy of NOEI

In early 1923 Maui's civic and business leaders resurrected their interest in completing a belt road through to Hana. Together with a new Hawaii governor, Wallace Farrington, [Maui residents] were finally able to make their dream of a road to Hana a reality. ...

In January 1923, County Engineer Paul Low prepared estimates for completing the Hana Belt Road for the County Board of Supervisors. Low compiled his data based on previous surveys calculated by Maui Loan Fund Commission engineers, including Howell. ... For reasons that were not specified, Low divided the project into two sections. The ***first section*** [emphasis added] *was between Kailua and Keanae, a distance of 11.67 miles, and the* ***second*** [emphasis added] [section] *from Keanae to Wailuaiki, a distance of 5.66 miles.*[7]

BUILDING THE ROAD: KAILUA TO KEANAE, 1923 - 1925

In early 1923, the county government demonstrated its determination to go ahead with the project by purchasing a steam shovel and drill and assigned a gang of twenty men to begin work on the new road, even though the territorial legislature had not yet approved the sale of bonds for the project. The county established a prison camp in Kailua to house the fifty convicts expected to work on the road. Within months, leaders purchased another steam shovel and drill so that work could proceed from both ends of the road. Funding eventually was secured from the territorial and federal governments.[8]

7 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 35-36.

8 *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 40.

CONNECTING THE ROADS
1923 - 1925

In May 1925, two county supervisors, Antonino Garcia and Frank Summerfeld, along with two other government officials, drove out towards Keanae to check on the construction progress. Although the men intended to park their car near the end of the construction zone and then walk out to view the other end of the project, by the time they arrived, workers were about to 'break through' and connect the two pieces of road. Too excited to miss the opportunity, they waited until the workers (or steamshovels) met, then drove in their car to the end of the new road. ...

[T]*he newspaper,* [The Maui News]*, credited William Pogue and Sam Kalama with the idea for building a road from Kailua to Keanae and on to Hana. In May 1895, the men visited Keanae and after a rough trip over the government trail, discussed the idea of building a belt road. Thirty years later, on June 11, 1925, both men rode over the new road to Keanae with Governor Farrington and SPW,* [Superintendent of Public Works, Lyman] *Bigelow to attend the celebration of its opening. The official automobile led a procession of more than one hundred cars.*[9]

#42 Honomaele Stream Bridge approach
Courtesy of HAER HI-75

#42 Honomaele Stream Bridge
Courtesy of NOEI

DESIGNED DATE	BUILT DATE	BRIDGE # & STREAM NAME	DESIGNER	NOTES
1924	1924	42 Honomaele	A. P. Low	
1925	1925	17 West Wailuaiki	A. H. Wong	
		37 Lanikele	A. P. Low	
Unknown	1925	04 Oopuola	County Engineer's Office	As-builts of the bridge were drawn in 1931 as part of an alteration.
1925	1926	30 Kupukoi		
		31 Kahalaowaka		
		32 Pupape		

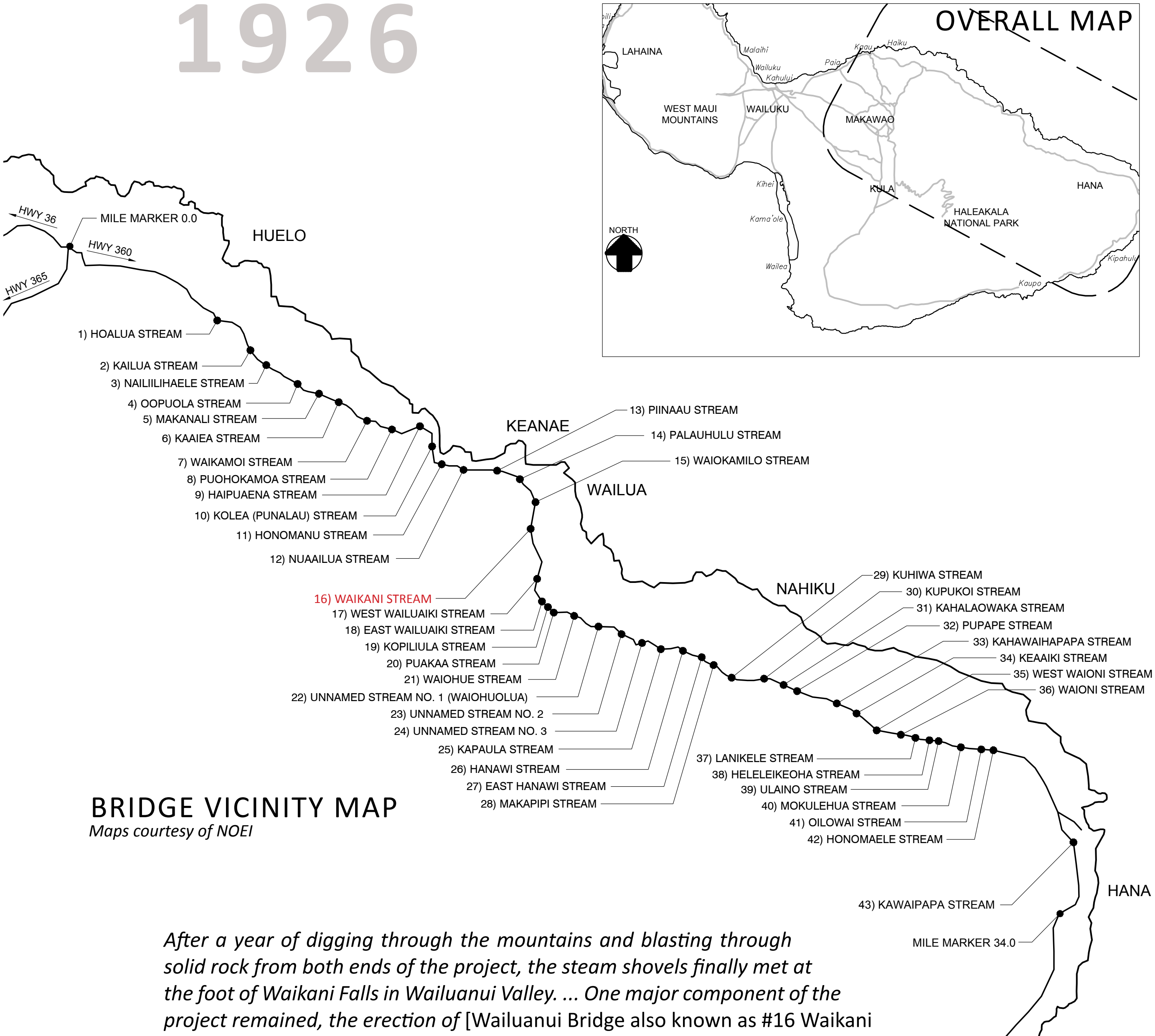
BUILDING THE ROAD: KEANAE TO WAILUAIKI, 1925 - 1926

Assistant County Engineer A. H. Wong and three others from the county engineer's office were dispatched into the field for additional survey work in August 1925. Wong led the team in inspecting wood bridges between Kopiliula Gulch and Hana and in assessing which should be replaced.[10]

9 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 38-39.

10 Ibid., 40.

1926



BRIDGE VICINITY MAP

Maps courtesy of NOEI

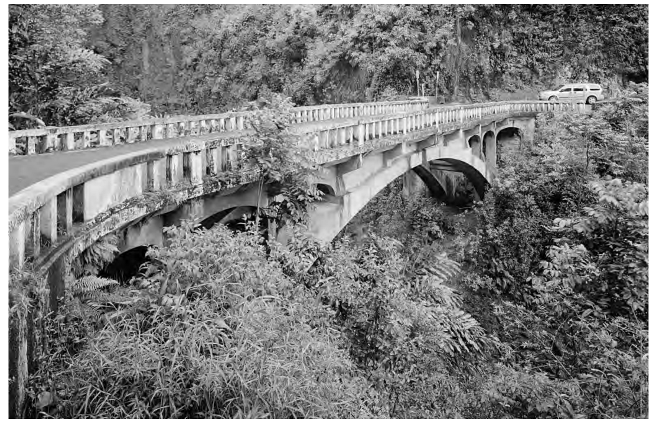
After a year of digging through the mountains and blasting through solid rock from both ends of the project, the steam shovels finally met at the foot of Waikani Falls in Wailuanui Valley. ... One major component of the project remained, the erection of [Wailuanui Bridge also known as #16 Waikani Stream Bridge]. *That project had been delayed until the road was cleared through to the worksite so that materials could be delivered.*[11]

#16 Waikani Stream Bridge
Courtesy of FAI

11 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 43.

In August 1926, Akiona's crews began building the framework for Wailuanui Bridge. ... Wailuanui Bridge is a concrete-arch structure 130' long and 90' high, designed by architect William D'Esmond in partnership with Low. The open-spandrel bridge features two rib arches and dramatically crosses a deep gorge at the head of Wailuanui Valley. The bridge is located at the end of the mile-long ledge over Wailua, which Low had described in May 1926 as 'without comparison.' Wailuanui Bridge was the major piece of construction remaining to be completed before the Hana Belt Road could be opened to traffic.[12] [See HAER drawing in Section B, 16 Waikani Stream Bridge.]

[On November 13, 1926, t]he same day that The Maui News *announced the date of the official opening, heavy rains washed out the bridge's formwork and scaffolding. Approximately 600 bags of cement for the project were washed away, and landslides covered the road near the structure with loose earth. Low visited the work site and determined that the damage was not serious. One major problem was the formwork for the center arch, which had washed away. The concrete had been setting for nearly a month, and the formwork had been scheduled for removal in a few days. ... After assessing the damage, Low opined that it would cause only a few days delay.*[13]



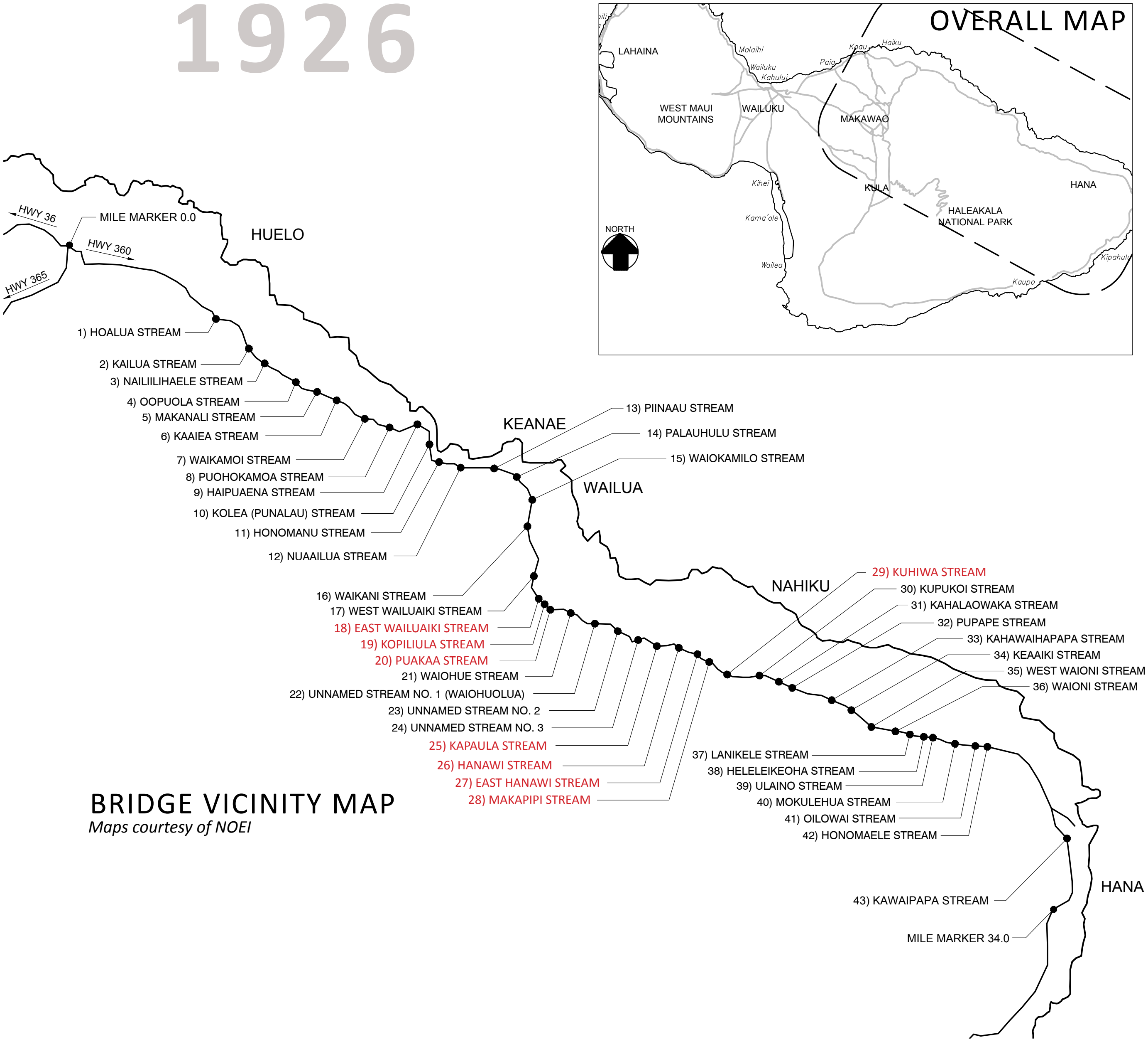
#16 Waikani Stream Bridge
Courtesy of HAER HI-75

#16 Waikani Stream Bridge aerial
Courtesy of HAER HI-75

12 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 43.

13 Ibid., 44.

1926



BRIDGE VICINITY MAP

Maps courtesy of NOEI

ENDING HANA'S CENTURIES OF ISOLATION

The Hana Belt Road opened to the public as scheduled on December 18, 1926. Honiron, *a publication of Honolulu Iron Works, described the road as 'spectacularly chiseled out of abrupt cliffs and precipitous valleys.' It noted that miles of the roadway were nothing more than a 16'-wide shelf cut into the mountainside, with towering masses of rock above and sheer drops measuring hundreds of feet to the ocean below.*[14]

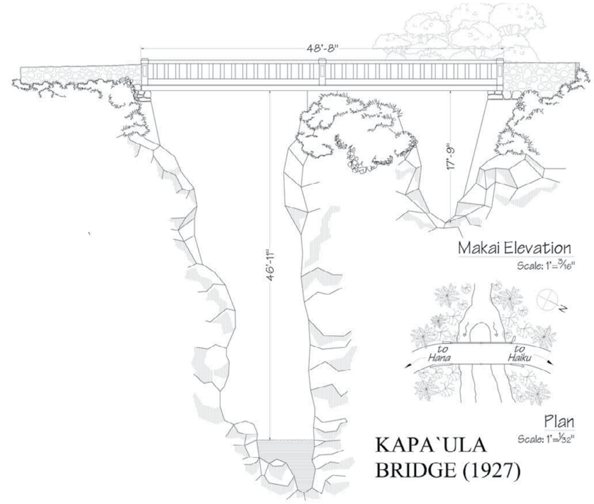
A grand procession of 200 automobiles traveled over the Hana Belt Road on opening day without incident. Police were posted at locations along the entire route to direct traffic and assist motorists. Signs marked 'bad turn' and 'go slow' were installed to mark dangerous curves and other points in the road. Scouts were available to assist in the event of a flat tire or car trouble. Although Low's 1923 estimates to complete the road to Hana included pavement, the road was not paved when it was opened in 1926.[15]

14 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 46.

15 Ibid., 47.

ENDING HANA'S CENTURIES OF ISOLATION 1926

#28 Makapipi Stream Bridge
Courtesy of HAER-HI 75



#25 Kapaula Stream Bridge built on natural rock supports
Courtesy of HAER-HI 75

Numerous bridges were built as part of the final phase of Hana Belt Road construction. Bridge inspection reports from the Hawaii Department of Transportation indicate that fourteen bridges were built in 1926 and two each in 1928 and 1929.[16]

Contrary to his plans of January 1923, Low reported that the roadway would eventually be 20' wide, but for this project, only 16' was being benched into the mountains [to reduce cost].[17]

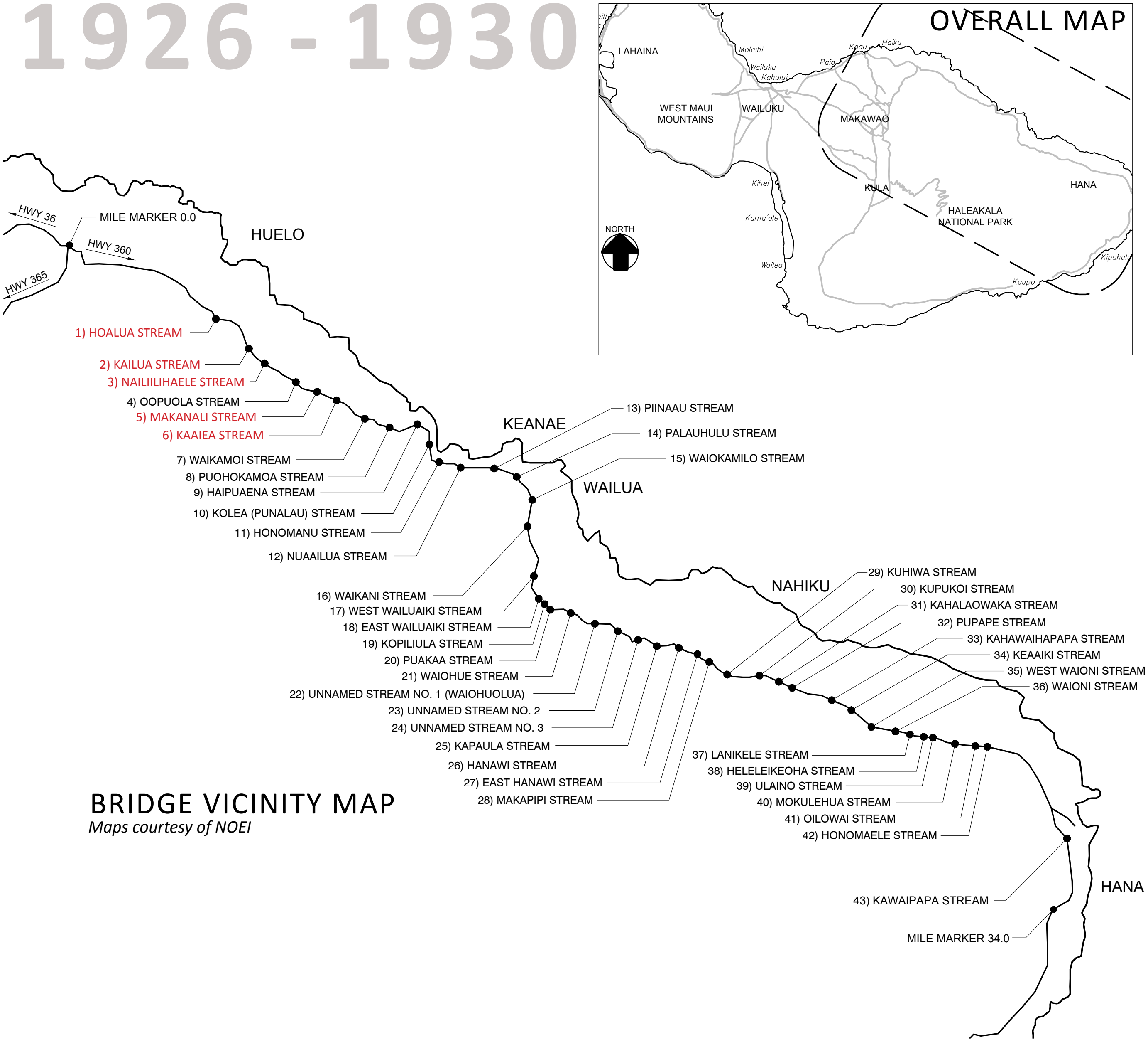
DESIGNED DATE	BUILT DATE	BRIDGE # & STREAM NAME	DESIGNER	NOTES
Unknown	1926	18 East Wailuaiki	A. P. Low	
		*19 Kopiliula	Unknown	*Kopiliula Stream Bridge was possibly built in 1914 by Wilson & McCandless.
		20 Puaakaa		
		25 Kapaula		
		26 Hanawi	County Engineer's Office	HDOT states Hanawi was built in 1926 along with #29 Kuhiwa. However, according to SPW reports, Hanawi was built in 1929.
		27 East Hanawi	Unknown	
		28 Makapipi		
1926		29 Kuhiwa	A. H. Wong	HDOT states Kuhiwa was built in 1926 along with Hanawi. However, *The Maui News* reports a completion date of 1927.

*For more information on #19 Kopiliula, see *Road to Nowhere 1913-1916*.

16 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 40.

17 Ibid., 41.

1926 - 1930



BRIDGE VICINITY MAP
Maps courtesy of NOEI

OTHER WORK TO BE DONE [1926 - 1930]

While many bridges were built in 1926, not all were ready when the road opened, such as the [#29] *Kuhiwa Bridge whose plans and DOT records indicate the date of construction was 1926. A* [The] Maui News *article, on the other hand reported that bids for the bridge were not opened until March 1927 and that the structure was completed in November 1927. ...*

[After a slew of proposals/bids from various contractors, which were higher than the estimated construction cost, t]*he Board of Supervisors rejected all the bids as too high and decided that county workers would build the structure instead.*[18] [A. P. Low estimated that the savings in man-power, reuse of materials, and other savings would result in a net cost to the county of $500 to build. The contractor's bids ranged from $7,800 to $10,500.]

18 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 47.

CONTINUED WORK
1926 - 1930

#26 Hanawi Stream Bridge
Courtesy of HAER-HI 75

#29 Kuhiwa Stream Bridge
Courtesy of HAER-HI 75

#3 Nailiilihaele Stream Bridge
Courtesy of HAER-HI 75

#6 Kaaiea Stream Bridge
Courtesy of HAER-HI 75

<table>
<tr><th>DESIGNED DATE</th><th>BUILT DATE</th><th>BRIDGE # & STREAM NAME</th><th>DESIGNER</th><th>NOTES</th></tr>
<tr><td rowspan="4">Unknown</td><td rowspan="2">1928</td><td>05 Makanali</td><td>Department of Public Works</td><td></td></tr>
<tr><td>06 Kaaiea</td><td>Department of Public Works</td><td></td></tr>
<tr><td rowspan="2">1929</td><td>01 Hoalua</td><td></td><td></td></tr>
<tr><td>02 Kailua</td><td></td><td></td></tr>
<tr><td>1929</td><td>1930</td><td>03 Nailiilihaele</td><td>County Engineer’s Office</td><td></td></tr>
</table>

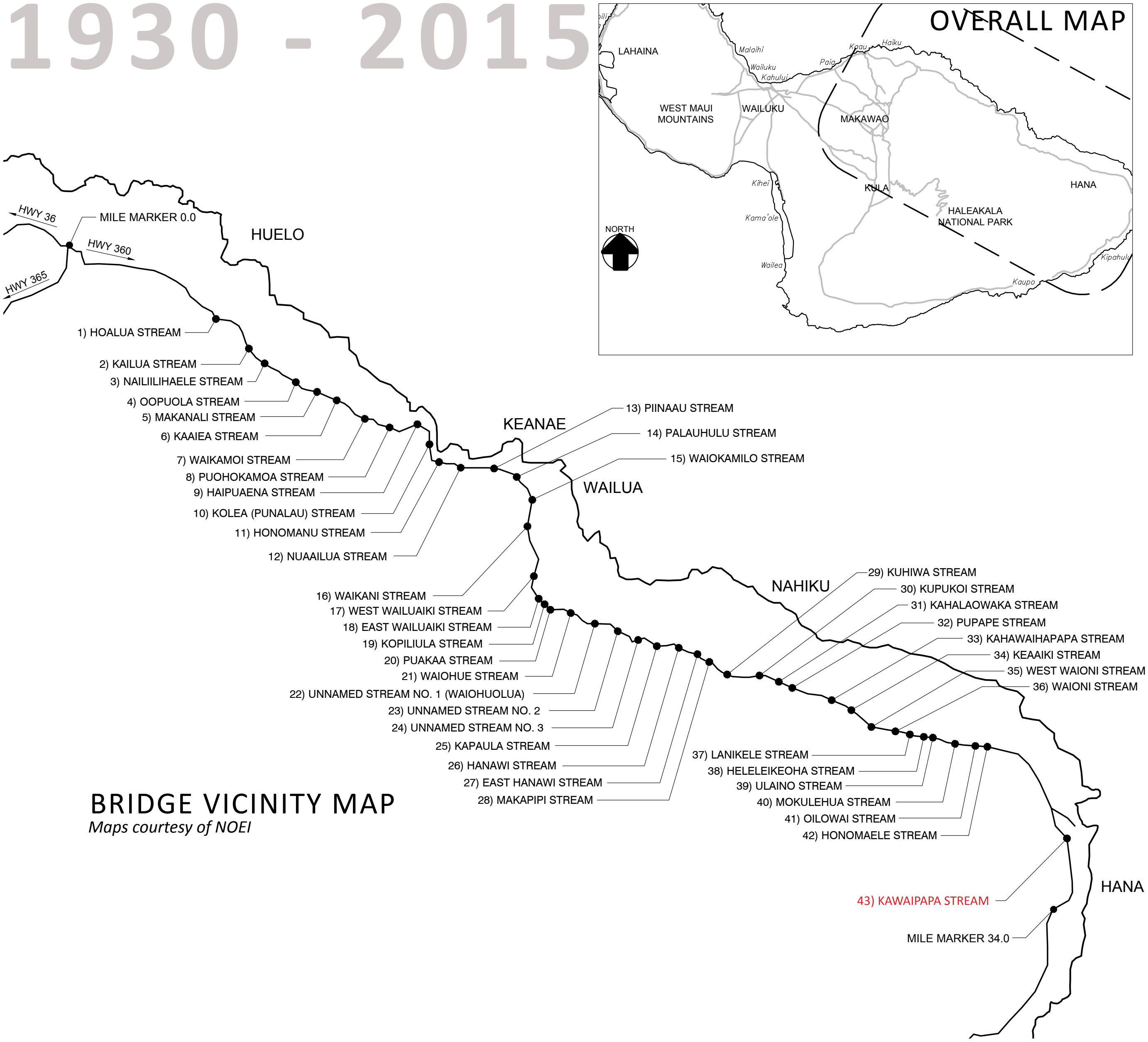
DOT records state that the [#26] *Hanawi Bridge, which is a twin bridge of* [#29] *Kuhiwa, was also built in 1926. The SPW Report, however, noted that Hanawi Bridge and its approach were built for $7,600 in 1929. The SPW Report recorded the bridges that were built by the county, and as per the law, checked and approved by the SPW.*[19]

Other bridges built after the completion of the belt road were [#5] *Makanali and* [#6] *Ka`aiea in 1928, and* [#1] *Holua and* [#2] *Kailua in 1929. ... Also built by the County Engineer’s Office after the road opened was Na`ili`iliha`ele Bridge in 1930. The new concrete girder bridge probably replaced the wood bridge built by* [Hugh] *Howell in 1906.*[20]

19 “Hana Belt Road,” Historic American Engineering Record, HAER HI-75 (2005), 48.

20 Ibid.

1930 - 2015



Maps courtesy of NOEI

Bridge plans indicate that portions of the Hana Highway and several bridges were widened during the 1930s.

> "Work on Maui Bridges continued throughout the 1930s with monies from several sources - The Emergency Relief Funds, Hawaii Special Funds and the Public Highway Funds."[21]

According to historic drawings dated November 1939, #15 Waiokamilo Stream Bridge was widened to 34 feet in 1940. The designer, David K. Kapohakimohewa, replaced the original solid parapet railings with a distinctive Greek Cross design and applied the same railing design to the adjacent companion culvert (25C Waiokamilo Culvert).

According to drawings dated April 1939, #12 Nuaailua Stream Bridge was widened to 24 feet circa 1939 – 1940. Although the widened design called for the replacement of the solid parapet railings, the upstream railing was left in place. This makes this a "hybrid" bridge with one solid parapet and a newer downstream open picket railing. This is the only such example along the Hana Highway.

> *In addition to road widening, the Works Progress Administration completed some paving in the Wailua area in 1936. Although paving was included as part of Low's 1923 estimates, the road was not entirely paved until the 1960s.*[22]

21 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 6.

22 *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 23.

#15 Waiokamilo Stream Bridge was widened in 1937 and its original solid parapets were replaced with an open Greek cross railing
Courtesy of NOEI

(25C) Waiokamilo Culvert (#15 Waiokamilo Stream Bridge's companion culvert) was also built in 1921 and widened in 1937
Courtesy of NOEI

#43 Kawaipapa Stream Bridge
Courtesy of NOEI

Downstream elevation of double cell box culvert addition to #43 Kawaipapa Stream Bridge
Courtesy of NOEI

One of the last bridges to be built before the town of Hana along Route 360 was #43 Kawaipapa in 1947.[23] This bridge is the only Post WWII bridge along the Hana Highway. When the Hana Belt Road Historic District was nominated to the National Register in 2001, it was deemed that this particular bridge suffered from a loss of integrity due to a significant alteration, and it was thus considered a non-contributing feature within the historic district. The NRHP form states,

> [T]*he bridge was altered in 1991 when a new* [culvert] *was added to the to the west end of the original structure. The 1991 bridge expansion was modeled on the original bridge, with replications of the post-and-beam bridge walls. The consequence of the expanded bridge was that the original bridge lost its historic integrity and is a noncontributing structure.*[24]

23 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 49.

24 *Hana Belt Road*, National Register of Historic Places #20010615 (May 2001), 23.

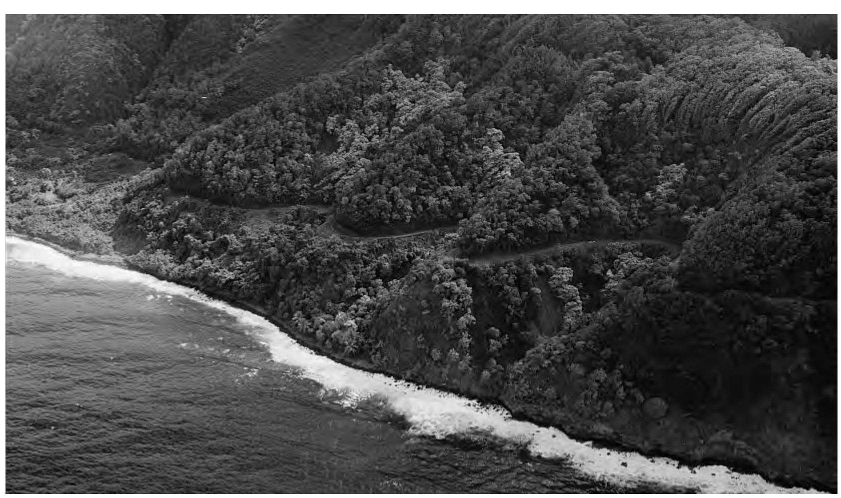
PRESENT DAY HANA
2015

Historic HAER photo of #19 Kopiliula Stream Bridge
Courtesy of HAER HI-75

Much more than a scenic drive, the Hana Belt Road remains the only direct overland route to central Maui for residents of the Hana region's coastal communities. Local residents today refer to the road as their "lifeline" to the rest of Maui. Those early proponents who initially championed a road to Hana and its necessary funding, as well as the engineers and builders who undertook the difficult task to develop and construct this road through its uniquely challenging terrain, had remarkable foresight for the transportation needs of East Maui residents. After completion, it took almost 25 years to fully realize the reality of a paved road that allowed Maui residents to travel to and from Hana with relative ease, during the first half of the 20th century.

Completion of the Hana Belt Road was a lengthy endeavor and required ongoing improvements and alterations during its overall construction in order to accommodate vehicular traffic and reflect changing transportation needs throughout the area. Under the direction of the County Engineer, several bridges were widened during the late 1930s. These changes are occasionally reflected in the historic drawings and as-builts that were available to the team during the research phase of this project.

The last existing bridge to be constructed along the state-owned portion of the Road to Hana is #43 Kawaipapa Stream Bridge (1947), currently the only bridge within the Hana Belt Road Historic District that was considered a non-contributing feature at the time that the National Register nomination was prepared in 2001. Amongst the chain of 43 state-owned bridges, #43 Kawaipapa Stream Bridge is a unique post-war design and its 1991 expansion is reflective of changing transportation and community needs in much the same way that 1930s bridge widening projects attempted to improve existing conditions, as well as anticipate future needs. It is recommended that #43 Kawaipapa Stream Bridge, with community support, be considered a contributing feature within the Hana Belt Road Historic District, because its construction helps fully illustrate the story of developing East Maui's historic and present-day lifeline from Hana to central Maui.



Historic HAER photo of Hana Belt Road
Courtesy of HAER HI-75

SECTION B

BRIDGES

BRIDGES OVERVIEW

The 43 individual chapters presented in this section have been adapted with specific information for each particular bridge, with relevant cultural, historical, and technical information, as well as detailed treatment recommendations for each historic bridge.

Bridge inventory sheets contain the following information:

- Photographs and maps,
- Location information,
- Documentation of existing conditions,
- Structural conditions, such as load rating and overall condition,
- Pertinent considerations adjacent to bridge locations, such as private property, utilities, and signage,
- Archaeological sites identified within vicinity of the bridge,
- Statement of historic/cultural significance and historic references, and
- Character-defining features of each bridge, as well as

Detailed written pages also address:

- References to current civil, electrical, and structural conditions, and identified issues,
- Historic and cultural site context pertinent to each historic bridge location, and
- Site-specific recommendations by the team tailored to the individual conditions at each bridge.

Lastly, current drawings indicate existing conditions and present conceptual treatment recommendations with preferred railing type for each bridge. Historic and related HAER drawings have been included for individual bridges when available.

Bridge Matrix

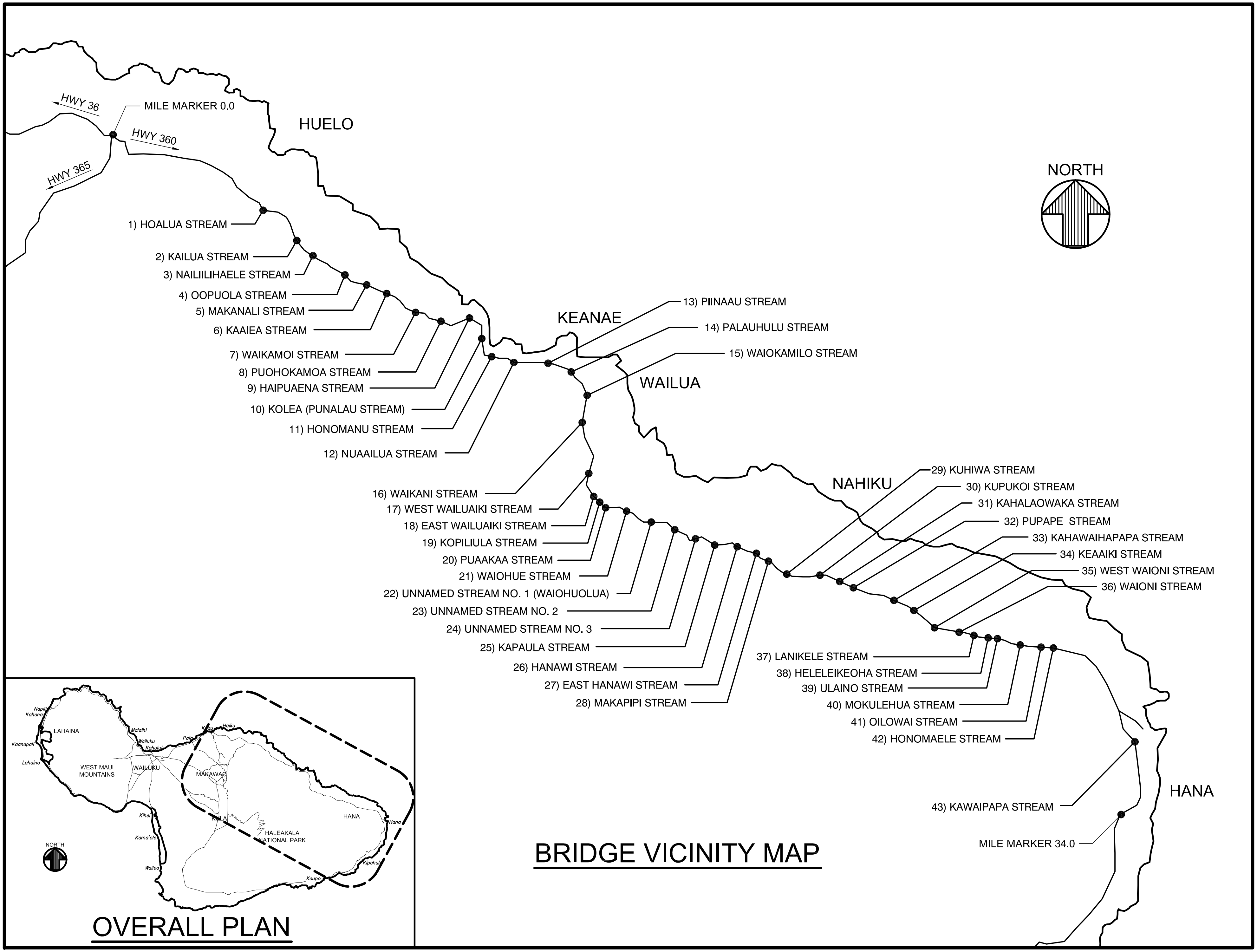
Hana Highway, Route 360

	Bridge Number	Bridge Name	Feature Crossed	Construction Date	Bridge Type	Superstructure	Substructure	Parapets/RailingType
1	009003600500509	Hoalua Stream Bridge	Hoalua Stream	1929	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Vertical
2	009003600500588	Kailua Stream Bridge	Kailua Stream	1929	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
3	009003600500624	Nailiilihaele Bridge	Nailiilihaele Stream	1930	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Multi-column Bent	Concrete Open Vertical
4	009003600500797	Oopuola Bridge	Oopuola Stream	1925	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
5	009003600500824	Makanali Stream Bridge	Makanali Gulch	1928	Concrete Slab	Concrete Slab	Masonry Abutment	Concrete Open Vertical
6	009003600500858	Kaaiea Stream Bridge	Kaaiea Stream	1928	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
7	009003600500990	Waikamoi Stream Bridge	Waikamoi Stream	1912	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Double Column Pier	Concrete Solid
8	009003600501098	Puohokamoa Bridge	Puohokamoa Stream	1912	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Wall Pier	Concrete Solid with Cap
9	009003600501145	Haipuaena Stream Bridge	Haipuaena Stream	1912	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Double Column Pier	Concrete Solid with Cap
10	009003600501317	Kolea (Punala Stream) Bridge	Punalau Stream	1911	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Solid
11	009003600501372	Honomanu Stream Bridge	Honomanu Stream	1911	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Wall Pier	Concrete Solid
12	009003600501540	Nuaailua Bridge	Nuaailua Stream	1911	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Vertical
13	009003600501662	Piinaau Stream Bridge	Piinaau Stream	1916	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Vertical
14	009003600501679	Palauhulu Stream Bridge	Palauhulu Stream	1916	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Vertical
15	009003600501811	Waiokamilo Stream Bridge	Waiokamilo Stream	1921	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Greek Cross
16	009003600501942	Waikani Stream Bridge	Waikani Stream	1926	Open Spandrel Arch	Concrete Open Spandrel Arch	Concrete Abutment Wall	Concrete Open Vertical
17	009003600502086	West Wailuaiki Stream Bridge	West Wailuaiki Stream	1937	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Wall Pier	Concrete Open Vertical
18	009003600502131	East Wailuaiki Stream Bridge	East Wailuaiki Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
19	009003600502189	Kopiliula Stream Bridge	Kopiliula Stream	1926	Concrete Girder	Concrete Through Girder	Concrete Abutment Wall and Concrete Double Column Pier	Concrete Solid
20	009003600502231	Puaakaa Stream Bridge	Puakaa Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Vertical
21	009003600502250	Waiohue Stream Bridge	Waiohue Stream	1937	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Rubble Masonry Pier	Concrete Solid with Cap
22	009003600502298	Unnamed Bridge No. 1 (Waiohuolua Bridge)	Unnamed Stream	1920	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Solid with Cap
23	009003600502300	Unnamed Bridge No. 2	Unnamed Stream	1920	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Solid with Cap

Bridge Matrix

Hana Highway, Route 360

	Bridge Number	Bridge Name	Feature Crossed	Construction Date	Bridge Type	Superstructure	Substructure	Parapets/RailingType
24	009003600502301	Unnamed Bridge No. 3	Paakea Gulch	1920	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Solid
25	009003600502339	Kapaula Stream Bridge	Kapaula Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Wall Pier	Concrete Open Vertical
26	009003600502402	Hanawi Stream Bridge	Hanawi Stream	1926	Closed Spandrel Arch	Concrete Closed Spandrel Arch	Concrete Abutment Wall	Concrete Open Vertical
27	009003600502419	East Hanawi Stream Bridge	Hanawi Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
28	009003600502502	Makapipi Stream Bridge	Makapipi Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Multi-column Bent	Concrete Open Vertical
29	009003600502523	Kuhiwa Stream Bridge	Kuhiwa Stream	1926	Closed Spandrel Arch	Concrete Closed Spandrel Arch	Concrete Abutment Wall	Concrete Open Vertical
30	009003600502546	Kupukoi Stream Bridge	Kupukoi Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
31	009003600502598	Kahalaowaka Stream Bridge	Unnamed Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
32	009003600502652	Pupape Stream Bridge	Manawaikeae Stream	1926	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall	Concrete Open Vertical
33	009003600502664	Kahawaihapapa Stream Bridge	Kahawaihapapa Stream	1922	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Wall Pier	Concrete Open Vertical
34	009003600502681	Keaaiki Stream Bridge	Keaaiki Stream	1921	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
35	009003600502697	West Waioni Stream Bridge	West Waioni Stream	1920	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
36	009003600502702	Waioni Stream Bridge	Waioni Stream	1920	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
37	009003600502779	Lanikele Stream Bridge	Heleleikeoha Stream	1925	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Wall Pier	Concrete Open Vertical
38	009003600502795	Heleleikeoha Stream Bridge	Kakamalaole Stream	1917	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
39	009003600502801	Ulaino Stream Bridge	Ulaino Stream	1914	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Multi-column Bent	Concrete Open Vertical
40	009003600502835	Mokulehua Stream Bridge	Mokulehua Gulch	1908	Concrete Slab	Concrete Slab	Masonry Abutment and Concrete Wall Pier	Concrete Solid
41	009003600502922	Oilowai Stream Bridge	Oilowai Gulch	1914	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment	Concrete Open Vertical
42	009003600502958	Honomaele Stream Bridge	Honomaele Gulch	1924	Concrete Tee Beam	Concrete Tee Beam	Masonry Abutment and Concrete Wall Pier	Concrete Open Vertical
43	009003600503347	Kawaipapa Stream Bridge	Kawaipapa Gulch	1947	Concrete Tee Beam	Concrete Tee Beam	Concrete Abutment Wall and Concrete Wall Pier	Concrete Open Horizontal


HUELO
KEANAE
WAILUA
NAHIKU
HANA
NORTH
HWY 36
HWY 360
HWY 365
MILE MARKER 0.0
1) HOALUA STREAM
2) KAILUA STREAM
3) NAILIILIHAELE STREAM
4) OOPUOLA STREAM
5) MAKANALI STREAM
6) KAAIEA STREAM
7) WAIKAMOI STREAM
8) PUOHOKAMOA STREAM
9) HAIPUAENA STREAM
10) KOLEA (PUNALAU STREAM)
11) HONOMANU STREAM
12) NUAAILUA STREAM
13) PIINAAU STREAM
14) PALAUHULU STREAM
15) WAIOKAMILO STREAM
16) WAIKANI STREAM
17) WEST WAILUAIKI STREAM
18) EAST WAILUAIKI STREAM
19) KOPILIULA STREAM
20) PUAAKAA STREAM
21) WAIOHUE STREAM
22) UNNAMED STREAM NO. 1 (WAIOHUOLUA)
23) UNNAMED STREAM NO. 2
24) UNNAMED STREAM NO. 3
25) KAPAULA STREAM
26) HANAWI STREAM
27) EAST HANAWI STREAM
28) MAKAPIPI STREAM
29) KUHIWA STREAM
30) KUPUKOI STREAM
31) KAHALAOWAKA STREAM
32) PUPAPE STREAM
33) KAHAWAIHAPAPA STREAM
34) KEAAIKI STREAM
35) WEST WAIONI STREAM
36) WAIONI STREAM
37) LANIKELE STREAM
38) HELELEIKEOHA STREAM
39) ULAINO STREAM
40) MOKULEHUA STREAM
41) OILOWAI STREAM
42) HONOMAELE STREAM
43) KAWAIPAPA STREAM
MILE MARKER 34.0
BRIDGE VICINITY MAP
LAHAINA
WEST MAUI MOUNTAINS
WAILUKU
MAKAWAO
HANA
HALEAKALA NATIONAL PARK
NORTH
OVERALL PLAN

01 Hoalua Stream Bridge

01

HOALUA STREAM BRIDGE

Bridge Number	009003600500509			Island	Maui		
Date of Construction	1929			Route	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of FAI

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 53m 42s
Longitude	156d 13m 11s
Mile Point	5.07
Location	5.09 miles east of Kaupakalua Road
Feature Crossed	Hoalua Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	48.88 feet
Number of Spans	1
Maximum Span	47.9 feet
Deck Width	• Curb-to-Curb = 16.73 feet • Out-to-Out = 18.04 feet
Abutment Material	• Concrete Abutment
Wingwall Material	None
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	3
Parapet / Railing Height	• Upstream Railing Height = 25 inches • Downstream Railing Height = 32 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. = 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Hoalua Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1929. The superstructure consists of a concrete deck slab with AC pavement overlay supported on three concrete tee beams, which are spaced approximately 6 feet on-center. The substructure consists of concrete abutments, bearing on natural rock formations on the Kahului side and a CRM wall on the Hana side.

Setting of Hoalua Stream Bridge
Courtesy of NOEI

Hoalua Stream Bridge downstream elevation
Courtesy of FAI

Hana approach to Hoalua Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Hoalua Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Underside of concrete tee beam structure
Courtesy of NOEI

Downstream Hana approach wall
Courtesy of NOEI

Concrete abutment resting on CRM base, Hana side
Courtesy of NOEI

Concrete abutment resting on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	West Hanawana and Hanehoi
Designer / Builder	Unknown
Historic Drawings	None
Alterations	Repair on east end of upstream parapet is not “in-kind”
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of concrete CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• SIHP -3133 is less than 200 meters south • SIHP -3134 is less than 200 meters southeast
Geographical Features / Setting	• Open area with dense, lush, hilly vegetation • Flowering African tulip trees in the distance
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Abutments • Concrete Open Vertical Railings • Unusually long non-arched single-span bridge
Detracting Features	• Excessive asphalt • Inappropriate parapet repair at Kahului downstream end

Significance & Context

Archaeological / Cultural Significance

The place name *Hoalua* is defined as, “Bay, fishing site, landing, Huelo, Maui. Small bay that was a former canoe landing,”[1] or as, “two friends. Land section, Hamakualoa, Maui.”[2] The bridge spans Hoalua Stream, which forms the boundary between Hanehoi Ahupuaa and West Hanawana Ahupuaa.[3]

By the close of the year A. D. 1785 or the beginning of A. D. 1786, Kamehameha had defeated a number of Hawaii chiefs for supremacy of the island of Hawaii. Kamehameha then set his sights on Hana, and assembled an expedition to retake the districts of Hana and Kipahulu, knowing that the governor of Maui, Kahekili, was currently at war on Oahu. According to Kamakau, Kamehameha’s fleet landed at the shore from Hamoa to Kawaipapa.[4] The eldest son of Kahekili, Kalanikupule, was sent to rout the invaders from Hamakualoa. Led by the warrior Kamohomoho, the battle commenced at a small hill called Puukoae, situated on the *makai* side of Puumaile at Hanawana in Hoalua, where the Maui forces were victorious. This caused Kamehameha to beach his forces at Halehaku and force an additional attack alongside of a main road. Kamehameha routed the Maui forces and confronted them with the canon Lopaka. With men to haul the canon and operate it accurately, Kamehameha consolidated his victories and drove the Maui forces to the west. The summit known as Kapuaio Kamehameha in traditional times is located inland within the Halehaku Ahupuaa, in the *moku* of Hamakualoa.

Of this site, Fornander states:

> *About 1790, the chief Kamehameha of Hawaii Island gathered a large force of men and canoes to attack the island of Maui. Kamehameha’s campaign of war in Hamakualoa centered on a battle at a fortified position at Puukoae on Hanawana, which was attacked and taken by Kamehameha, who had brought his battle fleet around to the northern coast of Maui from Hana. The hill is known as “Kapuai-o-Kamehameha,” to the west of Halehaku Stream, is where he camped for the night after taking Puukoae. Kamehameha engaged Kapakahili in battle the following morning. In time, the Maui forces were routed and fled to Kokomo; further inland, where a final stand was made. Kapakahili was killed at Hamakualoa, the Maui men fled and dispersed, and the road to Wailuku lay open to Kamehameha*.[5]

1 John R. K. Clark, *Hawai‘i Place Names: Shores, Beaches and Surf Sites* (Honolulu: University of Hawaii Press, 2002).

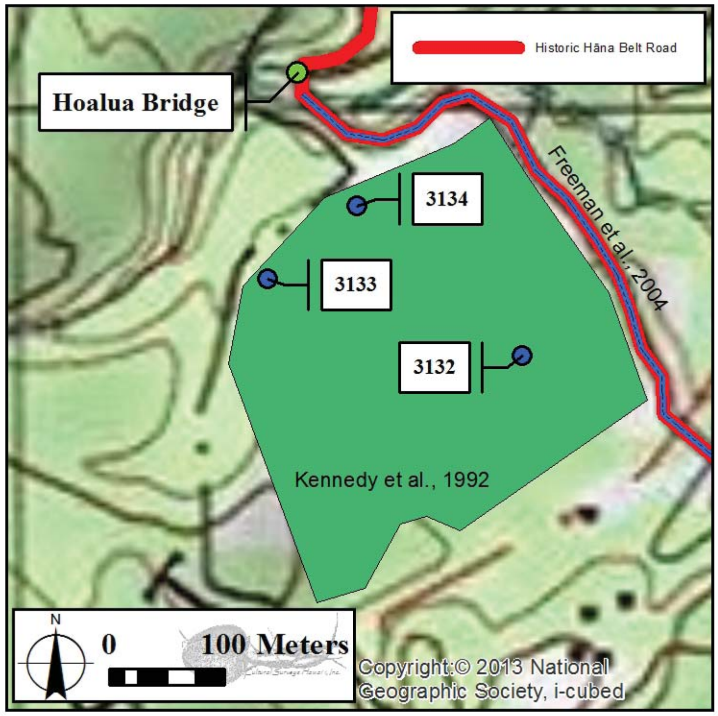
2 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

3 Joseph Iao, “Portion of Hamakualoa & Koolau Maui,” registered map no. 2482, Hawaii Territory Survey (1909).

4 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

5 Abraham Fornander, *An Account of the Polynesian Race; Its Origin and Migrations and the Ancient History of the Hawaiian People to the Times of Kamehameha I*, ed. John F. G. Stokes, 3 vols. (1878-1885).

Refer to Section G, Appendix 1, Section 3.1.1.1.1 for the story of Kamehameha's victory, and to Section G, Appendix 1, Figure 6 for nearby archaeological study areas.[6, 7]



Adjacent Cultural Sites

Walker Site 74, the Pohakuokaia Heiau, was described as being located in Kailua in the Hoalua Region at Hoalua below the church on a bluff near the end of a pineapple field. It was recorded as a small *heiau* with walls of basalt 3 feet high and 6 feet thick, measuring 60 x 30 x 20 x 12 x 28 x 50 feet. Beach stones were utilized in the construction, but no coral or pebbles were observed. Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway.

In 1992, Kennedy and others conducted and archaeological inventory survey with subsurface testing at TMK 2-9-10:3, located on the *mauka* side of Hana Highway near Hoalua Stream Bridge (refer to figure adjacent). Three sites were identified during the survey, including SIHP -3132 (317 meters southeast), a set of five mounds; SIHP -3133 (183 meters south), six agricultural terraces with two *auwai* and three walls; and SIHP -3134 (130 meters southeast), a complex of two irrigated terraces with one *auwai* and five wall segments. Refer to Section G, Appendix 1, Table 2: Previous archaeological studies conducted along Hana Highway, Route 360.

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6 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

7 Joseph Kennedy, Patrick Trimble, Laura Reintsema, and Mary Anne Maigret, "Archaeological Inventory Survey with Subsurface Testing Report at TMK: 2-9-10:3 West Hanawana Ahupuaʻa Makawao District, Island of Maui," inventory survey, Archaeological Consultants of Hawaii, Inc. (Haleiwa: 1992).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by brush and trees • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • No Passing Zone (W14-3) • One Lane Bridge (W5-3) w/ Advisory Speed Plaque (W13-1P (10))
	East Bridge Approach • Yield Sign (Damaged) w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • No Passing Zone (W14-3) • One Lane Bridge (W5-3) w/ Advisory Speed plaque (W13-1P (10 • "Unlawful to Litter $500 Fine" sign
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.37 • Operating Rating = 0.48
Condition	Functionally Obsolete

Civil & Traffic

Hoalua Stream Bridge is located at mile point 5.07 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound approach to the bridge is currently obstructed by brush and trees causing poor visibility of oncoming traffic. The westbound approach to the bridge is currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except for the Yield sign (on the eastbound west bridge approach). Also, there are missing Type 3 Object Markers (Left and Right) on both approaches to the bridge. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on October 9, 2013. The overall condition rating of the bridge at the time of inspection was fair.[8] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach roadway alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings have a height of 25 inches and 32 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.37 and operating rating is 0.48.

The current curb-to-curb dimension is 16.73 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

8 See Glossary for more information for condition ratings.

Recommendation

Base of end post and railing at Hoalua Stream Bridge obscured by asphalt
Courtesy of NOEI

It is recommended that the existing bridge structure of Hoalua Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated October 9, 2013, record drawings,[9] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Hoalua Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix G4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Hoalua Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

9 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74, November 1973.

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Three of the four approach corners have adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision occurring. The upstream Hana approach does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Existing CRM approach wall, obscured by cementitious materials
Courtesy of FAI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Inappropriate repair at Kahului side of downstream railing
Courtesy of NOEI

Detail of inappropriate repair at Kahului side of downstream railing
Courtesy of NOEI

Exterior face of upstream railing obscured by growth
Courtesy of NOEI

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage shall be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash-tested railing design height can be changed to match existing conditions.

Foundations & Abutments

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan.

Although the concrete/CRM abutments are a good intact example of this component along the Hana Highway, Route 360, following investigation of concrete/CRM abutments, if it is determined necessary that this component is to be replaced, the abutments are recommended to be replaced with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. Prior to removal, future design team shall document the existing appearance and condition of the abutments.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments supported on a combination of natural rock and CRM, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-2) and a "To Oncoming Traffic" sign (R1-2a) be added to both bridge approaches. It is also recommended that a yield line and a "right-side" object marker (OM3-R) are added to the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Object Marker Type 3 - Left and Right (OM3-L, OM3-R)
- Replace Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Prune roadside brush and trees

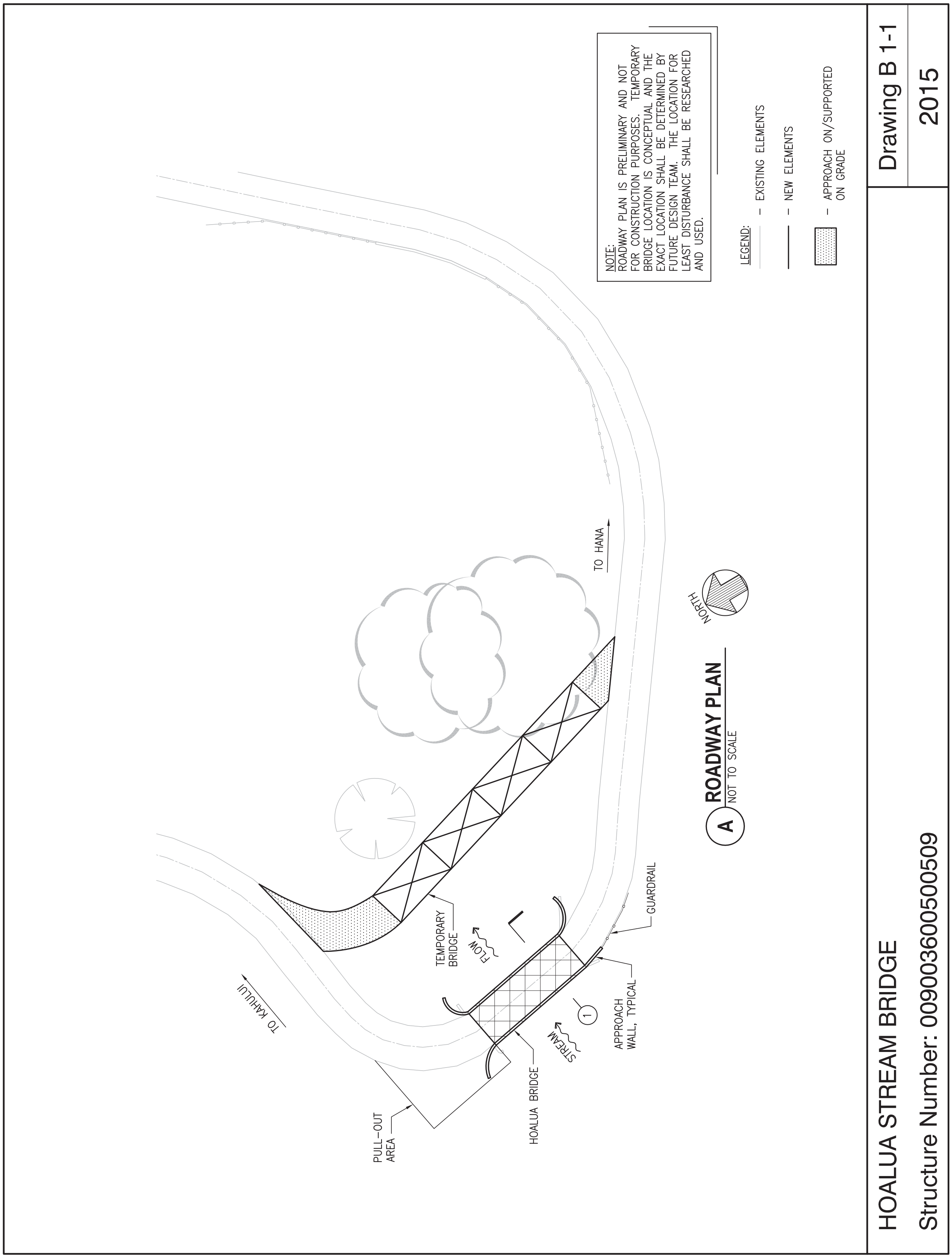
East Bridge Approach

- Add Yield sign (R1-2) and “To On Coming Traffic” plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left and Right (OM3-L, OM3-R)
- Prune roadside brush and trees

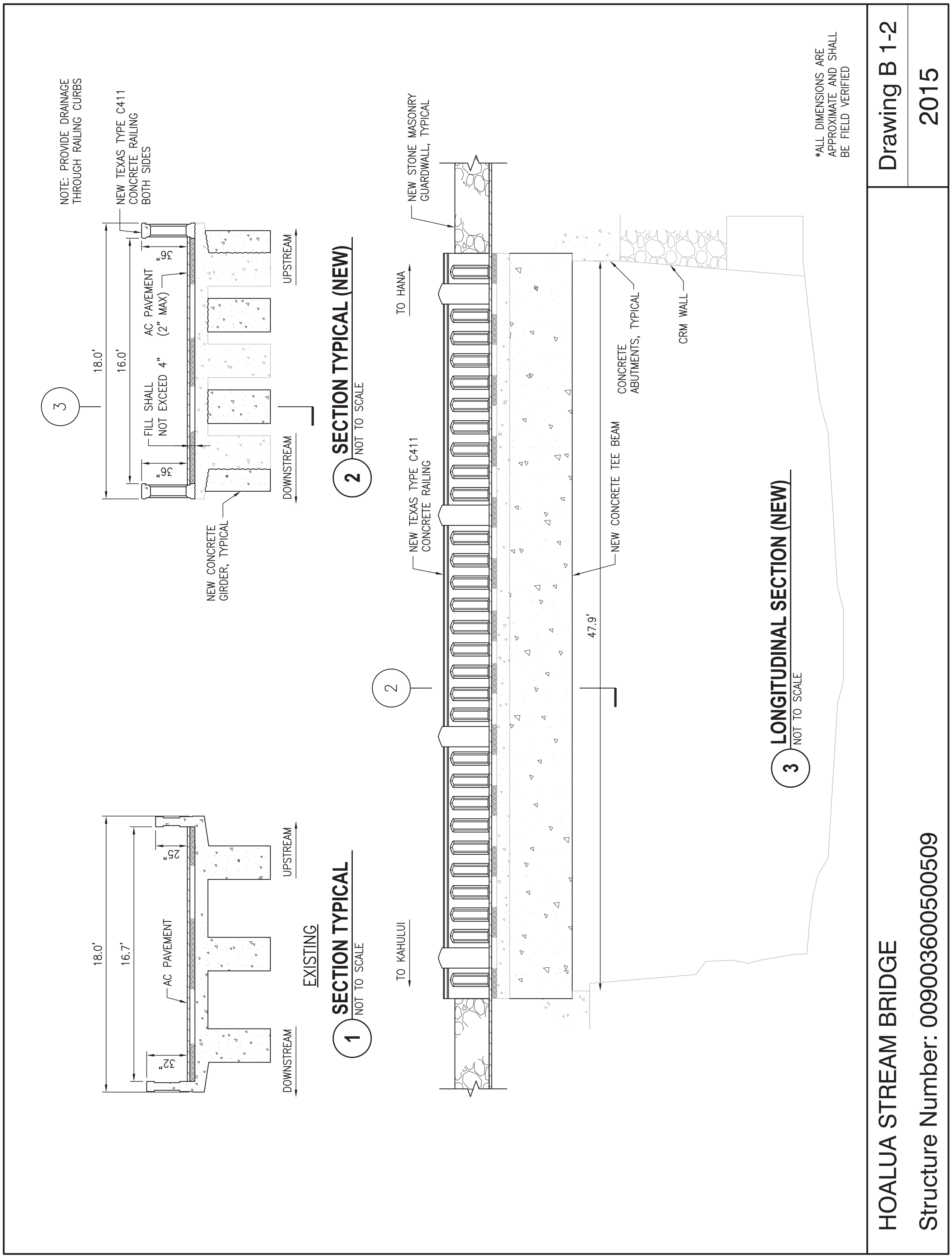
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Hoalua Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

02

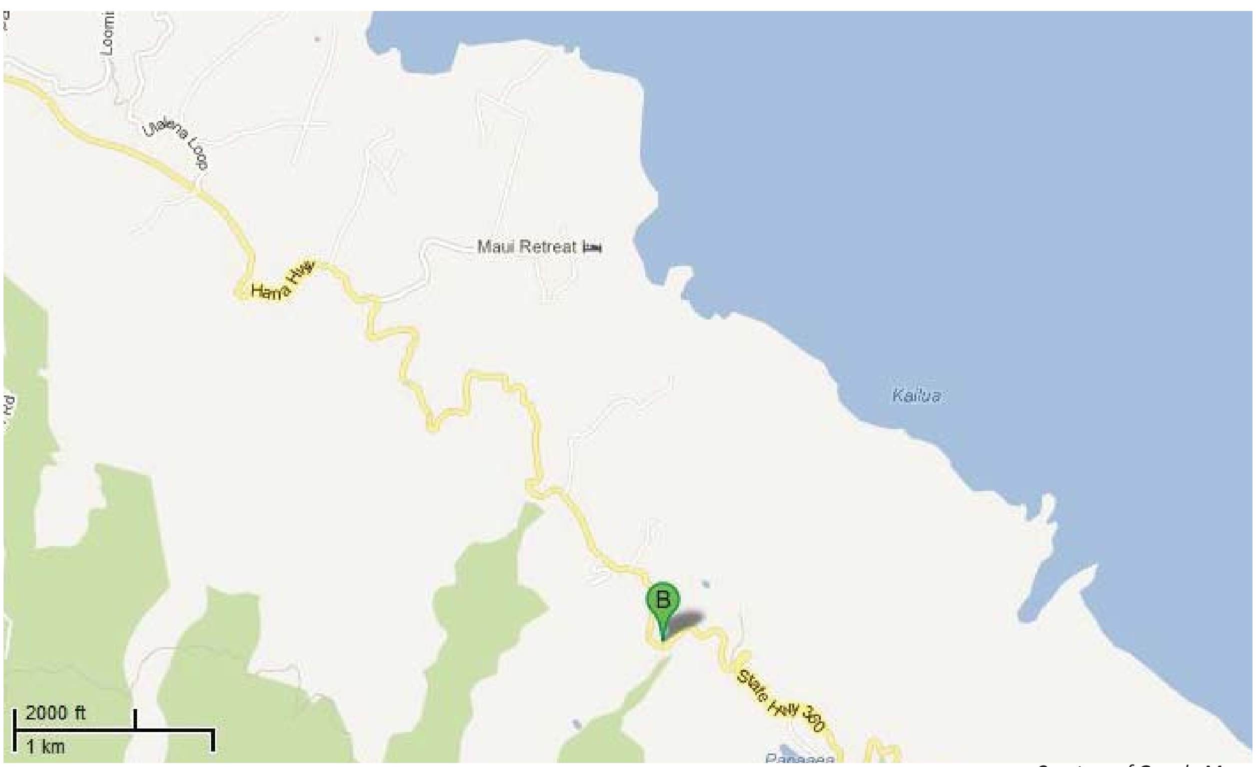
Kailua Stream Bridge

02

KAILUA STREAM BRIDGE

Bridge Number	009003600500588			**Island**	Maui		
Date of Construction	1929			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of FAI



Courtesy of Google Maps

Location

Latitude	20d 53m 16s
Longitude	156d 12m 49s
Mile Point	5.85
Location	6.26 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Kailua Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	40.03 feet
Number of Spans	1
Maximum Span	39.0 feet
Deck Width	• Curb-to-Curb = 20.34 feet • Out-to-Out = 21.65 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	3
Parapet / Railing Height	• Upstream Railing Height = 29 inches • Downstream Railing Height = 38 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. = 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kailua Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1929. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 6 feet on-center. The substructure consists of CRM abutments and wingwalls. The inspection report mentioned that the Kahului abutment bears directly on natural rock formations. The bearing under the Hana abutment is unknown and covered with vegetation.

Setting of Kailua Stream Bridge
Courtesy of FAI

Kailua Stream Bridge downstream elevation
Courtesy of FAI

Hana approach to Kailua Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kailua Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Downstream CRM wingwall, Hana side
Courtesy of NOEI

Downstream CRM wingwall, Kahului side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment set upon natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Puuomaile and Papaaea
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Exceptional example of CRM abutments on Hana Highway • Exceptional example of CRM wingwalls on Hana Highway • Exemplary example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Small concrete footing upstream of east abutment may be from an earlier bridge
Geographical Features / Setting	• Adjacent to residence on bluff above • Dry, shallow, rocky streambed with low-slope stream • Low shrubs and trees with grassy hill below house • Dense vegetation
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Open Vertical Railings • CRM Abutments • CRM Wingwalls • Natural Rock Formations • Unusually long non-arched single-span bridge
Detracting Features	• Excessive asphalt

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he present bridge replaced an earlier wooden truss structure built in 1902 as a wagon bridge. The extension of the Hana Highway commenced here in the 1920s. The County set up a convict camp in 1923 in Kailua to house convict laborers paving the road in the direction of Keanae. A similar camp at Keanae housed free laborers working in the opposite direction."[1] Other "[s]imilar replacement projects were conducted at Na'ili'ilihaele, Kea'aiki, Oiliwai [*sic*], Manawaikeae, and Kuhiwa."[2]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[3]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[4]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[5]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[6] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[7] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

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1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 63.

2 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 30.

3 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

4 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

5 Ibid.

6 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

7 "Roads and Bridges of County Weather Heavy Rain Storms," Maui News, April 6, 1927.

Archaeological / Cultural Significance

The place name Kailua is defined as, "gulch, Paia area; stream, Haiku area, east Maui… Lit., two seas."[8] The Kailua Stream Bridge spans Kailua Stream, which forms the border between Puuomaile and Papaaea Ahupuaa.[9, 10]

The *makai* side of Puuomaile was the scene of the battle between Kamehameha's army from Hawaii Island and that of the Maui chief Kalanikupule. The warrior Kapa-kahili commanded the Maui forces, but he was defeated by Kamehameha. The armies of Kapa-kahili were routed, and when they fled the battle, they were pursued and caught. As the Maui forces attempted to climb Opaepilau Gulch, they were overtaken and killed off by Kamehameha.[11]

According to Kamakau, a tradition of the Papaaea-Keanae region was that this area was the abode of the Hawaiian god of thunder, Kanehekili. Thunder and lightning were very strong in the days before European contact, and worship of the god Kanehekili was encouraged by special *kahuna* who could claim that they were descendants of this god.[12]

Also according to Kamakau, Kiha a Piilani's search for those who would help him in his war against Lono a Piilani included the seeking out of a wise person at Papaaea named Kukui hooleilei, who, in turn, directed Kiha a Piilani to the wise man Kaluko in the uplands of Keanae.[13]

In the early 1870s, the third, and last Catholic mission chapel in the Keanae district was located close to Kailua, about midway between Keanae and Peahi. It was a very small chapel dedicated to St. Augustine. It was built by Father James Beissel. In the course of many years, it has undergone much patching up, but basically it is the same old church, standing alone, close to the road.[14]

Both the Hamakua Ditch Company (precursor of the EMI Company), and the Haiku Sugar Company, managed by Samuel T. Alexander, commenced the construction of a ditch to acquire the water between the Honopou and Nailiilihaele streams. This project to construct the Hamakua Ditch took place in 1876. The digging of the Hamakua Ditch was a work of no small magnitude. A large gang of men, sometimes numbering two hundred, was employed in the work, and the providing of food, shelter, tools, etc., was equal to the care of a regiment of soldiers on the march. All the heavy timbers for flumes, etc., were painfully dragged up hill and down, and in and out of deep gulches, severely taxing the energies and strength of man and beast.[15]

The Halehaku Gulch is 250 feet wide and is crossed by the siphons of the Lowrie Irrigation Canal, which originated in Kailua and was constructed between the Kailua reservoir and Huelo in 1900 by the Spreckelsville Plantation.[16] The water of this canal is tapped at the 457-foot elevation of Kailua Gulch just above a reservoir, after which the water

8 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

9 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

10 U.S. Geological Survey, ed., *Haiku Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

11 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

12 Samuel Kamakau, *Na Hana a Ka Po'E Kahiko, the Works of the People of Old* (Honolulu: Bishop Museum Press, 1976).

13 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

14 Robert Schoofs, *Pioneers of the Faith: History of the Catholic mission in Hawaii, 1827-1940* (Honolulu: Louis Boeynaems, 1978).

15 Thomas G. Thrum, "Reinforced Concrete Siphon at Kailua," The Hawaiian Planter's Record, ed. C. F. Eckart (Hawaiian Sugar Planter's Association, 1918).

16 Wade W. Thayer, "The Lowrie Irrigation Canal," *Hawaiian Almanac and Annual* (1900-1901), 155-161.

enters an 800-foot-long tunnel. In 1900, Thayer reported that the roadway ceased at Kailua, and that continuing on to Hana was only possible by a trail. A reservoir was built at Papaaea, in the region where Kiha a Piilani began the construction of his *ala loa* [long road].[17]

In 1904, John Wilson and John Duggan became partners and were awarded the contract to begin to build the section of the road between Kailua and Keanae. The original specifications for the road to Hana are not known, but the improvements could not have been much more than a rough horse trail surfaced with stones.[18]

In the early 1920s, County engineer Paul Low divided the construction of the remaining sections of the Hana Belt Road into two: the Kailua to Keanae section, which measured 11.67 miles, and the Keanae to Wailua Iki section, which measured 5.66 miles. Construction from Kailua to Keanae was accomplished between 1923 and 1925. During the early 1920s, when the County of Maui Board of Supervisors were working to reduce construction costs for the Hana Belt road, planning included the use of a workforce of 50 prison laborers, to be housed in a prison labor camp to be constructed at a site east of Kailua. By 1923, the prison labor camp east of Kailua was ready.[19]

Refer to Section G, Appendix 1, Section 3.1.1.4 through Section 3.1.1.7 for the regional background summary of Kailua; Section G, Appendix 1, Section 3.1.4 for the history of the construction of the Hana Belt Road; and to Section G, Appendix 1, Figure 6 for nearby archaeological study areas.[20]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of the Kailua Stream Bridge.

17 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

18 Bob Krauss, *Johnny Wilson: First Hawaiian Democrat* (Honolulu: University of Hawaii Press, 1994).

19 Dawn E. Duensing, “The Hana Belt Road: Paving the Way for Tourism,” *The Hawaiian Journal of History* 41 (Honolulu: Hawaiian Historic Society, 2007).

20 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	Two Lanes (currently used as One Lane)
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by brush and trees • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Yield Sign (Damaged) w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left Object Marker (OM3-L)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.37 • Operating Rating = 0.47
Condition	Functionally Obsolete

Civil & Traffic

Kailua Stream Bridge is located at mile point 5.85 along Hana Highway and its existing conditions are as follows. This bridge is an observed one-lane bridge with an out-to-out width of 21.65 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound approach to the bridge it is currently obstructed by brush and trees causing poor visibility of oncoming traffic. The westbound approach to the bridge is currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on October 9, 2013. The overall condition rating of the bridge at the time of inspection was good.[21] The SI&A sheet for this bridge describes it as having two lanes on the structure. Bridge inspection photos show that the structure is not striped for two lanes and is posted with a "Yield to oncoming traffic" sign at the Kahului approach; therefore, this bridge is being utilized as a one-lane bridge. This bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach roadway alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in poor condition. The upstream and downstream railings had a height of 29 inches and 38 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.37 and the operating rating is 0.47.

The current curb-to-curb dimension is 20.34 feet, which for a one-lane bridge is adequate for this project's criteria minimum of 16 feet.

21 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kailua Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated October 9, 2013 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kailua Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Kailua Stream Bridge is currently used as a one-lane bridge and meets the standard width of a one-lane bridge; therefore, no widening is needed. Due to the curb-to-curb width and the curvature of the approach to this bridge, it is recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excessive asphalt overlay at the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Opening at existing CRM approach wall
Courtesy of FAI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance,

Damaged intermediate post with panel detail
Courtesy of NOEI

Good example of exposed curb base of open vertical railings
Courtesy of FAI

Exemplary CRM wingwalls, viewed from bridge
Courtesy of FAI

may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with a reconstructed CRM rock façades. To achieve this, the existing façades of the CRM abutments and CRM wingwalls are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM abutments and CRM wingwalls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM abutments and CRM wingwalls are to be placed in front of the new reinforced concrete abutments and wingwalls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

The existing CRM abutments and CRM wingwalls are exemplary examples of these bridge components. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of exemplary historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The natural rock foundations of this bridge are unique in the bridge's construction and contribute to the overall setting of the bridge. Therefore, all efforts should be made to preserve the appearance of the natural rock during bridge rehabilitation work. Documentation of the existing foundations is strongly recommended if it is not feasible to retain the natural rock foundations in future projects.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. Also, a chloride concentration analysis is recommended to be conducted on existing concrete girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. An object marker is recommended to be placed at the right-side bridge end treatment at the west approach of the bridge. A "Yield" sign (R1-1), "To Oncoming Traffic" sign (R1-2a) and yield line are recommended to be added to the east approach of the bridge. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Prune roadside brush and trees

East Bridge Approach

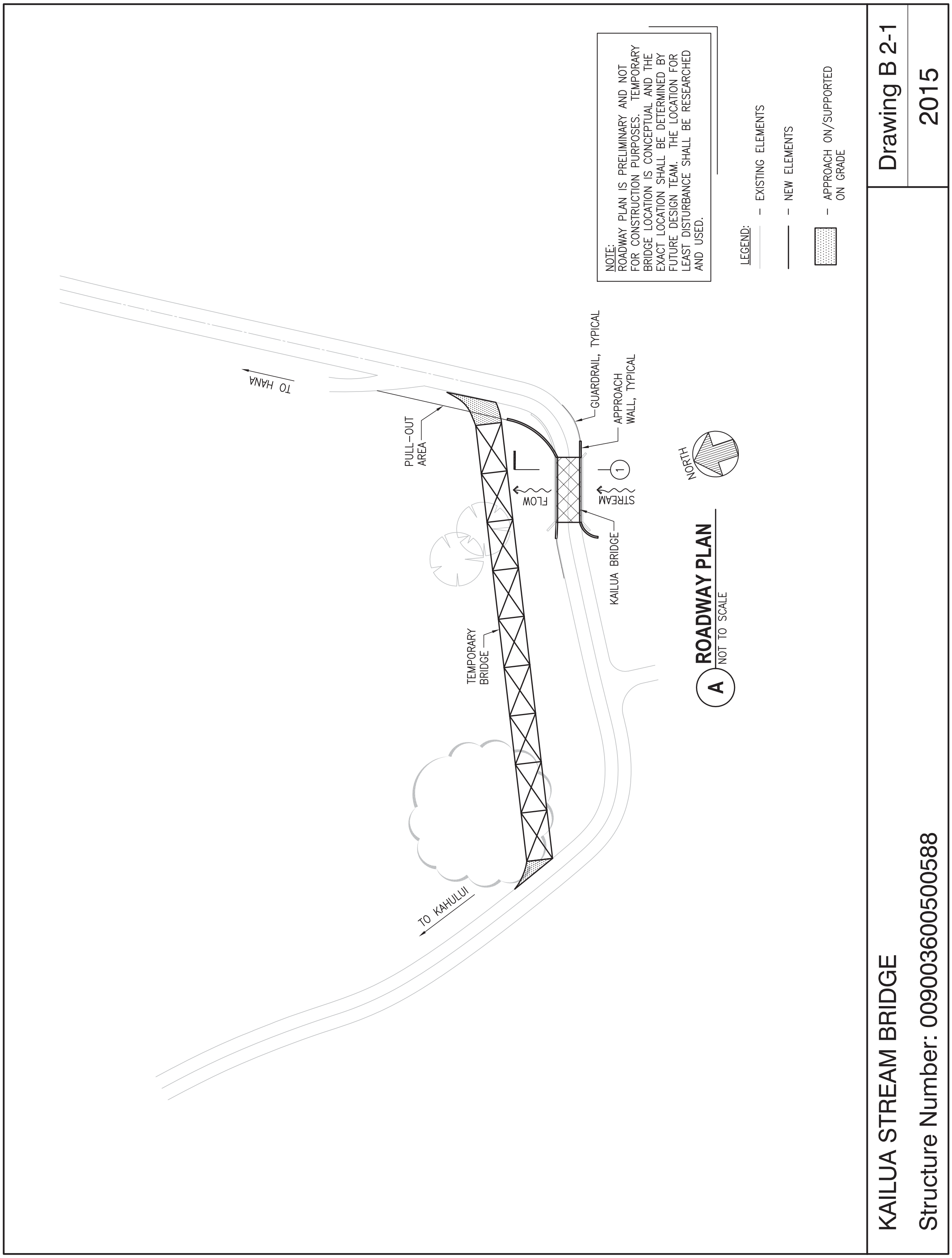
- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

- Add Object Marker Type 3 - Left (OM3-L)
- Prune roadside brush and trees

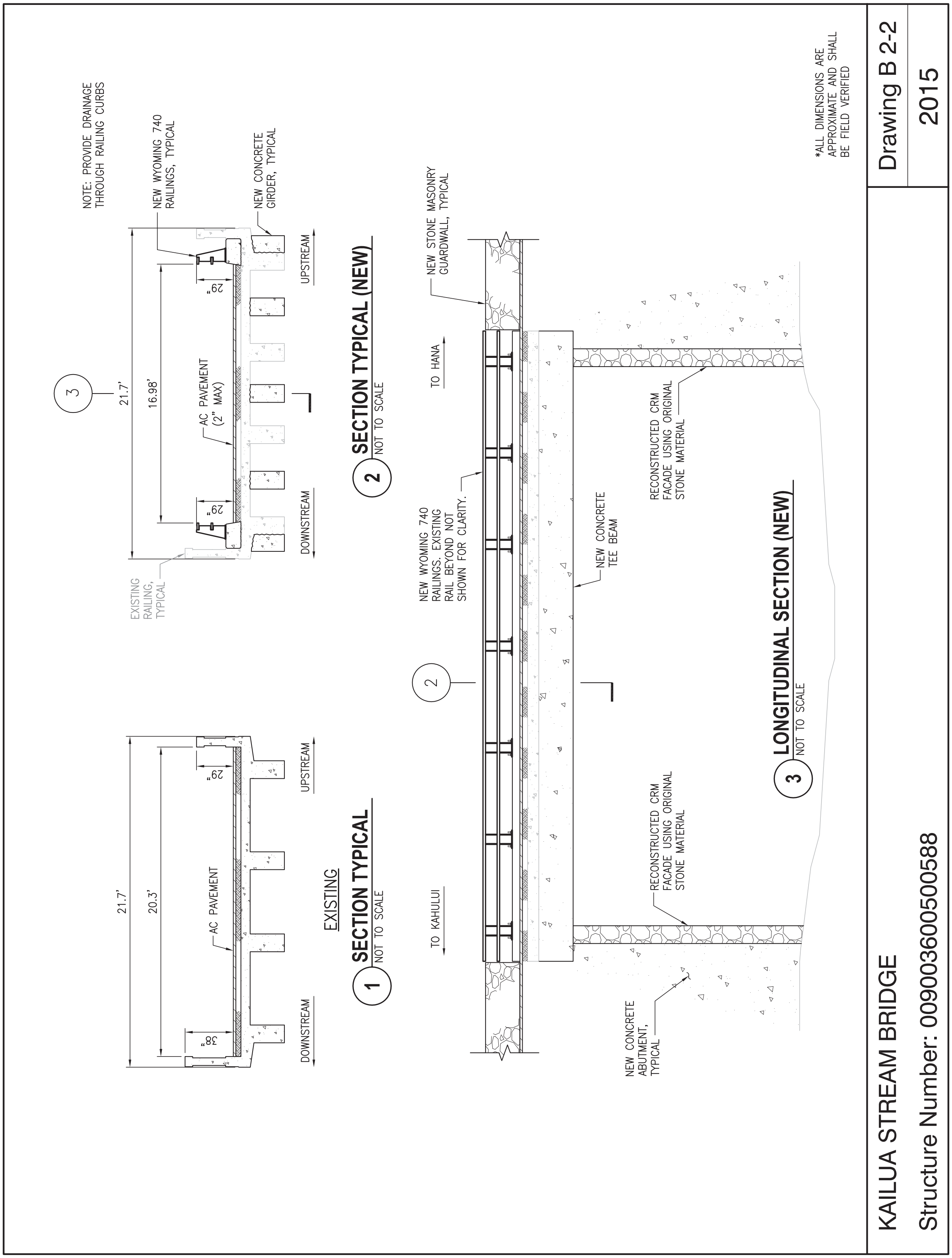
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

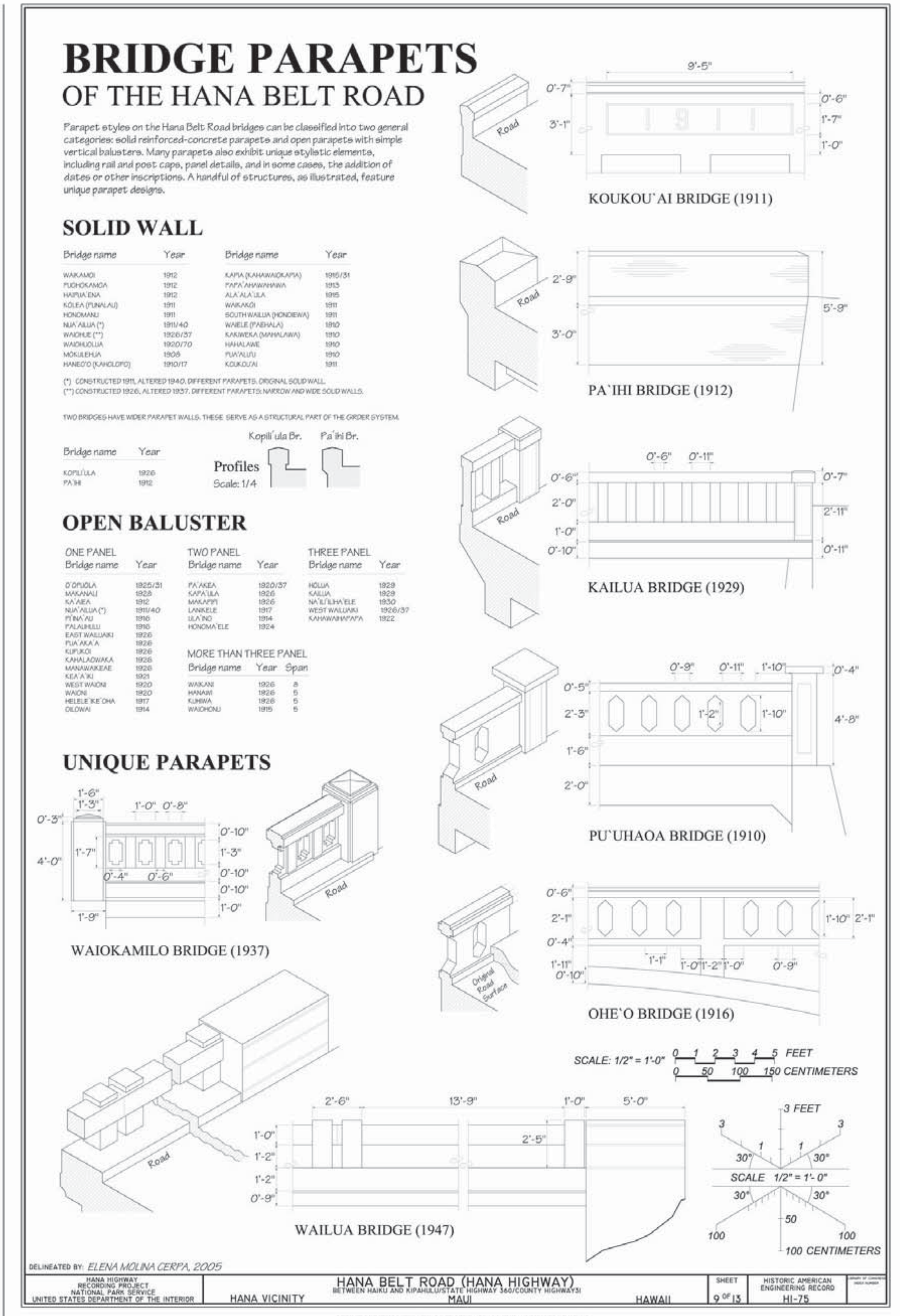
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Kailua Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



BRIDGE PARAPETS
OF THE HANA BELT ROAD

Parapet styles on the Hana Belt Road bridges can be classified into two general categories: solid reinforced-concrete parapets and open parapets with simple vertical balusters. Many parapets also exhibit unique stylistic elements, including rail and post caps, panel details, and in some cases, the addition of dates or other inscriptions. A handful of structures, as illustrated, feature unique parapet designs.

SOLID WALL

Bridge name	Year	Bridge name	Year
WAIKAMOI	1912	KAPIA (KAHAWAIOKAPIA)	1915/31
PUOHOKAMOA	1912	PAPA'AHAWAHAWA	1913
HAIPUA'ENA	1912	ALA'ALA'ULA	1915
KOLEA (PUNALAU)	1911	WAIKAKOI	1911
HONOMANU	1911	SOUTH WAILUA (HONOIEWA)	1911
NUA'AILUA (*)	1911/40	WAIELE (PAEHALA)	1910
WAIOHUE (**)	1926/37	KAKIWEKA (MAHALAWA)	1910
WAIOHUOLUA	1920/70	HAHALAWE	1910
MOKULEHUA	1908	PUA'ALU'U	1910
HANEO'O (KAHOLOPO)	1910/17	KOUKOU'AI	1911

(*) CONSTRUCTED 1911, ALTERED 1940. DIFFERENT PARAPETS. ORIGINAL SOLID WALL.
(**) CONSTRUCTED 1926, ALTERED 1937. DIFFERENT PARAPETS: NARROW AND WIDE SOLID WALLS.

TWO BRIDGES HAVE WIDER PARAPET WALLS. THESE SERVE AS A STRUCTURAL PART OF THE GIRDER SYSTEM.

Bridge name	Year
KOPILI'ULA	1926
PA'IHI	1912

Profiles
Scale: 1/4
Kopili'ula Br. Pa'ihi Br.

OPEN BALUSTER

ONE PANEL

Bridge name	Year
O'OPUOLA	1925/31
MAKANALI	1928
KA'AIEA	1912
NUA'AILUA (*)	1911/40
PI'INA'AU	1916
PALAUHULU	1916
EAST WAILUAIKI	1926
PUA'AKA'A	1926
KUPUKOI	1926
KAHALAOWAKA	1926
MANAWAIKEAE	1926
KEA'A'IKI	1921
WEST WAIONI	1920
WAIONI	1920
HELELE'IKE'OHA	1917
OILOWAI	1914

TWO PANEL

Bridge name	Year
PA'AKEA	1920/37
KAPA'ULA	1926
MAKAPIPI	1926
LANIKELE	1917
ULA'INO	1914
HONOMA'ELE	1924

THREE PANEL

Bridge name	Year
HOLUA	1929
KAILUA	1929
NA'ILI'ILIHA'ELE	1930
WEST WAILUAIKI	1926/37
KAHAWAIHAPAPA	1922

MORE THAN THREE PANEL

Bridge name	Year	Span
WAIKANI	1926	8
HANAWI	1926	5
KUHIWA	1926	5
WAIOHONU	1915	5

UNIQUE PARAPETS

WAIOKAMILO BRIDGE (1937)

WAILUA BRIDGE (1947)

KOUKOU'AI BRIDGE (1911)

PA'IHI BRIDGE (1912)

KAILUA BRIDGE (1929)

PU'UHAOA BRIDGE (1910)

OHE'O BRIDGE (1916)

SCALE: 1/2" = 1'-0" 0 1 2 3 4 5 FEET
0 50 100 150 CENTIMETERS

DELINEATED BY: ELENA MOLINA CERPA, 2005

HANA HIGHWAY RECORDING PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

HANA VICINITY

HANA BELT ROAD (HANA HIGHWAY)
BETWEEN HAIKU AND KIPAHULU/STATE HIGHWAY 360/COUNTY HIGHWAY31
MAUI

HAWAII

SHEET 9 OF 13

HISTORIC AMERICAN ENGINEERING RECORD
HI-75

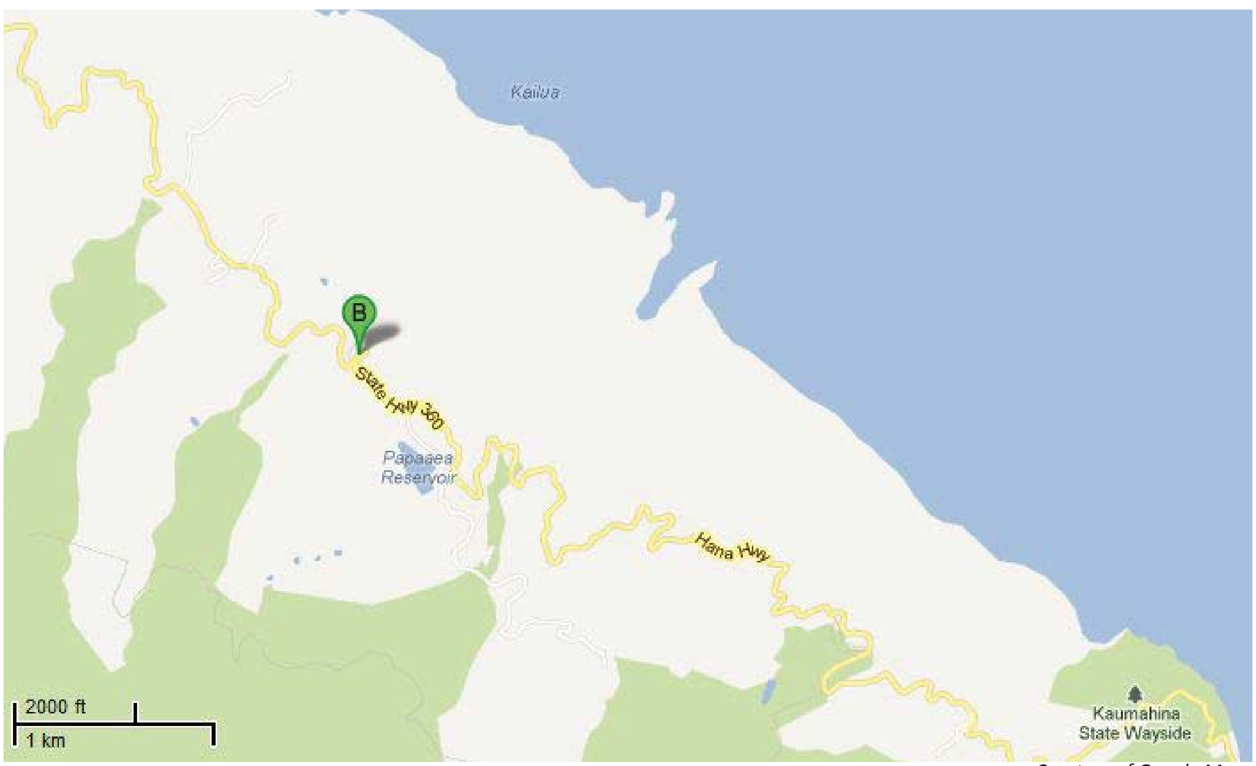
Courtesy of HAER HI-75

03 Nailiilihaele Stream Bridge

03 NAILIIILIHAELE STREAM BRIDGE

Bridge Number	009003600500624			**Island**		Maui	
Date of Construction	1930			**Route**		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 53m 13s
Longitude	156d 12m 37s
Mile Point	6.20
Location	5.90 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Nailiilihaele Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	63.98 feet
Number of Spans	3
Maximum Span	21.0 feet
Deck Width	• Curb-to-Curb = 19.66 feet • Out-to-Out = 22.00 feet
Abutment Material	• CRM Abutment (Hana) • Rubble Concrete Abutment (Kahului) • Reinforced Concrete Pier Cap and Columns on a Rubble Concrete Pier Wall
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	3
Parapet / Railing Height	• Upstream Railing Height = 34 inches • Downstream Railing Height = 34 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • Intermediate posts = 12 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Nailiilihaele Stream Bridge is a triple-span reinforced concrete tee beam bridge built in 1930. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 6 feet on-center in each span. The substructure consists of a CRM abutment on the Hana side, a concrete abutment on the Kahului side, and two piers, which are comprised of a reinforced concrete pier cap and columns supported on a rubble concrete pier wall. The bearing under the abutments and piers is unknown and covered beneath earth fill, rocks, and/or water.

Setting of Nailiilihaele Stream Bridge
Courtesy of FAI

EMI System located at upstream side of Nailiilihaele Stream Bridge; Unconnected pier remnant, Kahului side, visible in foreground
Courtesy of FAI

Hana approach to Nailiilihaele Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Nailiilihaele Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

End post detail, upstream railing
Courtesy of FAI

Concrete pier cap and pier columns supported on pier wall, 1 of 2
Courtesy of NOEI

Board-formed rubble concrete abutment, Kahului side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Papaaea and Papaaea Nui
Designer / Builder	County Engineer's Office - Unknown Designer Plans approved by Lyman H. Bigelow, Superintendent of Public Works
Historic Drawings	November 1929
Alterations	Unconnected pier remnant, upstream Kahului side
Replacement	None
Preservation Priority	Exceptional Curved Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of five bridges with curved parapets on Hana Highway, Route 360 • Exceptional example of CRM abutment (Hana) on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Exceptional example of concrete pier walls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• EMI System
Geographical Features / Setting	• Scenic, rural setting • Wide, deep stream • Lush vegetation
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutment (Hana) • Board-formed Rubble Concrete Abutment (Kahului) • Reinforced Concrete Pier Caps and Columns, with Rubble Concrete Pier Walls • CRM Wingwalls • Concrete Open Vertical Railings • Alignment: On curve with a view of EMI components
Detracting Features	• Excessive asphalt • Damaged and spalled railing components

Significance & Context

Bridge Site History

Historic drawings, dated November 1929, show the original 12-foot-wide wagon bridge (likely wood) that the existing bridge replaced. The original bridge was located upstream of the existing bridge and what appears to be the original mid-span pier of the wagon bridge remains in the streambed. The adjacent dam of the Hamakua ditch also shows in the 1929 bridge plans.

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he present bridge was built in 1930 and replaced an earlier 1906 bridge which carried a wagon road."[1] Other "[s]imilar replacement projects were conducted at [Kailua,] … Keaʻaiki, Oiliwai [*sic*], Manawaikeae, and Kuhiwa."[2]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[3]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[4]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[5]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[6] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[7] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

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1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 135.

2 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 30.

3 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

4 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

5 Ibid.

6 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

7 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

East Maui Irrigation

Nailiilihaele Stream Bridge is one of five historic Hana bridges that is adjacent to the man-made EMI system. The EMI system is a National Historic Civil Engineering Landmark. The EMI System is Hawaii's most dramatic water story. The Old Hamakua Ditch constructed between 1876 and 1878, along with the Reciprocity Treaty between the Kingdom of Hawaii and the United States in 1876, sparked the development of the Hawaiian Sugar industry.

> *• The East Maui Irrigation System demonstrated the feasibility of transporting water from steep tropical forested watersheds, with high rainfall, across difficult terrain to [the] fertile and dry plains [of central Maui]. Sugar production dramatically increased with irrigation and improved cultivation practices.*[8]

The Hamakua Ditch Company (precursor of the EMI Company), and the Haiku Sugar Company, managed by Samuel T. Alexander, commenced the construction of a ditch to acquire the water between the Honopou and Nailiilihaele streams. This project to construct the Hamakua Ditch took place in 1876.

> *The digging of the Hamakua Ditch was a work of no small magnitude. A large gang of men, sometimes numbering two hundred, was employed in the work, and the providing of food, shelter, tools, etc., was equal to the care of a regiment of soldiers on the march. All the heavy timbers for flumes, etc., were painfully dragged up hill and down, and in and out of deep gulches, severely taxing the energies and strength of man and beast.*[9]

The EMI System is the largest privately financed, constructed, and managed irrigation system in the United States.

> *• The construction of the Old Hamakua Ditch sparked major irrigation aqueduct construction on the Hawaiian Islands of Kauai, Oahu, Maui and Hawaii.*
> *• The East Maui Irrigation System was the forerunner of major aqueducts in the Western United States by the Bureau of Reclamation, irrigation districts and regional domestic supplies. Engineer M. M. O'Shaughnessy, in charge of constructing the Koolau Ditch in 1904 and 1905, subsequently built San Francisco Hetch Hetchy water system. Other engineers involved in Hawaii aqueducts subsequently worked in the western states.*[10]
> *• Constructed over a period of 47 years, in several phases, the private irrigation system eventually included 50 miles of tunnels; 24 miles of open ditches, inverted siphons and flumes; and incorporates approximately 400 intakes and 8 reservoirs.*[11]

8 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

9 Thomas G. Thrum, "Reinforced Concrete Siphon at Kailua," *The Hawaiian Planter's Record*, ed. C. F. Eckart (Hawaiian Sugar Planter's Association, 1918).

10 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

11 Ibid.

Archaeological / Cultural Significance

The place name *Nailiilihaele* is defined as, "walking pebbles. Stream, Haleakala, Maui."[12] The Nailiilihaele Stream Bridge spans Nailiilihaele Stream, which forms the border between Papaaea Ahupuaa and Papaaea Nui Ahupuaa.[13, 14]

According to Kamakau, a tradition of the Papaaea-Keanae region was that this area was the abode of the Hawaiian god of thunder – Kanehekili. Thunder and lightning were very strong in the days before European contact, and worship of the god Kanehekili was encouraged by special *kahuna* (priests) who could claim that they were descendants of this god.[15]

Also according to Kamakau, Kiha a Piilani's search for those who would help him in his war against Lono a Piilani included the seeking out of a wise person at Papaaea named Kukui hooleilei, who, in turn, directed Kiha a Piilani to the wise man Kaluko in the uplands of Keanae.[16]

Refer to Section G, Appendix 1, Section 3.1.1.6 – 3.1.1.7 for the regional history near Nailiilihaele Stream Bridge, and to Section G, Appendix 1, Figure 6 for nearby archaeological study areas.[17]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Nailiilihaele Stream Bridge.

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12 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

13 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

14 U.S. Geological Survey, ed., *Haiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

15 Samuel Kamakau, *Na Hana a Ka Po'E Kahiko, the Works of the People of Old* (Honolulu: Bishop Museum Press, 1976).

16 S. M. Kamakau, *Ruling Chiefs of Hawaii,* rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

17 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	Two Lanes (currently used as One Lane)
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by brush and deep trees • West Bound: No yield, Obstructed by brush and deep trees
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.80 • Operating Rating = 1.04
Condition	Functionally Obsolete

Civil & Traffic

Nailiilihaele Stream Bridge is located at mile point 6.20 along Hana Highway and its existing conditions are as follows. This bridge is observed to be a one-lane bridge with an out-to-out width of 22.00 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approach to the bridge are currently obstructed by brush and trees causing poor visibility of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on October 9, 2013. The overall condition rating of the bridge at the time of inspection was fair.[18] The SI&A sheet for this bridge describes it as having two lanes on the structure. Bridge inspection photos show that the structure is not striped for two lanes and is posted with a "Yield to Oncoming Traffic" sign at the Kahului approach; therefore, this bridge is being utilized as a one-lane bridge. This bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 34 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.80 and operating rating is 1.04.

The current curb-to-curb dimension is 19.66 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

18 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Nailiilihaele Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated October 9, 2013, record drawings,[19, 20] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Nailiilihaele Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

The intact nature of the bridge elements, wide clearance for a single-lane bridge, curved design, pier remnant of the original wagon bridge, and view of the adjacent EMI ditch all combine to make this an exceptional bridge to be preserved.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

EMI System located at upstream side of Nailiilihaele Stream Bridge
Courtesy of NOEI

19 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74, November 1973.

20 County Engineer's Office, "Nailiilihaele Bridge," Kailua-Kopiliula Bent Road, Job No. 171, Historic Drawings, November 1929.

Recommendations have been identified per bridge component, as follows:

Deck

The Nailiilihaele Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. Due to the curb-to-curb width and the curvature of the approach to this bridge, it is recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to “Railings/ Parapets” section for more information). AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team’s site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Existing moss-covered approach wall at Nailiilihaele Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge’s traffic safety features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Three of the four approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring.

The downstream Kahului approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Damaged intermediate post; Posts are obscured by dirt
Courtesy of NOEI

Exposed re-bar at girder
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Cracked and spalling concrete at pier connection
Courtesy of NOEI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Piers, Wingwalls, & Abutments

The CRM abutment (Hana side) is recommended to be replaced with a reinforced concrete structure with a reconstructed CRM rock façade. To achieve this, the existing façades of the CRM abutment (Hana side) is to have its rock configuration documented and recorded. Once documentation has been completed, the CRM abutment (Hana side) is to be carefully disassembled. Thorough documentation of the disassembling rock process is required so as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM abutment (Hana side) are to be placed in front of the new reinforced concrete abutment, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. The rubble concrete abutment (Kahului side) is recommended to be replaced with a reinforced concrete structure. However, prior to removal, the future design team shall document the existing appearance, condition, and rubble concrete sublayer.

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete pier walls and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A chloride concentration analysis is recommended to be conducted on the concrete core samples. Based on the results of the chloride concentration analysis, cathodic protection should be considered as a method to prolong the bridge's lifespan. Although the concrete pier walls are an exemplary example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier walls, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions.

The existing CRM abutment (Hana side) and pier wall are exemplary examples of these bridge components. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutment (Hana side), pier wall, and CRM wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. A "Yield" sign (R1-1) and a "To Oncoming Traffic" sign (R1-2a) are recommended to be added to both the east and west bridge approaches. It is also recommended that a yield line is added to the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Prune roadside brush and trees

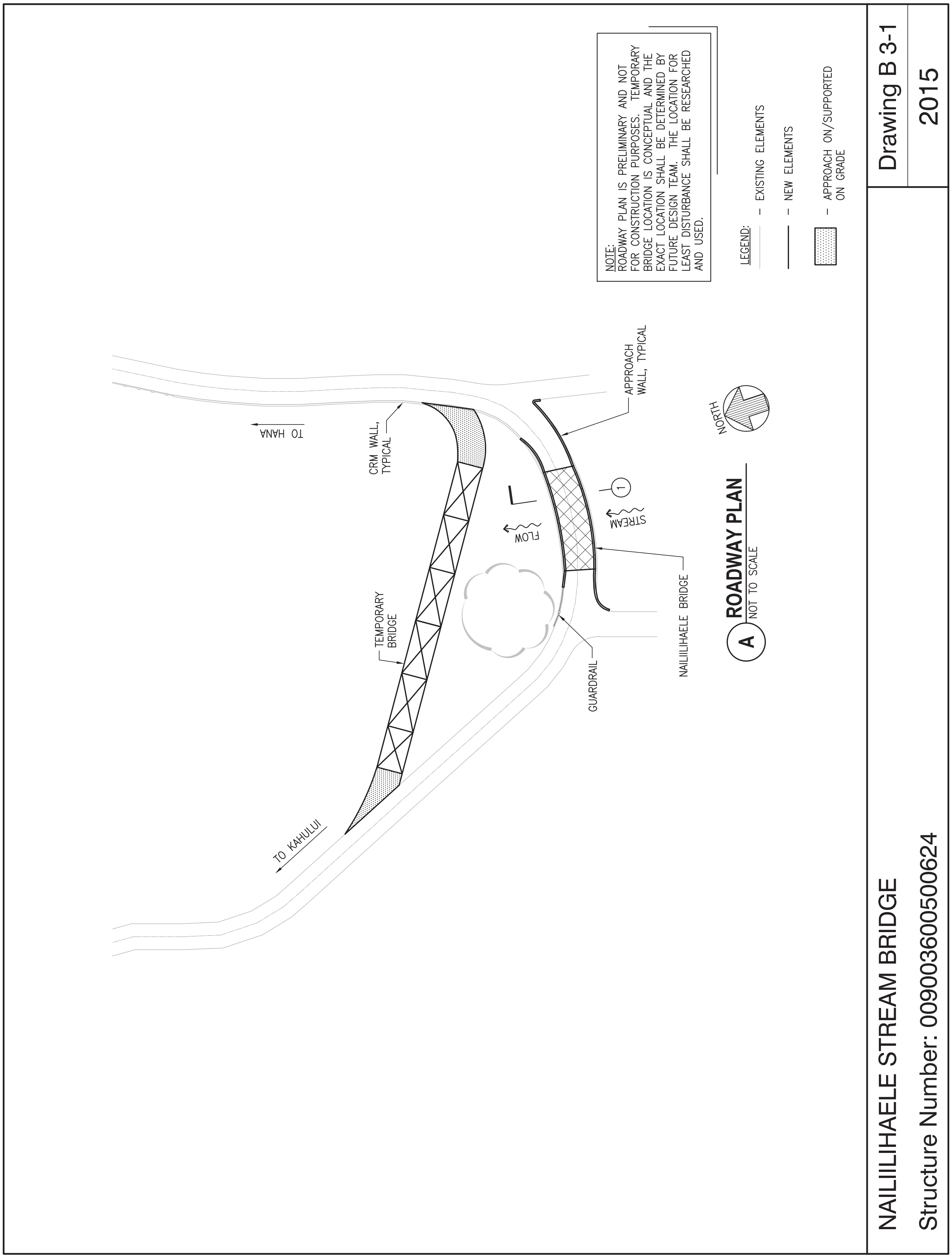
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left (OM3-L)
- Prune roadside brush and trees

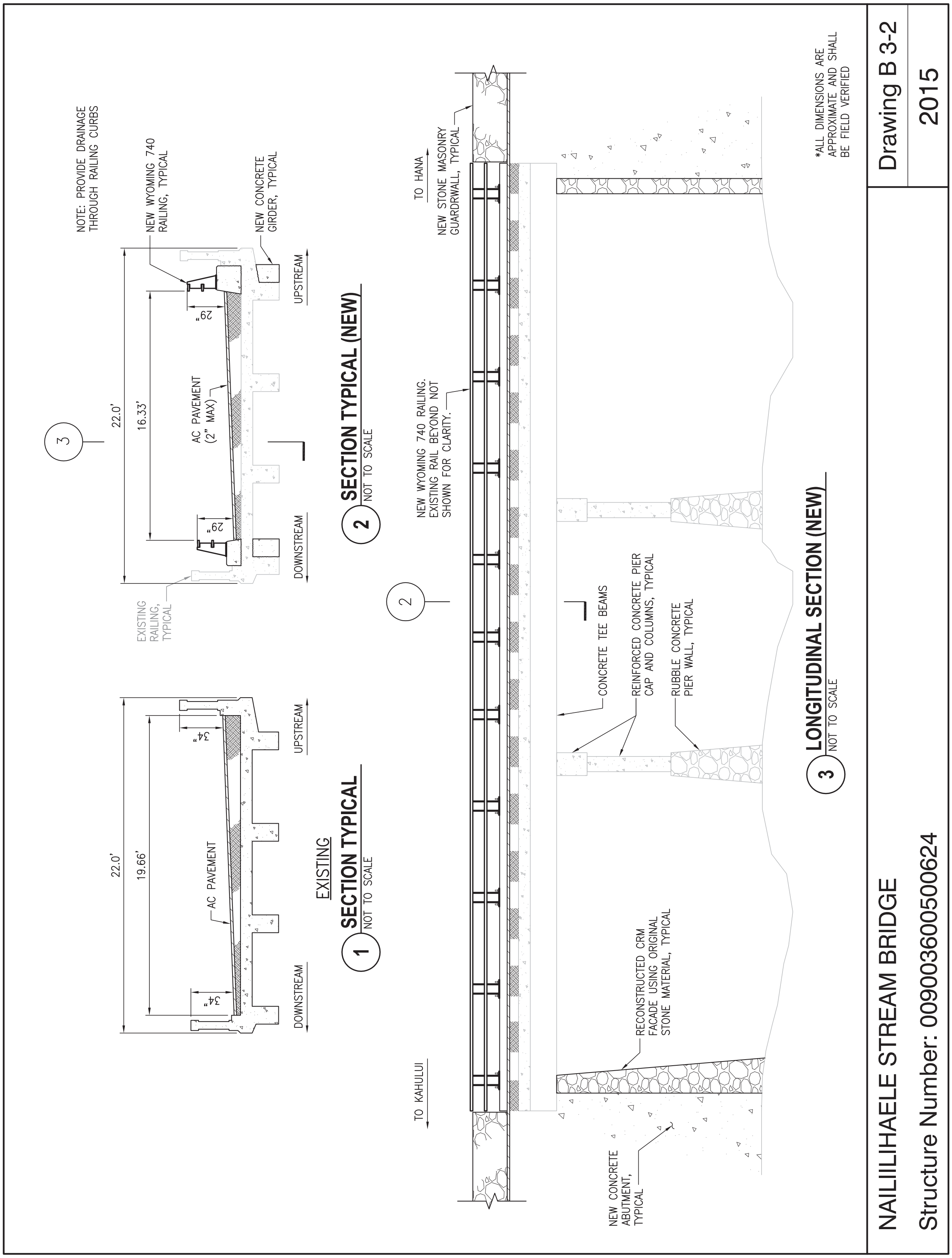
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

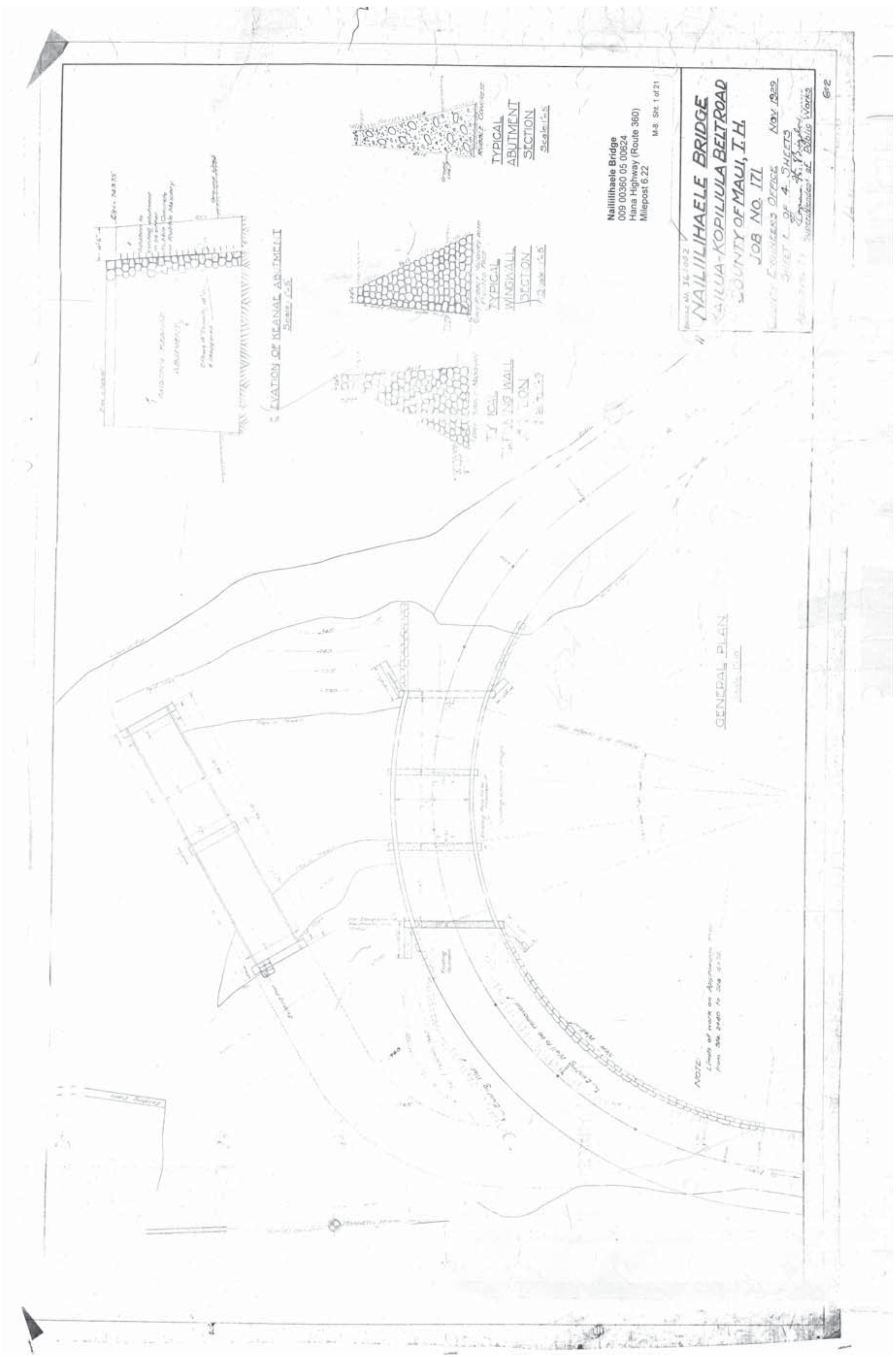
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Nailiilihaele Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



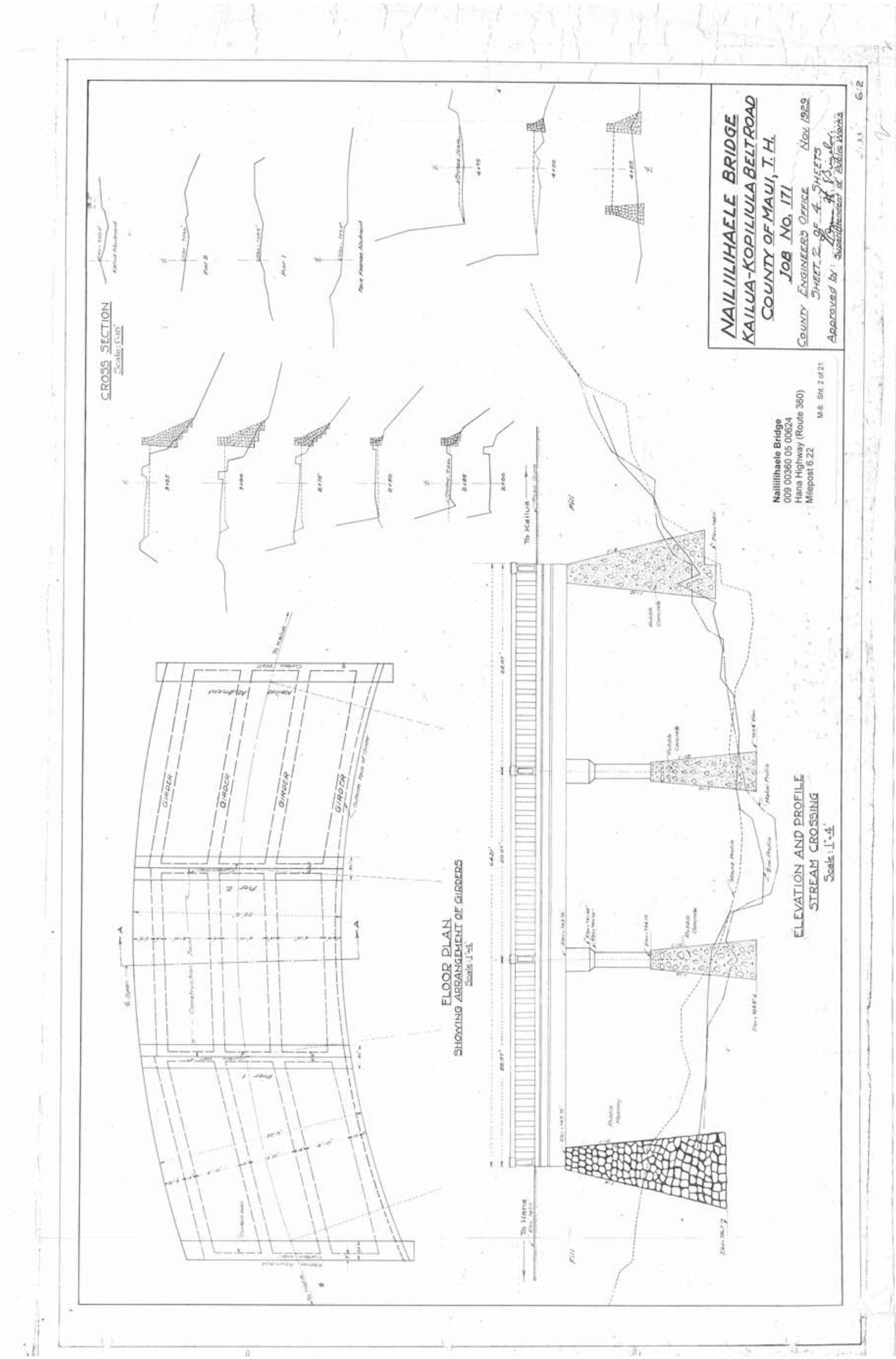
Courtesy of NOEI



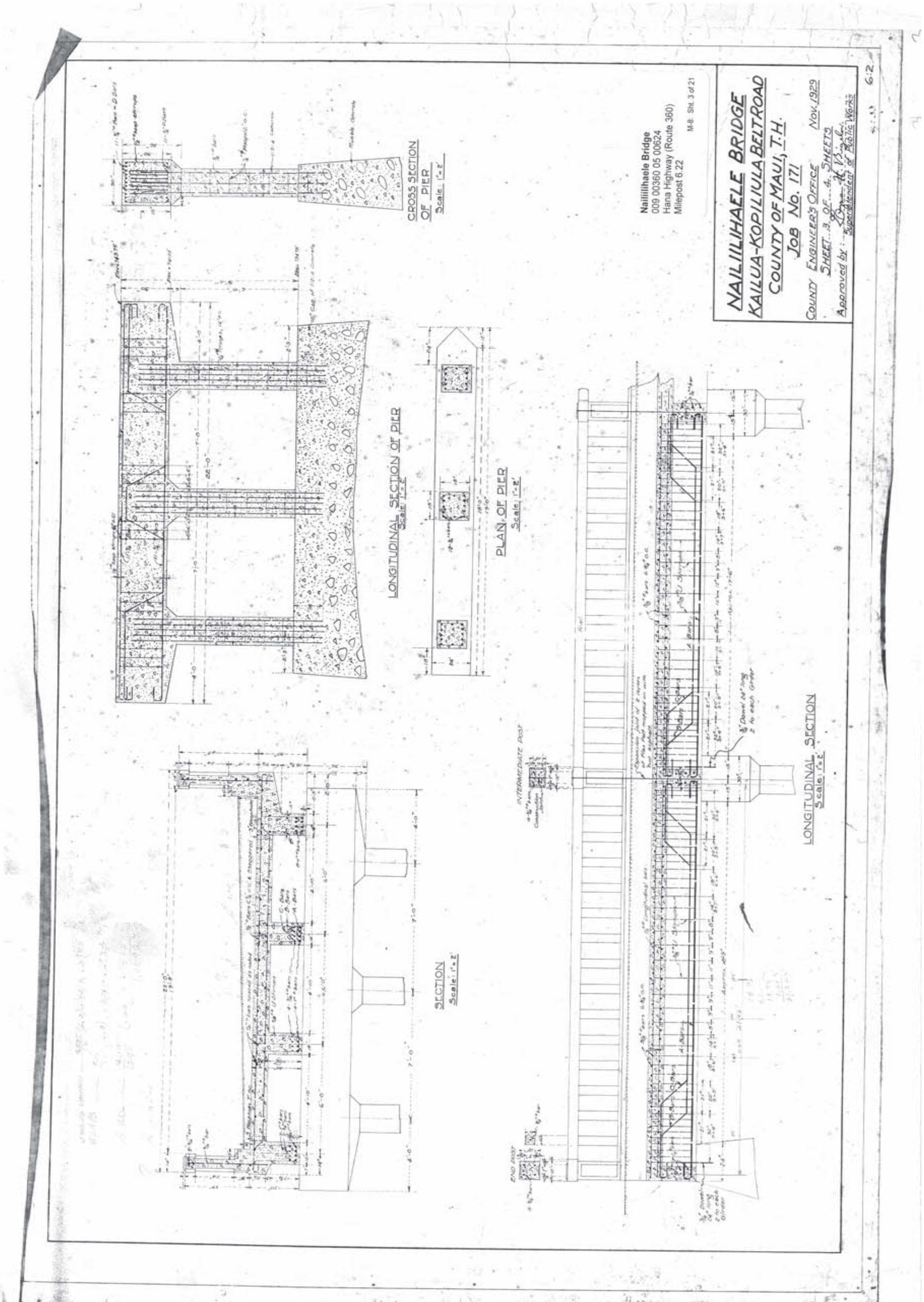
Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation

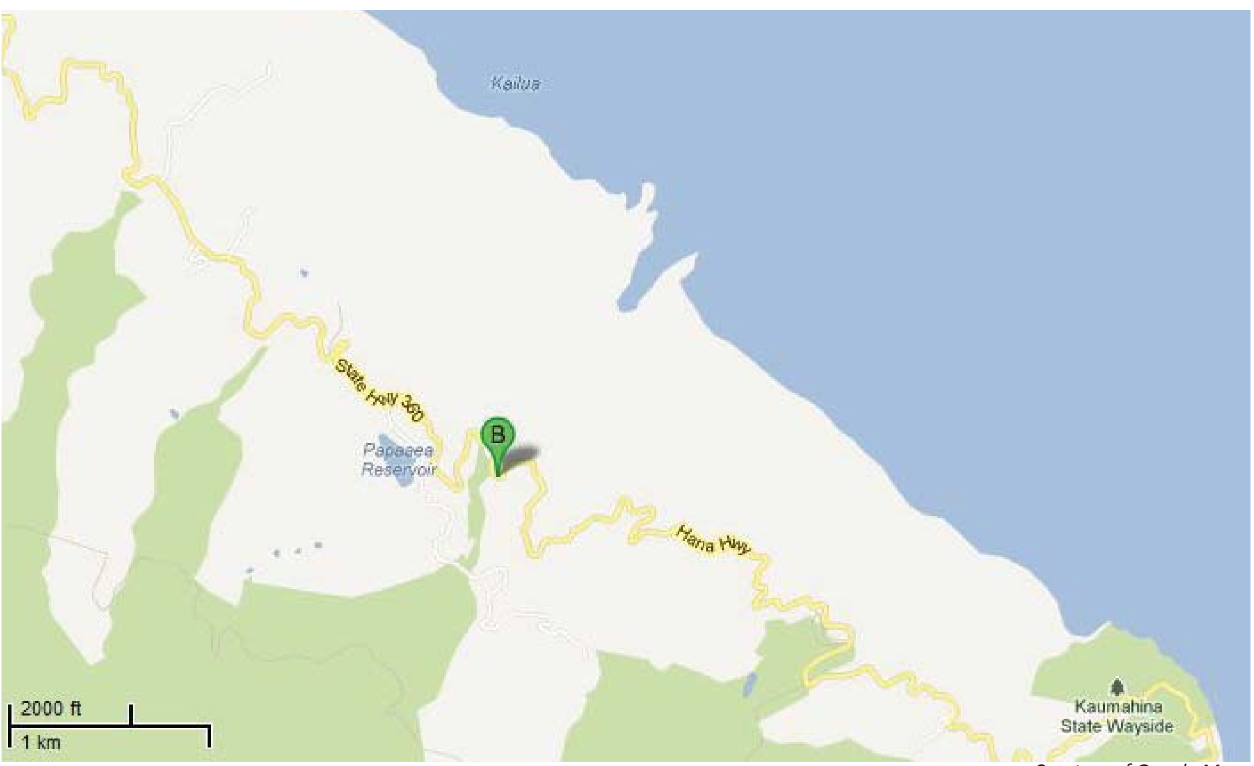
04

Oopuola Stream Bridge

04 OOPUOLA STREAM BRIDGE

Bridge Number	009003600500797			**Island**	Maui		
Date of Construction	1925			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of FAI



Courtesy of Google Maps

Location

Latitude	20d 52m 41s
Longitude	156d 12m 01s
Mile Point	7.92
Location	4.17 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Oopuola Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	29.86 feet
Number of Spans	1
Maximum Span	28.9 feet
Deck Width	• Curb-to-Curb = 20.34 feet • Out-to-Out = 21.65 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 35 inches • Downstream Railing Height = 37 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Oopuola Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1925. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 6 feet on-center. The substructure consists of CRM abutments and wingwalls. The bearing under the abutments is unknown and concealed below grade.

Setting of Oopuola Stream Bridge
Courtesy of NOEI

EMI System located at upstream side of Oopuola Stream Bridge
Courtesy of FAI

Hana approach to Oopuola Stream Bridge toward Kahului
Courtesy of FAI

Kahului approach to Oopuola Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of FAI

Downstream CRM wingwalls, Kahului side
Courtesy of NOEI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	West Makaiwa and East Makaiwa
Designer / Builder	County Engineer's Office - Unknown Designer
Historic Drawings	Original (1925) - none; Alteration (April 1931) - extant
Alterations	1931
Replacement	None
Preservation Priority	Exceptional Curved Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of five bridges with curved parapets on Hana Highway, Route 360 • Exceptional example of CRM abutments on Hana Highway • Exceptional example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• EMI System
Geographical Features / Setting	• A variety of lush vegetation, including mountain apple, kukui trees and African tulip trees, variegated ti leaf plants, and very tall, thin palm trees adjacent to the upstream roadside • Open, yet cool and quiet • Vegetation covers a partially hidden waterfall, that flows into the rocky stream filled with large boulders • A pathway shaded by large banyan trees and bamboo on the Kahului side approach leads to a section of the EMI System; EMI site at the end of the curved pathway is not readily visible to drivers from the road
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings • Alignment: On curve
Detracting Features	• Metal approach guardrails

Significance & Context

East Maui Irrigation

Oopuola Stream Bridge is one of five historic Hana bridges that is adjacent to the man-made EMI system. The EMI system is a National Historic Civil Engineering Landmark. The EMI System is Hawaii's most dramatic water story. The Old Hamakua Ditch constructed between 1876 and 1878, along with the Reciprocity Treaty between the Kingdom of Hawaii and the United States in 1876, sparked the development of the Hawaiian Sugar industry.

> *• The East Maui Irrigation System demonstrated the feasibility of transporting water from steep tropical forested watersheds, with high rainfall, across difficult terrain to [the] fertile and dry plains [of central Maui]. Sugar production dramatically increased with irrigation and improved cultivation practices.*[1]

The Hamakua Ditch Company (precursor of the EMI Company), and the Haiku Sugar Company, managed by Samuel T. Alexander, commenced the construction of a ditch to acquire the water between the Honopou and Nailiilihaele streams. This project to construct the Hamakua Ditch took place in 1876.

> *The digging of the Hamakua Ditch was a work of no small magnitude. A large gang of men, sometimes numbering two hundred, was employed in the work, and the providing of food, shelter, tools, etc., was equal to the care of a regiment of soldiers on the march. All the heavy timbers for flumes, etc., were painfully dragged up hill and down, and in and out of deep gulches, severely taxing the energies and strength of man and beast.*[2]

The EMI System is the largest privately financed, constructed, and managed irrigation system in the United States.

> *• The construction of the Old Hamakua Ditch sparked major irrigation aqueduct construction on the Hawaiian Islands of Kauai, Oahu, Maui and Hawaii.*
> *• The East Maui Irrigation System was the forerunner of major aqueducts in the Western United States by the Bureau of Reclamation, irrigation districts and regional domestic supplies. Engineer M. M. O'Shaughnessy, in charge of constructing the Koolau Ditch in 1904 and 1905, subsequently built San Francisco Hetch Hetchy water system. Other engineers involved in Hawaii aqueducts subsequently worked in the western states.*[3]
> *• Constructed over a period of 47 years, in several phases, the private irrigation system eventually included 50 miles of tunnels; 24 miles of open ditches, inverted siphons and flumes; and incorporates approximately 400 intakes and 8 reservoirs.*[4]

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1 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

2 Thomas G. Thrum, "Reinforced Concrete Siphon at Kailua," *The Hawaiian Planter's Record*, ed. C. F. Eckart (Hawaiian Sugar Planter's Association, 1918).

3 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

4 Ibid.

Archaeological / Cultural Significance

The Hawaiian word *oopuola* is defined as, “A stroke in *lua* fighting; fish was said to be taboo to those learning the stroke. Lit., alive *‘o’opu*.”[5] According to Liliuokalani’s translation of the Kumulipo, Oopuola means, “live mudfish.”[6]

The Oopuola Stream Bridge spans Oopuola Stream, which marks the boundary between the Hamakualoa and Koolau Districts, and divides West and East Makaiwa Ahupuaa.[7,8] The stream in this gulch once watered small *loi kalo* (irrigated taro) areas.[9]

According to the historian Kamakau, god-associated accounts in the lands of Papaaea, Oopuola, and Keanae center on the god Kane, (whose attributes also include *ka wai ola* – the waters of life – *kalo*, and sunlight) and a manifestation of thunder and lightning. Kanehekili, Kanewawawhilani, Kahoalii, Kauilanuimakehaikalani, and the many other gods who belong to the upper and lower strata of the firmament, are called “gods of the heavens.” The first *kahu* who observed the *kapus* of these gods was named Hekili (Thunder). He lived at Papaaea where this man was born in a place where thunder claps very loudly, with double claps, and there comes flashes of lightning that smash to pieces the forest of Oopuloa.[10]

In Fornander’s Legend of Kihapiilani, after Kiha a Piilani and Umi conquered the fortress of Kauiki, Kiha a Piilani began to construct a “roadway from Kawaipapa to the forests of Oopuloa [sic],” which “was made and paved with smooth rocks.”[11]

Refer to Section G, Appendix 1, Section 3.1.2.1 for the regional history near Oopuola Stream Bridge, and to Section G, Appendix 1, Figure 8 for nearby archaeological study areas.[12, 13]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Oopuola Stream Bridge.

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5 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

6 Martha W. Beckwith, *The Kumulipo*, trans. Liliuokalani (Honolulu: B. P. Bishop Museum, 1951).

7 Joseph Iao, “Portion of Hamakualoa & Koolau Maui,” registered map no. 2482, Hawaii Territory Survey (1909).

8 U.S. Geological Survey, ed., *Haiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

9 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991).

10 Kepa Maly and Onaona Maly, *A Collection of Native Traditions and Historical Accounts of the Lands of Hamakua Poko, Hamakua Loa and Ko‘Olau, Maui Hikina (East Maui), Island of Maui,* vol. 1 of *Wai O Ke Ola: He Wahi Mo‘Olelo No Maui Hikina* (Hilo: Kumu Pono Associates, 2001).

11 Abraham Fornander, “Legend of Kihapiilani,” *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians’ Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, second series, trans. Thomas G. Thrum, vol. 5 of *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1918-1919), 176-182.

12 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

13 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, “Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

Civil & Traffic

Number of Lanes	Two Lanes (currently used as One Lane)
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear, no yield
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.58 • Operating Rating = 0.75
Condition	Functionally Obsolete

Civil & Traffic

The Oopuola Stream Bridge is located at mile point 7.92 along Hana Highway and its existing conditions are as follows. This bridge is an observed one-lane bridge with an out-to-out width of 21.65 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on October 9, 2013. The overall condition rating of the bridge at the time of inspection varied between fair and good.[14] Although this bridge is not striped for two-lane two-way traffic, the SI&A sheet for this bridge describes it as having two lanes on the structure. This bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and a rating of 3 for *approach alignment*. CRM walls are located at three corners of the approaches to the bridge. A metal guardrail and guardrail end treatment are located at the upstream Hana approach to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 35 inches and 37 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.58 and the operating rating is 0.75.

The current curb-to-curb dimension is 20.34 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

14 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Oopuola Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated October 9, 2013, record drawings,[15, 16] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Unique curved parapet bridge
Courtesy of NOEI

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Oopuola Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

Good example of exposed curb at base of open picket railing
Courtesy of FAI

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

The intact nature of the bridge elements, wide clearance for a single-lane bridge, curved design, and view of the adjacent EMI ditch all combine to make this an exceptional bridge to be preserved.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

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15 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

16 County Engineer's Office, "Oopuola Bridge," Hana Belt Road, County of Maui, Job No. 183, April 1931.

RECOMMENDATIONS

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Oopuola Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. Due to the curb-to-curb width and the curvature of the approach to this bridge, it is recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to “Railings/ Parapets” section for more information). AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team’s site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM abutments and parapet curvature visible from roadway
Courtesy of NOEI

CRM Approach Walls

Exemplary CRM wingwalls and abutments
Courtesy of NOEI

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic safety features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining three approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girder shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with reconstructed CRM rock façades. To achieve this, the existing façades of the CRM abutments and CRM wingwalls are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM abutments and CRM wingwalls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM abutments and CRM wingwalls are to be placed in front of the new reinforced concrete abutments and wingwalls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

The existing CRM abutments and CRM wingwalls are exemplary examples of these bridge components. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of exemplary historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

This bridge is scour critical and a POA has been created by HDOT. Currently, the POA does not recommend any immediate action.

Load Rating

Load rating for this bridge was updated with LRFR and a bridge load posting of 20 tons was recommended. Although this recommended posting is higher than the 10-tons general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3), it is still under the recommended design criteria of 40-tons. Therefore, it is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver’s visibility should be trimmed or removed per an approved landscape plan. A “Yield” sign (R1-1), “To Oncoming Traffic” sign (R1-2a) and yield line are recommended to be added to the east approach of the bridge. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets* *and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Prune roadside brush and trees

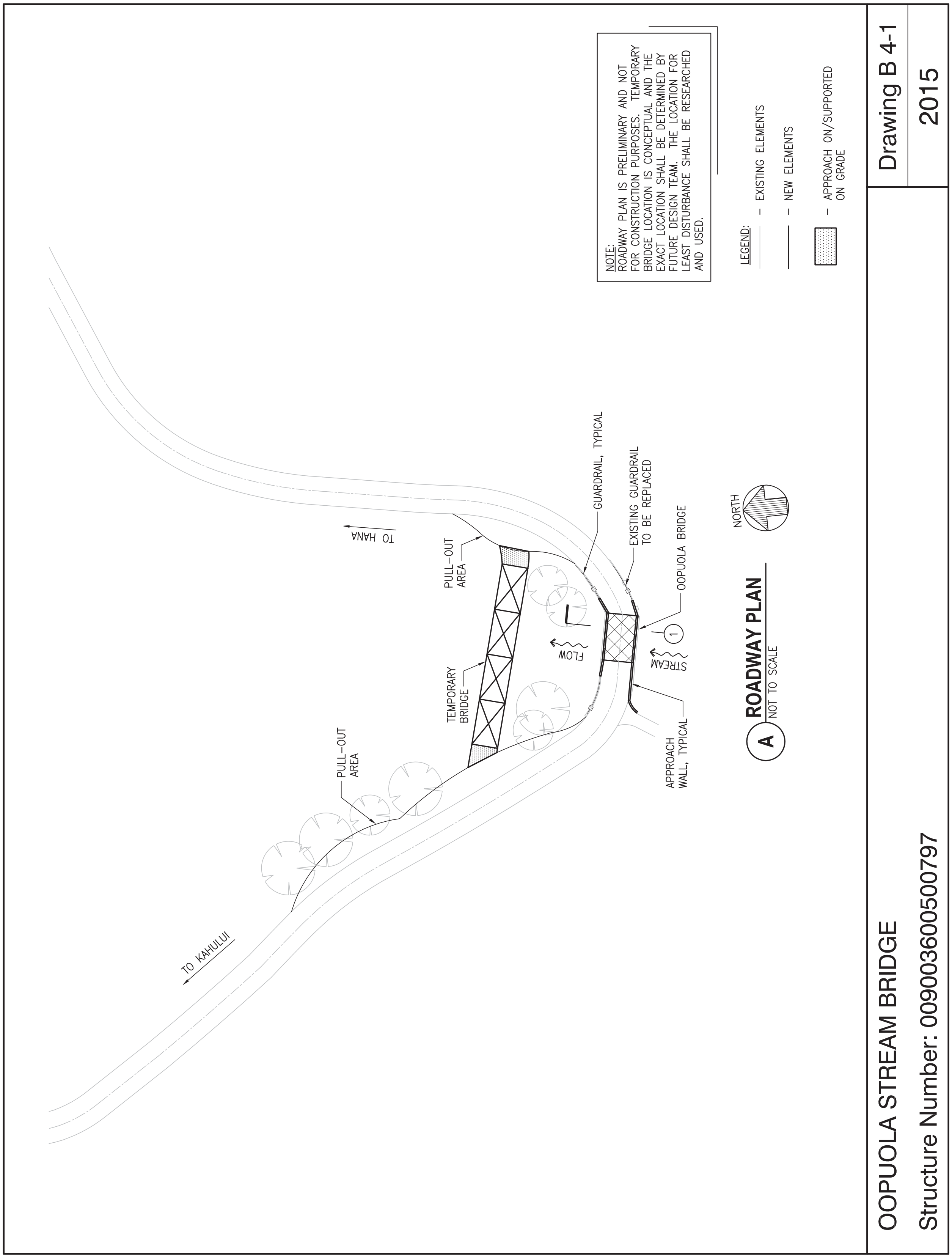
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Prune roadside brush and trees

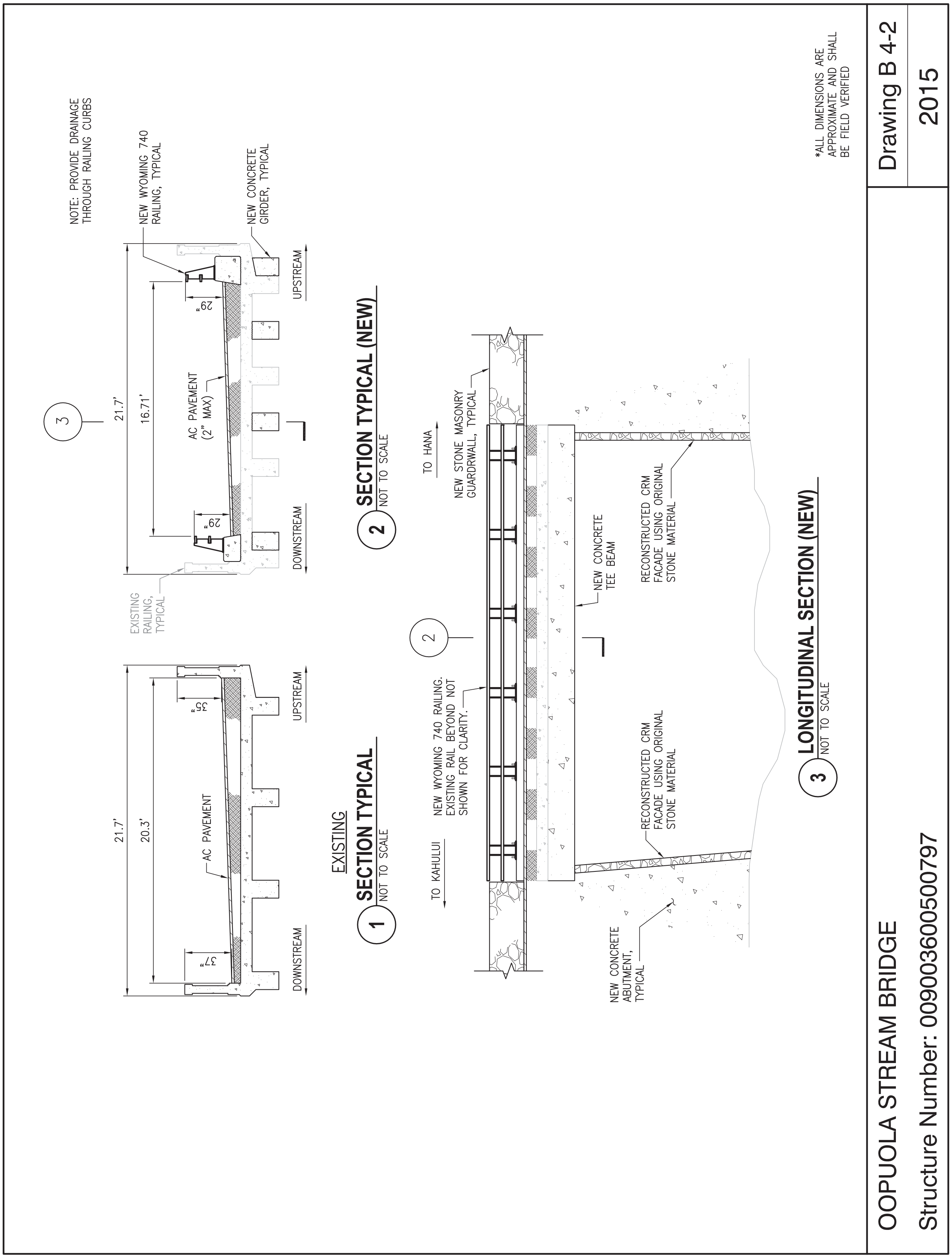
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

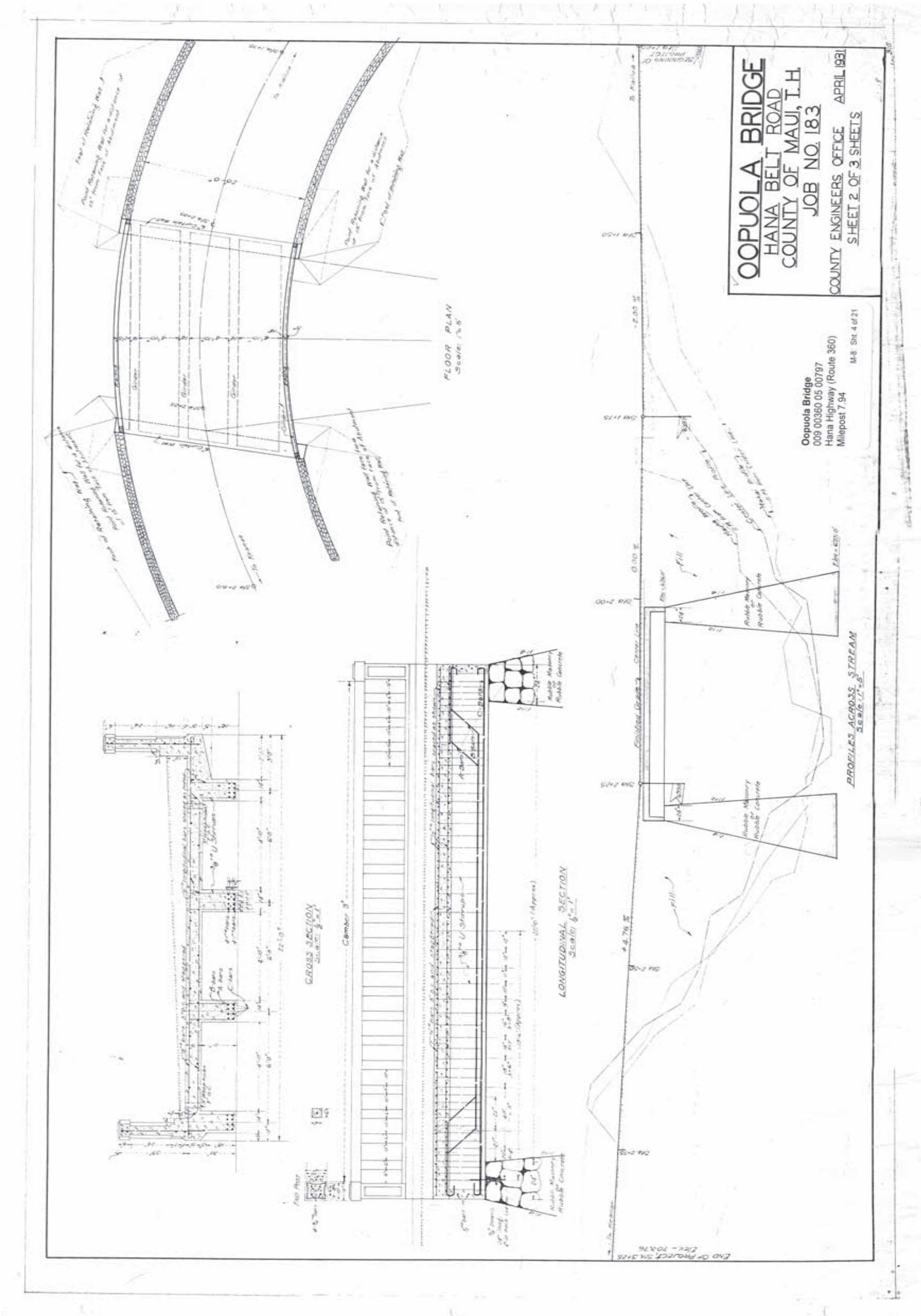
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Oopuola Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of HAER HI-75

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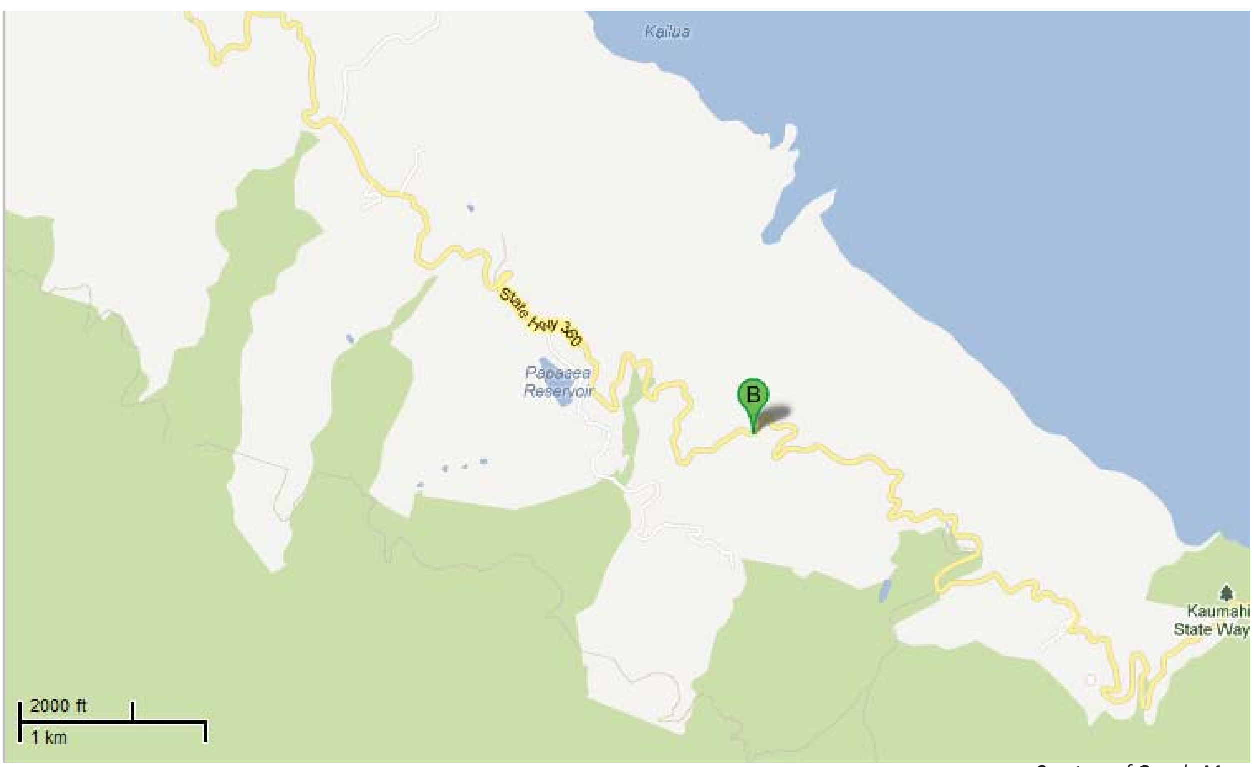
05

Makanali Stream Bridge

05 MAKANALI STREAM BRIDGE

Bridge Number	009003600500824			**Island**	Maui		
Date of Construction	1928			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 52m 46s
Longitude	156d 11m 47s
Mile Point	8.22
Location	3.90 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Makanali Gulch

Bridge Features

Bridge Type	Concrete Slab
Total Length	18.04 feet
Number of Spans	1
Maximum Span	13.1 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 17.72 feet
Abutment Material	CRM Abutment
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 35 inches • Downstream Railing Height = 35 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Makanali Stream Bridge is a single-span reinforced concrete slab bridge built in 1928. The superstructure consists of a concrete deck slab with AC pavement overlay. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of Makanali Stream Bridge
Courtesy of NOEI

Makanali Stream Bridge downstream elevation
Courtesy of FAI

Hana approach to Makanali Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Makanali Stream Bridge toward Hana
Courtesy of FAI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of FAI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Detail of EMI engineering system, tunnel toward Hana side
Courtesy of FAI

Detail of EMI engineering system
Courtesy of FAI

Significance & Context

Ahupuaa	East Makaiwa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• EMI System
Geographical Features / Setting	• Wooded yet open valley area; openness of the area is enhanced by unencumbered vistas towards the hills and horizon • Dense vegetation and groundcover • A visible, wooded pathway marked by a large banyan tree on the Kahului approach side leads to the adjacent EMI System; pathway is hidden behind the adjacent hill topography, making it not visible from the Kahului approach
Character Defining Features	• Concrete Slab Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Cementitious material obscures the face of CRM abutments

Significance & Context

East Maui Irrigation

Makanali Stream Bridge is one of five historic Hana bridges that is adjacent to the man-made EMI system. The EMI system is a National Historic Civil Engineering Landmark. The EMI System is Hawaii's most dramatic water story. The Old Hamakua Ditch constructed between 1876 and 1878, along with the Reciprocity Treaty between the Kingdom of Hawaii and the United States in 1876, sparked the development of the Hawaiian Sugar industry.

> *• The East Maui Irrigation System demonstrated the feasibility of transporting water from steep tropical forested watersheds, with high rainfall, across difficult terrain to [the] fertile and dry plains [of central Maui]. Sugar production dramatically increased with irrigation and improved cultivation practices.*[1]

The Hamakua Ditch Company (precursor of the EMI Company), and the Haiku Sugar Company, managed by Samuel T. Alexander, commenced the construction of a ditch to acquire the water between the Honopou and Nailiilihaele streams. This project to construct the Hamakua Ditch took place in 1876.

> *The digging of the Hamakua Ditch was a work of no small magnitude. A large gang of men, sometimes numbering two hundred, was employed in the work, and the providing of food, shelter, tools, etc., was equal to the care of a regiment of soldiers on the march. All the heavy timbers for flumes, etc., were painfully dragged up hill and down, and in and out of deep gulches, severely taxing the energies and strength of man and beast.*[2]

The EMI System is the largest privately financed, constructed, and managed irrigation system in the United States.

> *• The construction of the Old Hamakua Ditch sparked major irrigation aqueduct construction on the Hawaiian Islands of Kauai, Oahu, Maui and Hawaii.*
> *• The East Maui Irrigation System was the forerunner of major aqueducts in the Western United States by the Bureau of Reclamation, irrigation districts and regional domestic supplies. Engineer M. M. O'Shaughnessy, in charge of constructing the Koolau Ditch in 1904 and 1905, subsequently built San Francisco Hetch Hetchy water system. Other engineers involved in Hawaii aqueducts subsequently worked in the western states.*[3]
> *• Constructed over a period of 47 years, in several phases, the private irrigation system eventually included 50 miles of tunnels; 24 miles of open ditches, inverted siphons and flumes; and incorporates approximately 400 intakes and 8 reservoirs.*[4]

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1 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

2 Thomas G. Thrum, "Reinforced Concrete Siphon at Kailua," *The Hawaiian Planter's Record*, ed. C. F. Eckart (Hawaiian Sugar Planter's Association, 1918).

3 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

4 Ibid.

Archaeological / Cultural Significance

Makanali Stream Bridge spans Makanali Gulch, located in East Makaiwa Ahupuaa within the Koolau District.[5] Native families settled and cultivated gardens in the narrow valleys fed by small streams in this region.[6] No definition for the Hawaiian word *makanali* or any other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Section 3.1.2.8 for a broader regional history of the Koolau District, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[7, 8]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of the Makanali Stream Bridge.

Walker Site 81, the Nakeikiikalalomakaiwa Heiau, was listed by Walker as destroyed, but as having once been located in Makaiwa. Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway.

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5 U.S. Geological Survey, ed., *Haiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

6 Davianna Pomaikai McGregor, Ph. D., *Na Kuaʻaina: Living Hawaiian Culture* (Honolulu: University of Hawaii Press, 2007).

7 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

8 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear, No yield • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.42
Condition	Functionally Obsolete

Civil & Traffic

Makanali Stream Bridge is located at mile point 8.22 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 17.72 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approaches to the bridge are currently clear of any obstruction thus, providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 25, 2013. The overall condition rating of the bridge at the time of inspection was fair.[1] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. Both the upstream and downstream railings had a height of 35 inches. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

According to the SI&A sheet, load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.42.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

1 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Makanali Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 25, 2013 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Makanali Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Makanali Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. After installing the recommended Texas Type C411 concrete railings (refer to *Railing/Parapets*), the width does not meet the requirement and it is recommended that this bridge be exempt from HDOT 16-foot width design criteria due to its historic significance. Widening of this bridge is not recommended due to the close proximity of historic and cultural areas.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Rehabilitation to the bridge deck is recommended to increase the load carrying capacity of the bridge and to support the new concrete railings (refer to "Railings/ Parapets" and "Load Rating" sections for more information).

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Existing CRM approach wall
Courtesy of FAI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the*

Approaches). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

CRM abutment obscured by cementitious material
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The existing deck is not adequate enough to support these new railings, so it is recommended to provide additional support by thickening the deck. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash-tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to thicken the existing slab.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. A "Yield" sign (R1-1), "To Oncoming Traffic" sign (R1-2a) and yield line are recommended to be added to the west approach of the bridge. A "To Oncoming Traffic" sign (R1-2a) is recommended to be added to the "Yield" sign located at the east approach of the bridge. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Prune roadside brush and trees

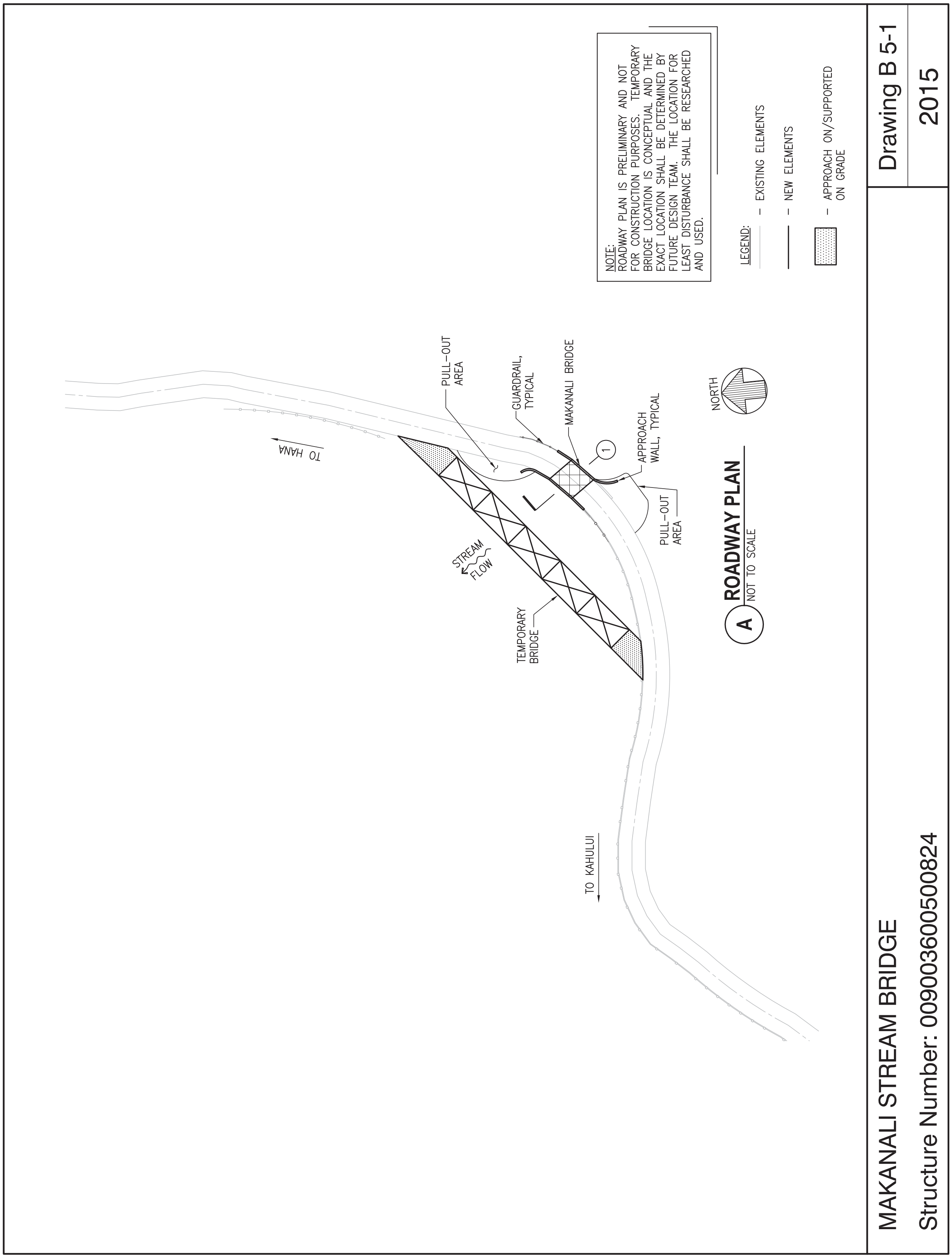
East Bridge Approach

- Prune roadside brush and trees

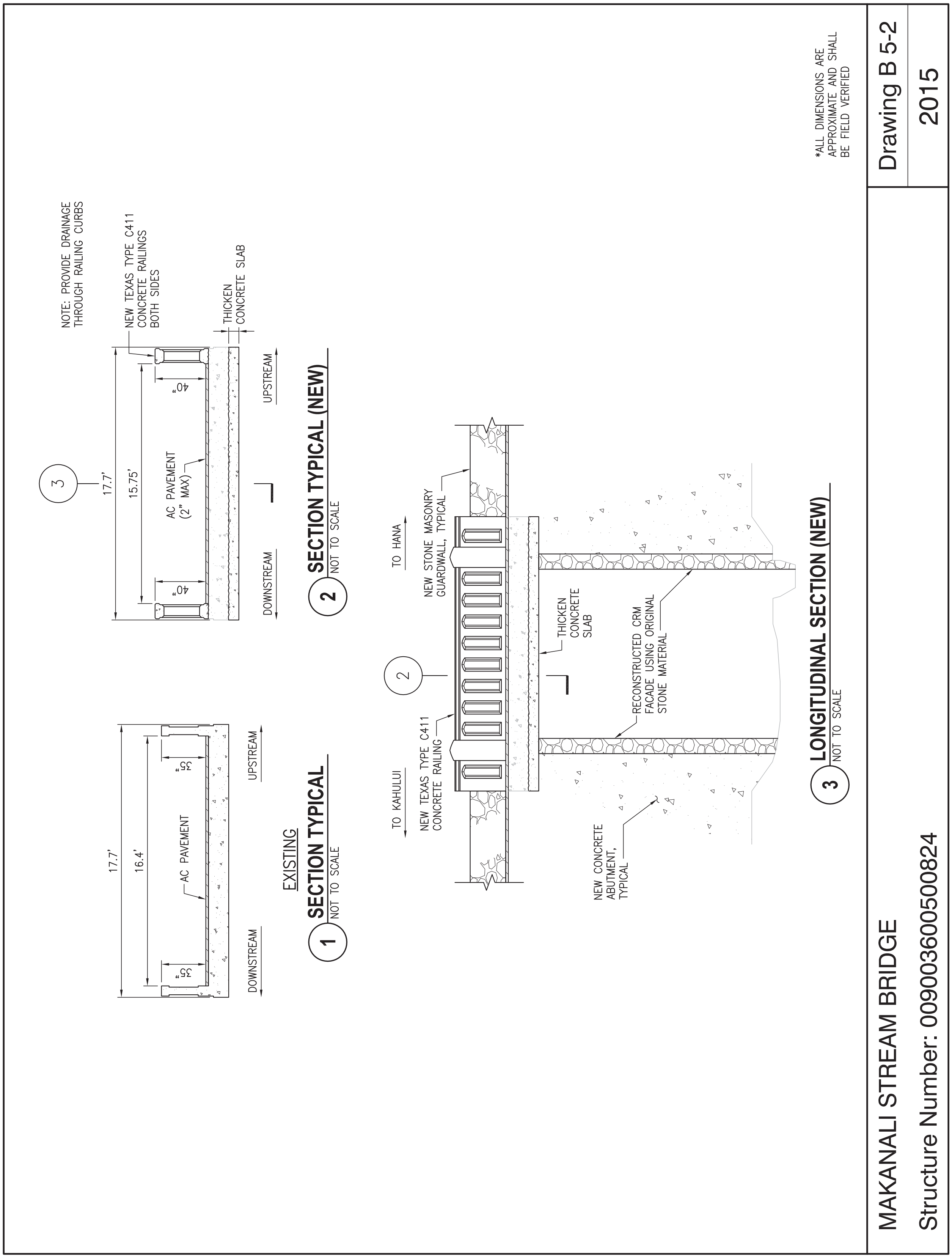
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

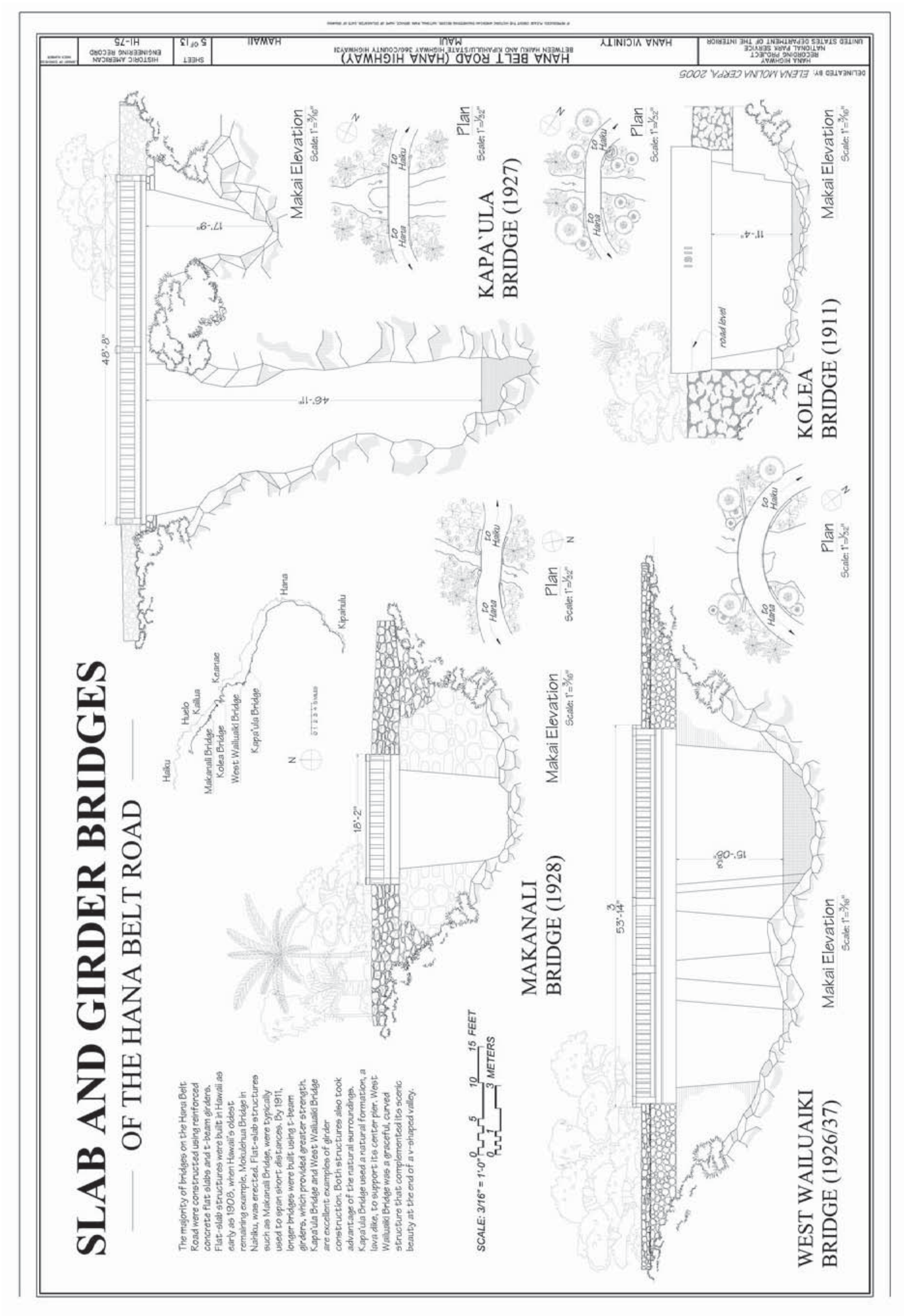
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Makanali Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of HAER HI-75

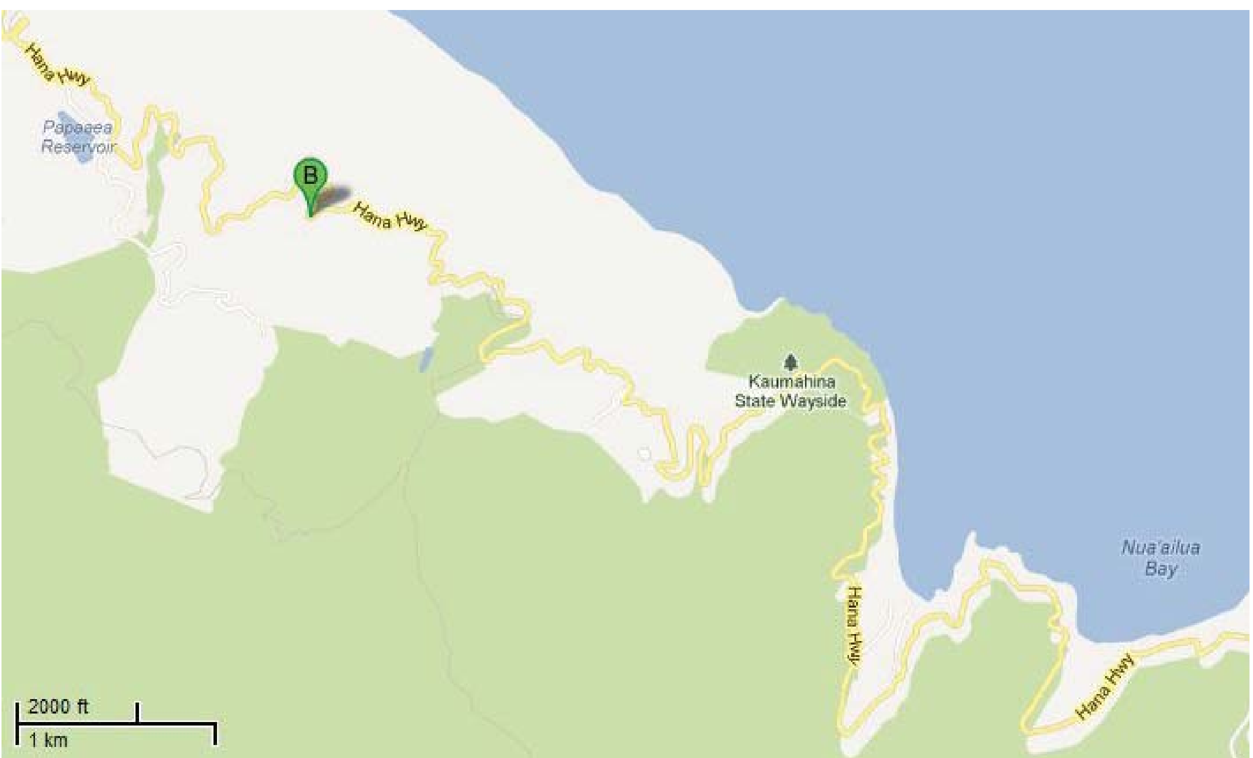
06

Kaaiea Stream Bridge

06

KAAIEA STREAM BRIDGE

Bridge Number	009003600500858			**Island**	Maui		
Date of Construction	1928			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 52m 42s
Longitude	156d 11m 43s
Mile Point	8.55
Location	3.56 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Kaaiea Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	21.98 feet
Number of Spans	1
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 16.00 feet • Out-to-Out = 18.60 feet
Abutment Material	CRM Abutment
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 21 inches • Downstream Railing Height = 27 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kaaiea Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1928. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments and wingwalls. The bearing under the abutments is unknown and concealed below grade.

Setting of Kaaiea Stream Bridge
Courtesy of FAI

Kaaiea Stream Bridge downstream elevation
Courtesy of NOEI

Hana approach to Kaaiea Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kaaiea Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Detail of EMI engineering system, located upstream of Kaaiea Stream Bridge
Courtesy of FAI

Detail of EMI engineering system, located upstream of Kaaiea Stream Bridge
Courtesy of FAI

Significance & Context

Ahupuaa	East Makaiwa and Mooloa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	Repair on upstream parapet, Hana side does not match original design
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• EMI System
Geographical Features / Setting	• Large grove of bamboo on the Hana side • Large lava rock wall on the upstream side of the Hana approach • A low waterfall flows into a pool on the upstream side of bridge • Located in a remote area at the end of a horseshoe-shaped valley • Picturesque setting • A portion of the EMI is located at the upstream side of Kaaiea Stream Bridge, visible from the road
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Cementitious material obscures the face of CRM abutments • Inappropriate railing repair at ends • End posts with panel detail and square post caps appear to be “buried” into the approach wall connections at each end and are not readily visible

Significance & Context

East Maui Irrigation

Kaaiea Stream Bridge is one of five historic Hana bridges that is adjacent to the man-made EMI system. The EMI system is a National Historic Civil Engineering Landmark. The EMI System is Hawaii's most dramatic water story. The Old Hamakua Ditch constructed between 1876 and 1878, along with the Reciprocity Treaty between the Kingdom of Hawaii and the United States in 1876, sparked the development of the Hawaiian Sugar industry.

> *• The East Maui Irrigation System demonstrated the feasibility of transporting water from steep tropical forested watersheds, with high rainfall, across difficult terrain to [the] fertile and dry plains [of central Maui]. Sugar production dramatically increased with irrigation and improved cultivation practices.*[1]

The Hamakua Ditch Company (precursor of the EMI Company), and the Haiku Sugar Company, managed by Samuel T. Alexander, commenced the construction of a ditch to acquire the water between the Honopou and Nailiilihaele streams. This project to construct the Hamakua Ditch took place in 1876.

> *The digging of the Hamakua Ditch was a work of no small magnitude. A large gang of men, sometimes numbering two hundred, was employed in the work, and the providing of food, shelter, tools, etc., was equal to the care of a regiment of soldiers on the march. All the heavy timbers for flumes, etc., were painfully dragged up hill and down, and in and out of deep gulches, severely taxing the energies and strength of man and beast.*[2]

The EMI System is the largest privately financed, constructed, and managed irrigation system in the United States.

> *• The construction of the Old Hamakua Ditch sparked major irrigation aqueduct construction on the Hawaiian Islands of Kauai, Oahu, Maui and Hawaii.*
> *• The East Maui Irrigation System was the forerunner of major aqueducts in the Western United States by the Bureau of Reclamation, irrigation districts and regional domestic supplies. Engineer M. M. O'Shaughnessy, in charge of constructing the Koolau Ditch in 1904 and 1905, subsequently built San Francisco Hetch Hetchy water system. Other engineers involved in Hawaii aqueducts subsequently worked in the western states.*[3]
> *• Constructed over a period of 47 years, in several phases, the private irrigation system eventually included 50 miles of tunnels; 24 miles of open ditches, inverted siphons and flumes; and incorporates approximately 400 intakes and 8 reservoirs.*[4]

1 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

2 Thomas G. Thrum, "Reinforced Concrete Siphon at Kailua," *The Hawaiian Planter's Record*, ed. C. F. Eckart (Hawaiian Sugar Planter's Association, 1918).

3 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

4 Ibid.

Archaeological / Cultural Significance

Ka aiea is Hawaiian for the hardwood Nothocestrum tree.[5] According to Fornander, the word *kaaiea* may also translate as, "the fatigued."[6] The bridge spans Kaaiea Stream, which forms the boundary between East Makaiwa Ahupuaa and Mooloa Ahupuaa.[7]

The Kaaiea Stream at Mooloa may have been named after a great chief brought to Hawaii by the Samoan king Paao, who visited Hawaii and returned to his home islands to seek a powerful chief to quell the anarchy he witnessed. According to Fornander, the chief Pili Kaaiea was brought to the Hawaiian Islands to bring an end to the anarchy.[8]

When Fornander recorded the traditions of the chief Pili Kaaiea, he found there were two sets of traditions regarding the origin of Paao. In both legends, Pili Kaaiea is brought to Hawaii to take possession of the islands, and it is from Pili Kaaiea that the principal chief families on Hawaii claimed descent.

Of the first of these legends, Fornander states:

> *The first legend about Paao was collected by David Malo. Malo states that Paao came from "Wawao;" a place that he left and proceeded then to Hawaii, where he established himself in the capacity of a high priest. Finding the island in a state of anarchy and without a sovereign chief, "on account of the crimes of Kapawa, the chief of Hawaii," he sent back (or went back himself) to his native islands, to invite Pili Kaaiea to come and take possession of Hawaii*.[9]

In the first legend, Paao came from one of the islands of the Tonga group. The second legend was collected by Samuel Kamakau, about which Fornander states:

> *The other legend, states that Paao came from "Opolu," in the Samoan group, and that he left those islands with Pili Kaaiea, Pili's wife, Hinaauaku, his own sister Namauuo-malaia, and thirty-five other relatives. After a long and dangerous voyage, Paao and his group arrived at the island of Hawaii, where Pili became sovereign chief of the island*.[10]

Refer to Section G, Appendix 1, Section 3.1.2.2 for the regional history of Kaaiea Stream, and to Section G, Appendix 1, Figure 8 for nearby archaeological study areas.[11]

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5 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

6 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

7 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

8 Abraham Fornander, *An Account of the Polynesian Race; Its Origin and Migrations and the Ancient History of the Hawaiian People to the Times of Kamehameha I*, ed. John F. G. Stokes, 3 vols. (1878-1885).

9 Ibid.

10 Ibid.

11 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of the Kaaiea Stream Bridge.

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.43
Condition	Functionally Obsolete

Civil & Traffic

Kaaiea Stream Bridge is located at mile point 8.55 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.60 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 25, 2013. The overall condition rating of the bridge at the time of inspection varied between fair and good.[1] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 21 inches and 27 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.43.

The current curb-to-curb dimension is 16.00 feet, which for a one-lane bridge meets the design criteria minimum of 16 feet.

1 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kaaiea Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 25, 2013 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kaaiea Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Exemplary EMI System rock wall, upstream Hana side
Courtesy of NOEI

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Curb base of open picket railing not visible due to excessive asphalt
Courtesy of FAI

Recommendations have been identified per bridge component, as follows:

Deck

The Kaaiea Stream Bridge currently meets the minimum standard width of 16 feet for a one-lane bridge; therefore, no widening is needed.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Inappropriate approach wall connection to railing
Courtesy of NOEI

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream and downstream Kahului, and upstream Hana, approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining downstream Hana approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash-tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a yield line is added to the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Prune roadside brush and trees

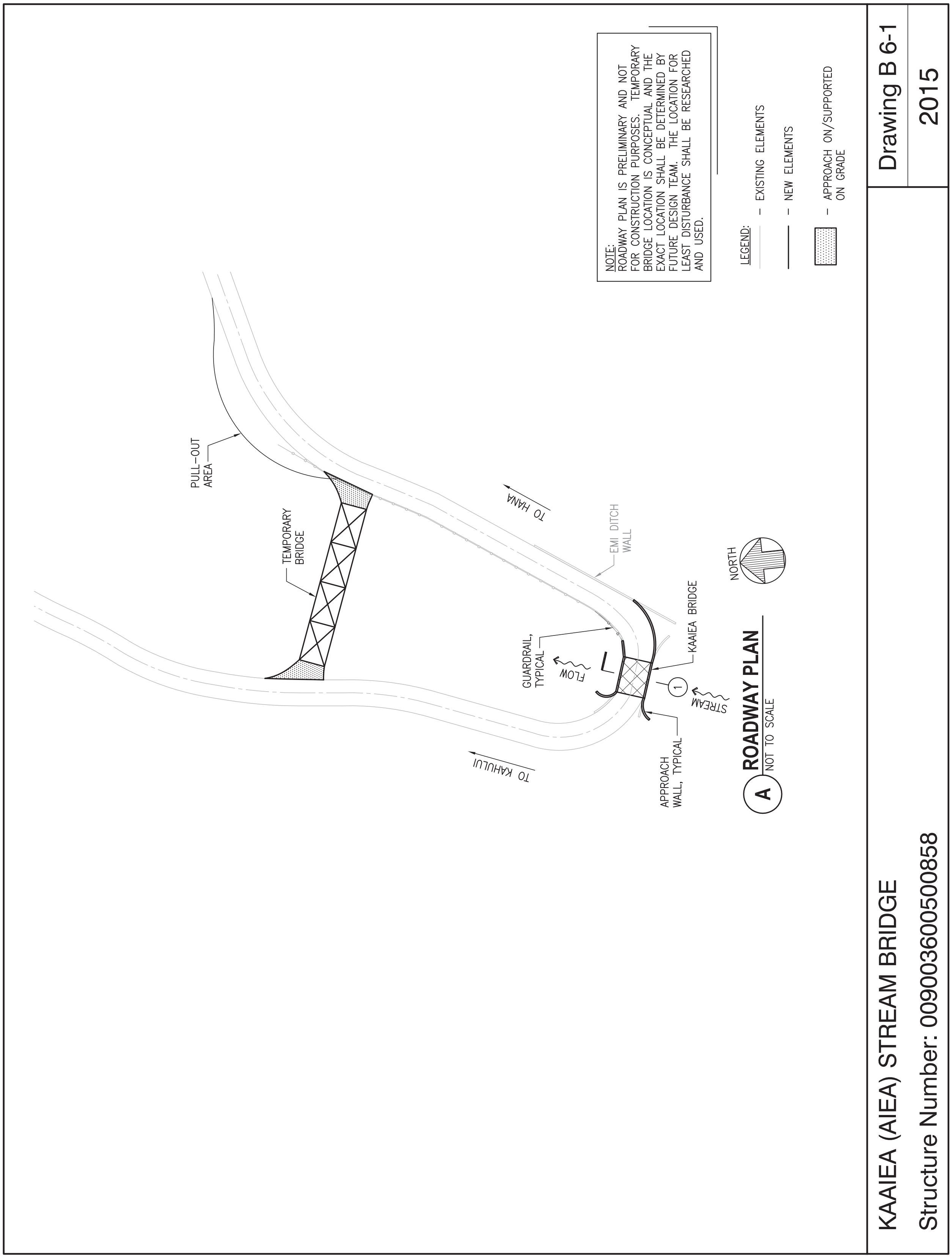
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Prune roadside brush and trees

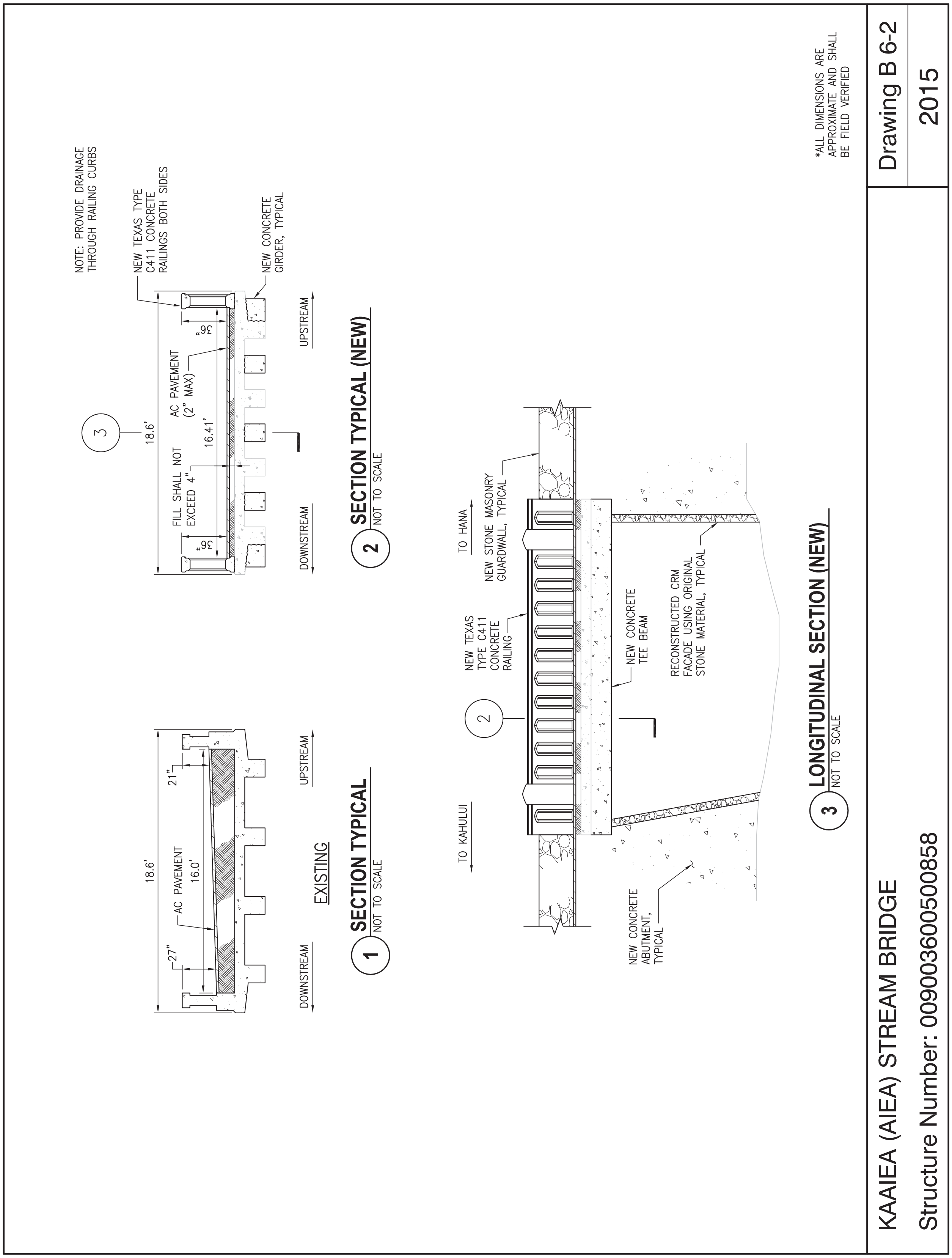
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Kaaiea Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

07
Waikamoi Stream Bridge

07 WAIKAMOI STREAM BRIDGE

<table>
<tr><th>Bridge Number</th><td colspan="3">009003600500990</td><th colspan="2">Island</th><td colspan="2">Maui</td></tr>
<tr><th>Date of Construction</th><td colspan="3">1912</td><th colspan="2">Route</th><td colspan="2">Hana Highway</td></tr>
<tr><th>Treatment Recommendation</th><td>X</td><td>Preservation</td><td>X</td><td>Rehabilitation</td><td></td><td>Restoration</td><td></td><td>Replacement</td></tr>
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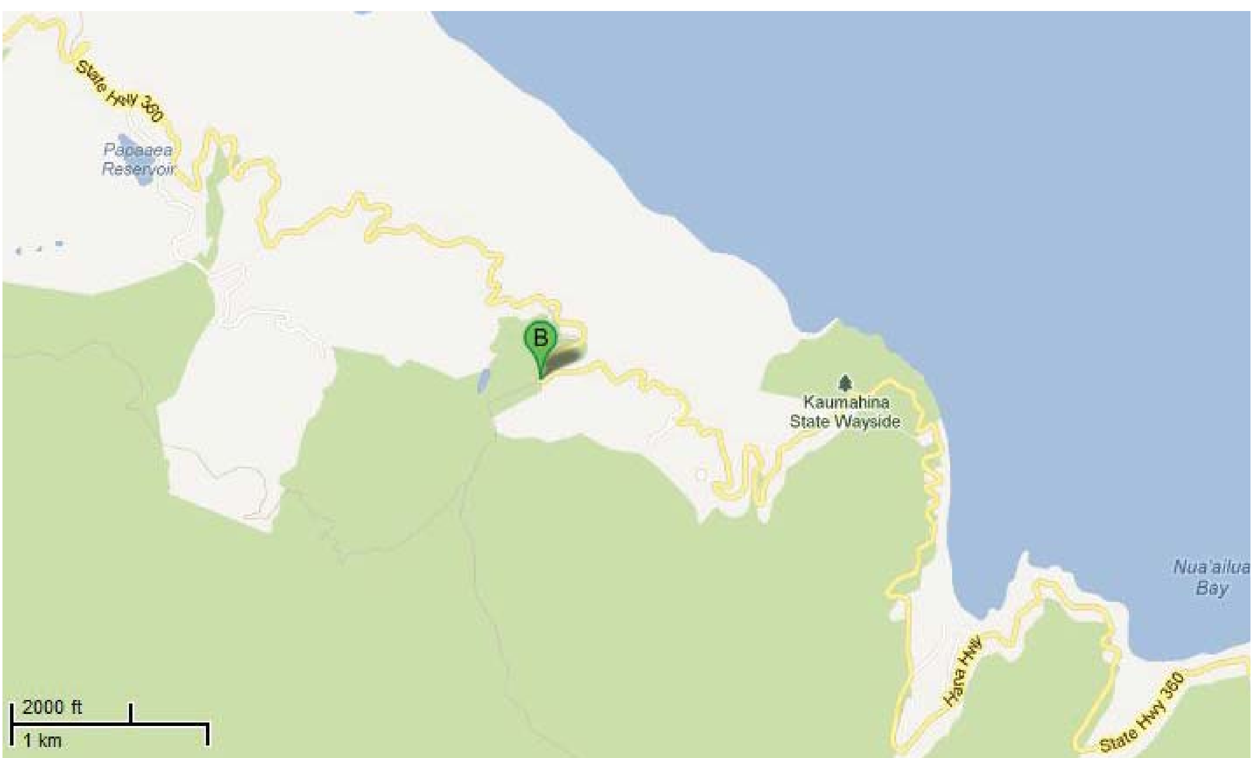


Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 52m 20s
Longitude	156d 11m 13s
Mile Point	9.86
Location	2.24 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Waikamoi Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	41.01 feet
Number of Spans	2
Maximum Span	19.0 feet
Deck Width	• Curb-to-Curb = 12.60 feet • Out-to-Out = 14.44 feet
Abutment Material	• Concrete Abutments • Reinforced Concrete Pier Cap and Columns
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Solid Reinforced Concrete Parapet
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 27 inches • Downstream Railing Height = 32 inches
Parapet / Railing Profile	• Saddle Coping Cap • Thickness = 7 inches
Parapet Inscription	“A.D. 1912” on downstream face

Bridge Features

Waikamoi Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1912. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center in each span. The substructure consists of concrete abutments, CRM wingwalls, and a reinforced concrete pier cap and columns. The abutments and pier columns bear directly on natural rock formations.

Setting of Waikamoi Stream Bridge
Courtesy of FAI

Waikamoi Stream Bridge upstream elevation
Courtesy of NOEI

Hana approach to Waikamoi Stream Bridge towards Kahului
Courtesy of FAI

Kahului approach to Waikamoi Stream Bridge towards Hana
Courtesy of NOEI

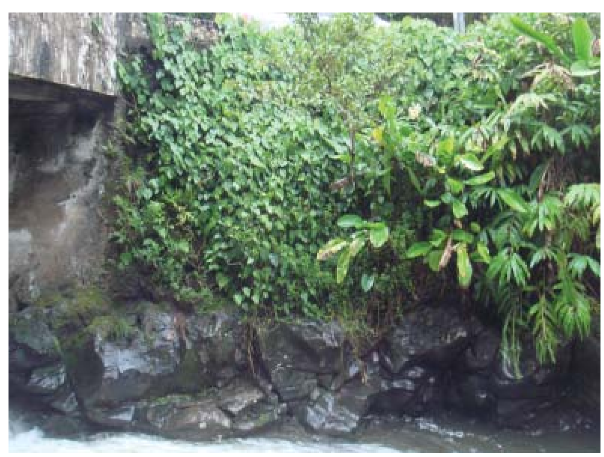
Solid concrete parapet with saddle coping, upstream side
Courtesy of FAI

Solid concrete parapet with saddle coping, downstream side
Courtesy of FAI

Waikamoi Stream Bridge downstream elevation with inscription
Courtesy of NOEI

Concrete pier with cutwater
Courtesy of NOEI

Concrete abutment resting on natural rock, Kahului side
Courtesy of NOEI



Downstream CRM wingwall
Courtesy of NOEI

Significance & Context

Ahupuaa	Kolea
Designer / Builder	Maui Loan Fund Commission - Hugh Howell, Senior Engineer Plans approved by Wm. F. Pogue [William Fawcett Pogue], Vice Chairman
Historic Drawings	June 1911 (approved July 1911)
Alterations	Half of parapet cap on upstream parapet, Hana side has been rebuilt
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Parapets/Railings
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of four solid parapet bridges with a date inscription on Hana Highway, Route 360; the other three similar bridges are Puohokamoa Stream, Haipuaena Stream, and Kolea (Punalau Stream) Bridges • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Exceptional example of concrete pier on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• EMI System
Geographical Features / Setting	• Area is hilly with vine groundcover and surrounded by large bamboo groves at both upstream and downstream areas • Large, flat rocks lie within the stream bed • Area is lush, yet rather open • Several waterfalls flow down the hillside, which consists of a picturesque, fern-covered rock wall • Flowering trees visible in the distance from the end of this valley
Character Defining Features	• Concrete Tee Beam Bridge • CRM Wingwalls • Reinforced Concrete Pier Cap and Columns with Cutwater • Concrete Solid Parapets with Cap and Panel Detail • Inset inscription "A.D. 1912" on two panels, downstream parapet
Detracting Features	• Excessive asphalt • Inappropriate parapet repair on downstream parapet

Significance & Context

Bridge Site History

In 1911, the Territorial Legislature established the LFC for the disbursement of funds for belt road construction in Hawaii. That same year, a record total of 21 bridges were built on Maui, with four new concrete bridges, including Waikamoi Stream Bridge, constructed on Hana Highway.[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that “very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the maximum [emphasis added] length of road.”[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, “and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair.”[4]

The County Engineer’s Office was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[5] By 1927, the local newspaper *Maui News* observed that “very few wooden structures are left on Maui… concrete bridges have been put in all over the County,”[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

2 Ibid.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 “Roads and Bridges of County Weather Heavy Rain Storms,” Maui News, April 6, 1927.

Archaeological / Cultural Significance

The place name *Waikamoi* is defined as, "Water of the moi taro, Keanae quad."[7] The bridge spans Waikamoi Stream, which travels through Kolea Ahupuaa.[8] Native families settled and cultivated gardens in the narrow valleys fed by small streams in this region.[9]

Kolea Ahupuaa is one of the boundaries of the Waiakamoi Preserve, which is further bounded by Puukalai-ipu Ahupuaa. It may be possible that Kolea Ahupuaa is named for the endemic plant (*Myrsine sandwicensis*), also known as the *Kolea lau lii*, once found in the mesic and wet forests and shrublands of east Maui. Early Hawaiian uses for the wood of the *Kolea lau lii* tree were for carving the gunwales (the uppermost portions of the hull) for canoes.[10] The tree is also known as a source for red dye for the making of designs on *kapa*, or bark-cloth. In the jungle-forests of the Hana region, these trees can grow to impressive size. *Kolea lau nui* (*Myrsine lessertiana*) is one of nineteen *Myrsine* species endemic to the Hawaiian Islands.[11] According to Kaaiakamanu, the bark, leaves and flowers of the *kolea* tree were used medicinally to treat *paaoao* (a childhood disease passed from the parents, such as syphilis and Gonorrhea) and *ea* (an infection).[12]

The region of the Waikamoi Preserve watershed, situated in the upper portion of Kalialianui Ahupuaa, represent some of the most significant native forest resources remaining in the Hawaiian Islands, and is part of a unique cultural landscape in that the native flora, fauna, mist, rains, water, natural phenomena and resources, are all believed to be *kino lau* (the myriad body-forms) of gods, goddesses, and lesser nature spirits of Hawaiian antiquity.[13]

Refer to Section G, Appendix 1, Section 3.2.1 for the regional history of the Koolau District and Kolea Ahupuaa, and to Appendix 1, Figure 8 for nearby archaeological study areas.[14, 15]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Waikamoi Stream Bridge.

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7 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

8 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

9 Davianna Pomaikai McGregor, Ph. D., *Na Kuaʻaina: Living Hawaiian Culture* (Honolulu: University of Hawaii Press, 2007).

10 Beatrice H. Krauss, *Plants in Hawaiian Culture* (Honolulu: University of Hawaii Press, 1993).

11 Native Plants Hawaii, "Myrsine lessertiana," University of Hawaii, http://nativeplants.hawaii.edu/plant/view/Myrsine_lessertiana (accessed 2012-2014).

12 Reverend Kalua M. Kaʻaiakamanu, *Native Hawaiian Medicine*, vol. 3 (Honolulu: First People's Introduction, 2003).

13 Kepa Maly and Onaona Maly, *A Collection of Native Traditions and Historical Accounts of the Lands of Hamakua Poko, Hamakua Loa and KoʻOlau, Maui Hikina (East Maui), Island of Maui,* vol. 1 of *Wai O Ke Ola: He Wahi MoʻOlelo No Maui Hikina* (Hilo: Kumu Pono Associates, 2001).

14 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

15 Joseph R. Arnold, Robert R. Hill, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Archaeological Monitoring Report for the Installation of Emergency Telephones Associated with the Hana Highway Improvements, District of Hana," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2007).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by roadside brush, opposite yield line too far to see • West Bound: Obstructed by brush
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Right Object Marker (OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.91 • Operating Rating = 1.17
Condition	Functionally Obsolete

Civil & Traffic

Waikamoi Stream Bridge is located at mile point 9.86 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 14.44 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approaches to the bridge are currently obstructed by brush and trees, causing poor visibility of oncoming traffic. Also, the placement of the yield line on the westbound approach is set too far back. Thus, when approaching from the west (Kahului) you are not able to see cars coming from the east (Hana). The signs in this area are in relatively good condition except for the “Yield” signs on the eastbound and westbound approach, both of which are currently obstructed by brush. Currently, there is no apron at either entrance of the bridge and there are no utilities in the vicinity.

The Waikamoi Bridge has been known to have a history of ponding and flooding. Since the parapet railing design does not have any openings or scuppers along its length, runoff is forced to accumulate at the center of the bridge (local low point) which leads to ponding and flooding. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way Maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations. The only nearby electrical installation is a solar-powered emergency telephone.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 25, 2013. The overall condition rating of the bridge at the time of inspection was fair.[16] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and a rating of 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 27 inches and 32 inches, respectively. Although the heights of the upstream and downstream parapets are adequate for a TL-2 rating, neither parapet has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.91 and the operating rating is 1.17.

The current curb-to-curb dimension is 12.60 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

16 See *Glossary* for more information on condition ratings.

Recommendation

It is recommended that the existing bridge structure of Waikamoi Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 25, 2013, record drawings,[17, 18, 19] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Waikamoi Stream Bridge upstream parapet showing vehicular scrape marks
Courtesy of NOEI

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Waikamoi Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

In order to improve the existing drainage conditions, a more detailed drainage study (with the aid of a topographic survey) should be conducted by the design engineer to analyze the magnitude of potential flooding. Drainage solutions may consist of multiple spillways or a drain inlet system that empties back into the stream under the appropriate and current water quality standards.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

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17 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

18 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

19 Maui Load Fund Commission, Territory of Hawaii, *Waiakamoi Bridge*, Koolau, Maui (June 1911).

Recommendations have been identified per bridge component, as follows:

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Deck

The Waikamoi Stream Bridge currently does not meet the minimum standard width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the bridge. Widening is preferred on the upstream side of the bridge as to preserve the historic inscription on the downstream parapet.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Date inscription visible on downstream parapet
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream and downstream Kahului and upstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining downstream Hana approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Waikamoi Stream Bridge downstream parapet showing inappropriate parapet repair
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Unique concrete pier columns with cutwater to be preserved and strengthened
Courtesy of NOEI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to preserve the historic inscriptions on the downstream parapet by constructing a crash-tested railing in front it. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical wall type SBC01c concrete parapet (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The existing deck does not have sufficient capacity to support the design loads of the railings. Additional support for the parapets will be required, for instance in the such as form of a new girder under the bridge. Refer to current drawings for this bridge.

CRM wingwall is partially obscured by non-historic cementitious material
Courtesy of NOEI

Also, drainage should be provided through the base of each parapet. Per community feedback, it is noted that ponding occurs during heavy rains on this bridge.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions, have an exterior panel detail and a sloped top cap appearance.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

It is recommended to investigate the current material composition of the concrete abutments, pier, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete pier wall and concrete abutments are an exemplary example and a good intact example, respectively, of these components along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments and concrete pier wall, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, it is recommended to be replaced in-kind with reinforced concrete structures detailed and finished to match existing conditions.

The existing concrete pier wall are exemplary examples of these bridge components. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete pier wall, concrete abutments, and CRM wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Object Marker Type 3 – Left and Right (OM3-L, OM3-R)
- Remove overgrown plants and brush from Yield sign
- Prune roadside brush and trees

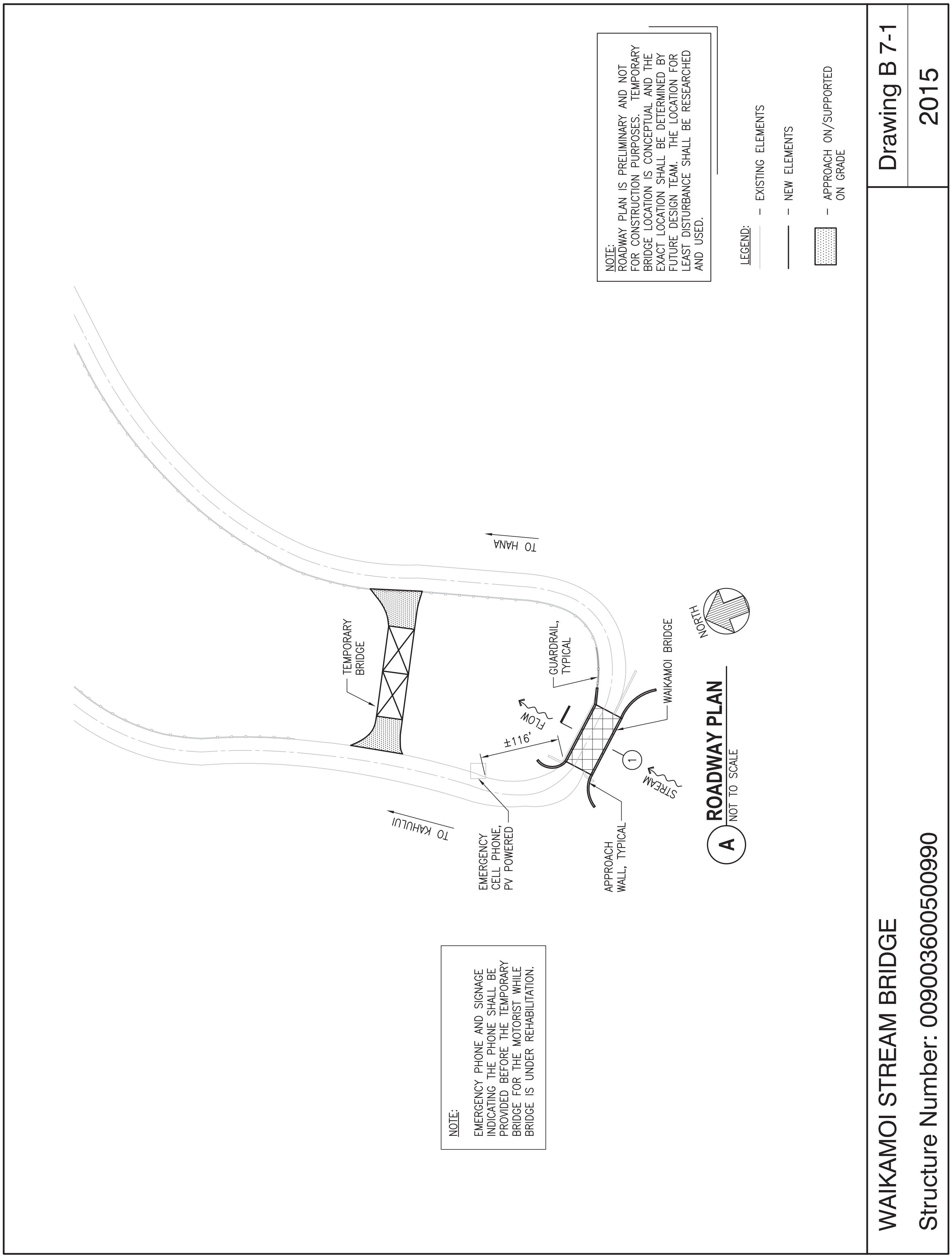
East Bridge Approach

- Add Object Marker Type 3 – Left (OM3-L)
- Remove overgrown plants and brush from Yield sign
- Prune roadside brush and trees

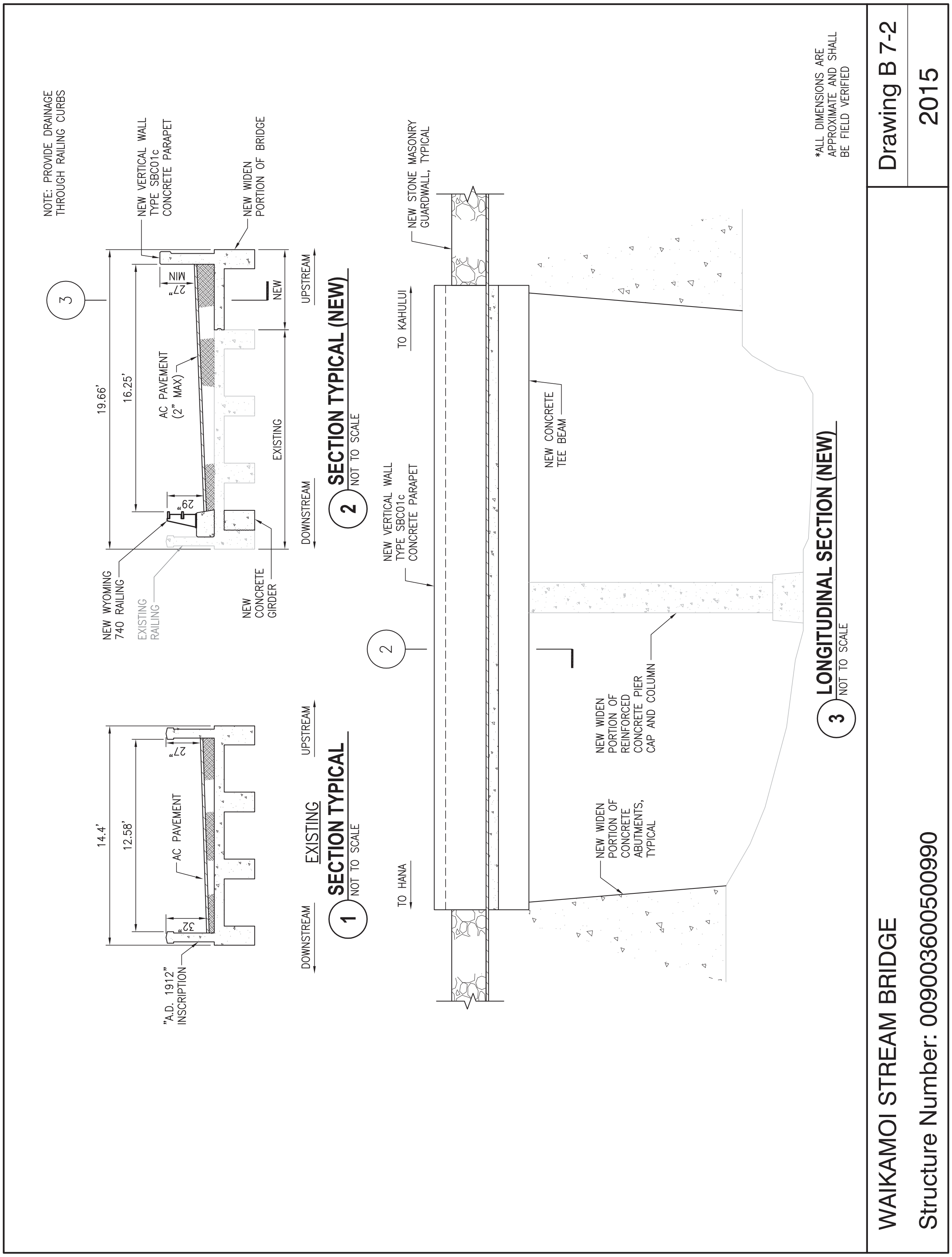
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

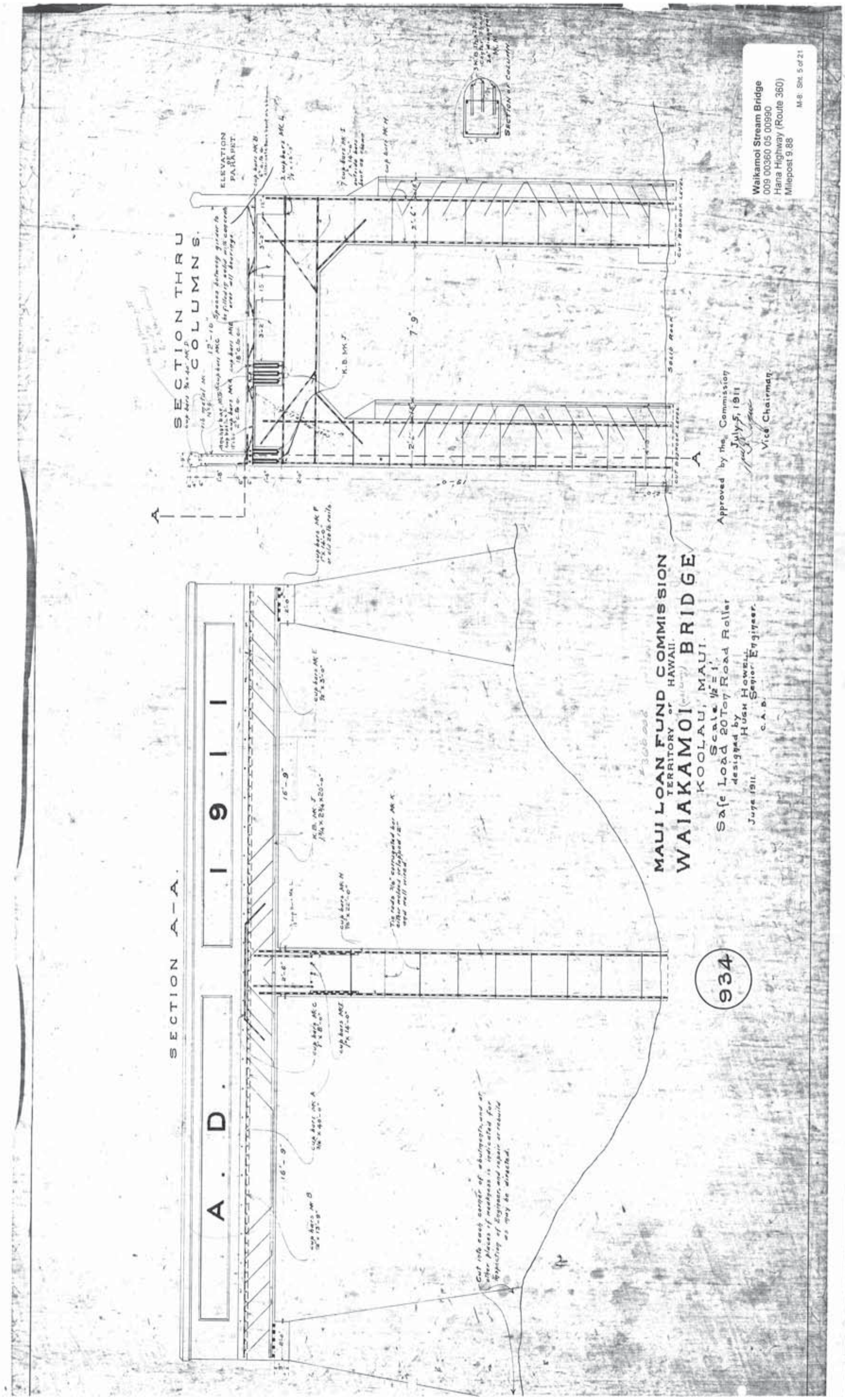
There is an existing solar-powered emergency cell phone located approximately 116 feet before the west side of the bridge. If the temporary bypass bridge is built before the emergency phone, access to the phone and signage indicating the phone's location should be provided for motorists.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

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08

Puohokamoa Stream Bridge

08 PUOHOKAMOA STREAM BRIDGE

Bridge Number	009003600501098			**Island**	Maui		
Date of Construction	1912			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 52m 02s
Longitude	156d 10m 42s
Mile Point	10.95
Location	1.16 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Puohokamoa Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	56.10 feet
Number of Spans	2
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 15.09 feet • Out-to-Out = 17.06 feet
Abutment Material	• Concrete Abutments with a CRM base • Concrete Pier Wall with a CRM base
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Solid Reinforced Concrete Parapet
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 30 inches • Downstream Railing Height = 32 inches
Parapet / Railing Profile	• Saddle coping cap • Thickness = 7 inches
Parapet Inscription	“A.D. 1912” on downstream face

Bridge Features

Puohokamoa Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1912. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span. The substructure consists of concrete abutments supported on a CRM base with CRM wingwalls. The center concrete pier wall is supported on a CRM base. The bearings under the abutments and pier are unknown and concealed below grade.

Setting of Puohokamoa Stream Bridge
Courtesy of FAI

Puohokamoa Stream Bridge downstream elevation with inscription
Courtesy of FAI

Hana approach to Puohokamoa Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Puohokamoa Stream Bridge toward Hana
Courtesy of NOEI

Solid concrete parapet with saddle coping, upstream side
Courtesy of NOEI

Solid concrete parapet with saddle coping, downstream side
Courtesy of NOEI

Puohokamoa Stream Bridge downstream elevation with inscription
Courtesy of FAI

Concrete pier wall with CRM base
Courtesy of NOEI

Concrete abutment, Kahului side
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Kolea and Loiloa
Designer / Builder	Maui Loan Fund Commission - Hugh Howell, Senior Engineer
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Parapets/Railings
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of four solid parapet bridges with a date inscription on Hana Highway, Route 360; the other three similar bridges are Waikamoi Stream, Haipuaena Stream, and Kolea (Punalau Stream) Bridges • Good intact example of concrete abutments on Hana Highway • Good intact example of concrete pier wall on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• SIHP -1509 located less than 200 meters south-southwest
Geographical Features / Setting	• Adjacent to arboretum • There is an open view of the stream, which is a popular swimming hole; there are several shallow pools and large rocks in the downstream area • There is open but dense groundcover on the downstream hillside, with ti leaf plants • Note: Flash flood and falling rock warnings in this area • Note: This property is located adjacent to private property, leading from the rubble pathway
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Abutments with CRM Base • CRM Wingwalls • Concrete Pier Wall with CRM Base • Concrete Solid Parapets with Cap and Panel Detail • Inset inscription “A.D. 1912” on two panels, downstream parapet
Detracting Features	• Inappropriate parapet repair • Excessive asphalt

Significance & Context

Bridge Site History

In 1911, the Territorial Legislature established the LFC for the disbursement of funds for belt road construction in Hawaii. That same year, a record total of 21 bridges were built on Maui, with four new concrete bridges, including Puohokamoa Stream Bridge, constructed on Hana Highway.[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the maximum [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The County Engineer's Office was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

2 Ibid.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," Maui News, April 6, 1927.

Archaeological / Cultural Significance

The place name *Puohokamoa* is defined as, "the fowl was startled. Stream, Hana, Maui."[7] The bridge spans Puohokamoa Stream, which forms the boundary between Kolea Ahupuaa and Loiloa Ahupuaa.[8] Native families settled and cultivated gardens in the narrow valleys fed by small streams in this region.[9]

Kolea Ahupuaa is one of the boundaries of the Waiakamoi Preserve, which is further bounded by Puukalai-ipu Ahupuaa. It may be possible that Kolea Ahupuaa is named for the endemic plant (*Myrsine sandwicensis*), also known as the *Kolea lau lii*, once found in the mesic and wet forests and shrublands of east Maui. Early Hawaiian uses for the wood of the *Kolea lau lii* tree were for carving the gunwales (the uppermost portions of the hull) for canoes.[10] The tree is also known as a source for red dye for the making of designs on *kapa*, or bark-cloth. In the jungle-forests of the Hana region, these trees can grow to impressive size. *Kolea lau nui* (*Myrsine lessertiana*) is one of nineteen *Myrsine* species endemic to the Hawaiian Islands.[11] According to Kaaiakamanu, the bark, leaves and flowers of the Kolea tree were used medicinally to treat *paaoao* (a childhood disease passed from the parents, such as syphilis and gonorrhea) and *ea* (an infection).[12]

Refer to Section G, Appendix 1, Section 3.2.1 for the regional history of the Koolau District and Kolea Ahupuaa, and to Section G, Appendix 1, Figure 8 for nearby archaeological study areas.[13]

Adjacent Cultural Sites

Puohokamoa Bridge was assigned its own State site number, SIHP -1509, in the Hawaii Register of Historic Places in 1974. However, it is also listed as a feature of SIHP -1638, the Hana Belt Road, on the National Register of Historic Places.[14]

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7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

9 Davianna Pomaikai McGregor, Ph. D., *Na Kua'aina: Living Hawaiian Culture* (Honolulu: University of Hawaii Press, 2007).

10 Beatrice H. Krauss, *Plants in Hawaiian Culture* (Honolulu: University of Hawaii Press, 1993).

11 Native Plants Hawaii, "Myrsine lessertiana," University of Hawaii, http://nativeplants.hawaii.edu/plant/view/Myrsine_lessertiana (accessed 2012-2014).

12 Reverend Kalua M. Ka'aiakamanu, *Native Hawaiian Medicine*, vol. 3 (Honolulu: First People's Introduction, 2003).

13 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

14 Hana Belt Road, National Register of Historic Places #20010615 (May 2001).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Marker (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.35 • Operating Rating = 0.45
Condition	Structurally Deficient

Civil & Traffic

Puohokamoa Stream Bridge is located at mile point 10.95 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 17.06 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good. Currently, there is no apron at either entrance of the bridge and there are no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way Maps or any easements in this area.

The Puohokamoa Bridge has been known to have a history of ponding and flooding. Since the parapet railing design does not have any openings or scuppers along its length, runoff is forced to accumulate at the center of the bridge (local low point) which leads to ponding and flooding. The Puohokamoa Stream Bridge was also identified to be a scour critical bridge.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 25, 2013. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[15] This one-lane bridge is *structurally deficient* due to a rating of 4 for the deck. This bridge is also *functionally obsolete*, due to a rating of 2 for *deck geometry* and *approach alignment*, and is scour critical with a rating of 3. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in poor condition. The upstream and downstream parapets had a height of 30 inches and 32 inches, respectively. Although the heights of the upstream and downstream parapets are adequate for a TL-2 rating, neither parapet is crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.35 and operating rating is 0.45.

The current curb-to-curb dimension is 15.09 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

15 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Puohokamoa Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 25, 2013, record drawings,[1, 2] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Puohokamoa Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

In order to improve the existing drainage conditions, a more detailed drainage study (with the aid of a topographic survey) should be conducted by the design engineer to analyze the magnitude of potential flooding. Drainage solutions may consist of multiple spillways or a drain inlet system that empties back into the stream under the appropriate and current water quality standards.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Puohokamoa Stream Bridge currently does not meet the minimum standard width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the bridge. Widening is preferred on the upstream side of the bridge so

1 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

2 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

as to preserve the historic inscription on the downstream parapet.

There are also no recommendations for adding a pedestrian or bicycle access route.

The bridge deck is structurally deficient. Repairs to the deck shall include, but not be limited to, epoxy injection crack repairs, chipping out and replacing exposed severely corroded reinforcing, and chipping out and patching delaminated and spalled areas with an epoxy non-shrink grout. Finish of the repaired area shall match the original condition of the bridge. Sprayed shotcrete finish shall not be permitted.

Special attention should be paid to removing excessive asphalt overlay at the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Inappropriate parapet repair
Courtesy of FAI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Parapet cap detail, damaged
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Spall at upstream corner of pier
Courtesy of NOEI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to preserve the historic inscriptions on the downstream parapet by constructing a crash-tested railing in front it. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical wall type SBC01c concrete parapet (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The existing deck does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapets will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions, have an exterior panel detail and a sloped top cap appearance.

Foundations, Piers, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the concrete abutments, pier wall, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments and concrete pier wall are good intact examples of these components along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments and concrete pier wall, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments and concrete pier wall, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

This bridge is scour critical and a POA has been created by HDOT. Currently, the POA does not recommend any immediate action.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that object markers (OM3-L & OM3-R) are added to the end treatments of the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

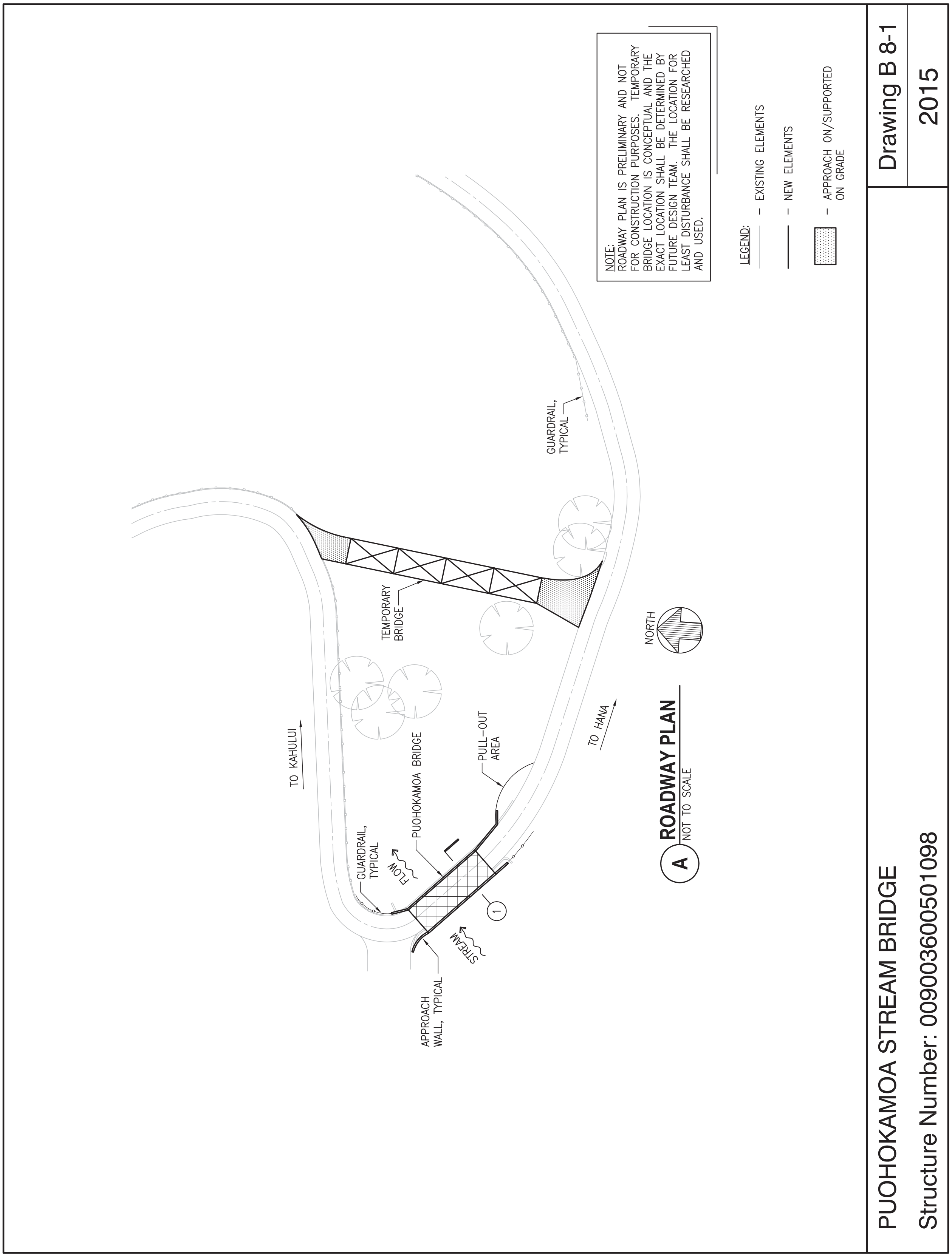
West Bridge Approach

- Add Object Marker Type 3 - Left & Right (OM3-L and OM3-R)

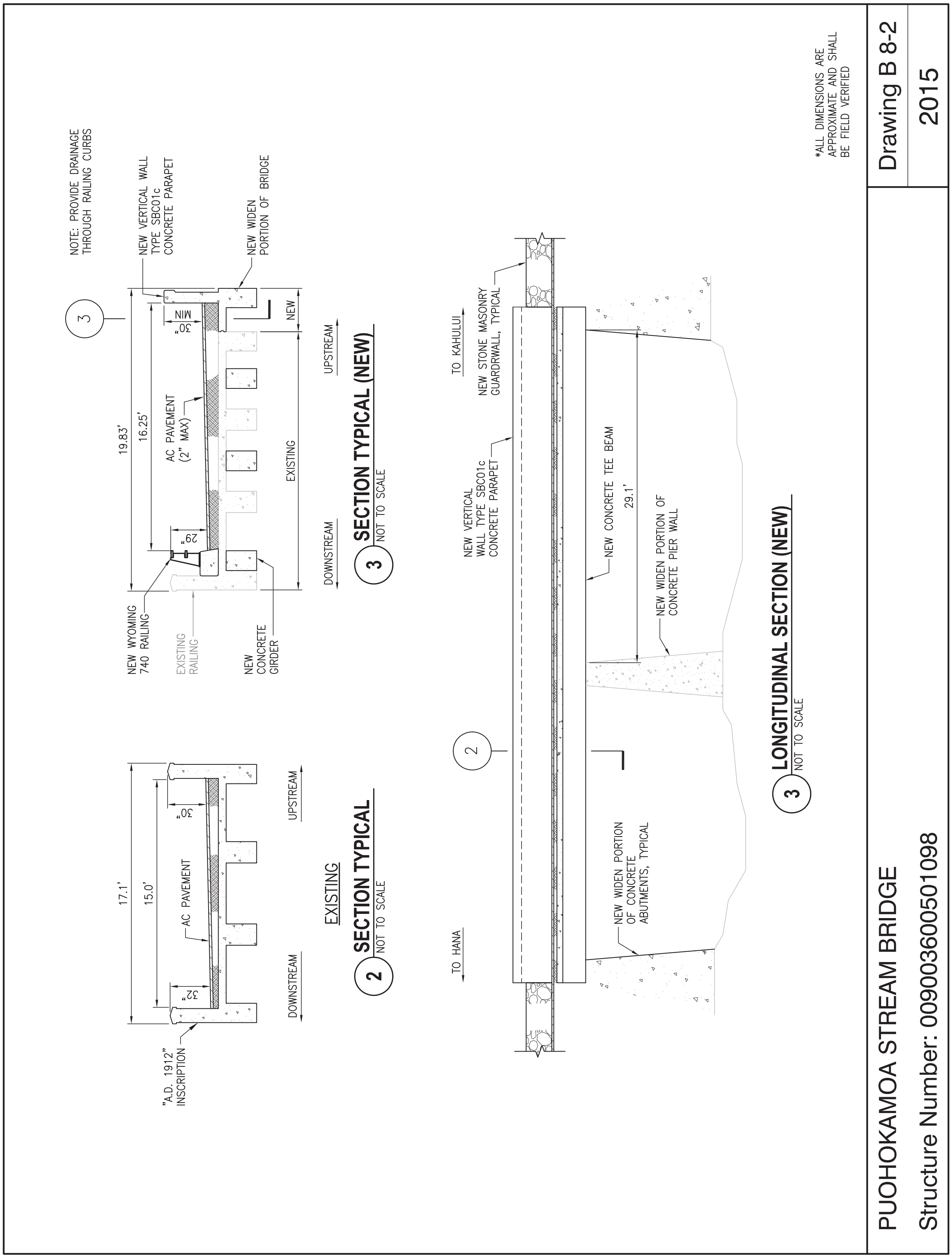
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Puohokamoa Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

09

Haipuaena Stream Bridge

09 HAIPUAENA STREAM BRIDGE

Bridge Number	009003600501145			**Island**	Maui	
Date of Construction	1912			**Route**	Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of Google Maps

Location

Latitude	20d 51m 59s
Longitude	156d 10m 35s
Mile Point	11.42
Location	0.69 miles west of Kaumahina State Wayside Park Road
Feature Crossed	Haipuaena Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	34.12 feet
Number of Spans	2
Maximum Span	16.1 feet
Deck Width	• Curb-to-Curb = 12.80 feet • Out-to-Out = 14.44 feet
Abutment Material	• Concrete Abutments • Reinforced Concrete Pier Cap and Columns
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Solid Reinforced Concrete Parapet
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 30 inches • Downstream Railing Height = 35 inches
Parapet / Railing Profile	• Saddle coping cap • Thickness = 7 inches
Parapet Inscription	"A.D. 19__" on downstream face Note: Date drawn on record drawings is 1911; however, the current parapet is damaged and the date cannot be confirmed

Bridge Features

Haipuaena Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1912. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center in each span. The substructure consists of concrete abutments, CRM wingwalls, and a reinforced concrete pier cap and columns. The abutments and pier columns bear directly on natural rock formations.

Setting of Haipuaena Stream Bridge
Courtesy of FAI

Haipuaena Stream Bridge downstream elevation with inscription
Courtesy of FAI

Hana approach to Haipuaena Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Haipuaena Stream Bridge toward Hana
Courtesy of NOEI

Solid concrete parapet with saddle coping, upstream side
Courtesy of FAI

Solid concrete parapet with saddle coping, downstream side
Courtesy of FAI

Haipuaena Stream Bridge downstream elevation with inscription
Courtesy of FAI

Concrete pier with cutwater
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Concrete abutment, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Keopuka
Designer / Builder	Maui Loan Fund Commission - Hugh Howell, Senior Engineer Plans approved by Wm. F. Pogue [William Fawcett Pogue], Vice Chairman
Historic Drawings	June 1911 (approved July 1911)
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Solid Parapet
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of four solid parapet bridges with a date inscription on Hana Highway, Route 360; the other three similar bridges are Waikamoi Stream, Puohokamoa Stream, and Kolea (Punalau Stream) Bridges • Good intact example of concrete pier wall on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• SIHP -1509 located less than 200 meters southwest
Geographical Features / Setting	• A remote area with a picturesque area that invites passersby to slow for photographs • Dense, vegetative groundcover with large African tulip and kukui trees • Possible swimming hole location, with access at the Hana side along a slightly hidden pathway marked by a magenta-colored flowering tree
Character Defining Features	• Concrete Tee Beam Bridge • CRM Wingwalls • Reinforced Concrete Pier Cap and Columns with Cutwater • Concrete Solid Parapets with Cap and Panel Detail • Inset inscription “A.D. 19__” on two panels, downstream parapet
Detracting Features	• Excessive asphalt • Inappropriate parapet repair

Significance & Context

Archaeological / Cultural Significance

The place name *Haipuaena* is defined as, “broken wild-flower. Stream, Haleakala. Maui.”[1] The bridge spans Haipuaena Stream, which appears to lie within Keopuka Ahupuaa.[2, 3]

Native Hawaiian families settled and cultivated gardens in the narrow valleys fed by small streams in this region, including Haipuaena Stream. In the broad, deep valley of Honomanu nearby, which has a large stream and a broad beach for fishing canoes and net fishing, a large Native Hawaiian population constructed terraces deep into the valley for taro cultivation.[4]

Refer to Section G, Appendix 1, Section 3.2.1 for the regional history of the Koolau District and Kolea Ahupuaa, and to Section G, Appendix 1, Figure 8 for nearby archaeological study areas.[5]

Adjacent Cultural Sites

Puohokamoa Bridge, located approximately 100 meters northwest of Haipuaena Bridge, was assigned its own State site number, SIHP -1509, in the in Hawaii Register of Historic Places in 1974. However, it is also listed as a feature of SIHP -1638, the Hana Belt Road, on the National Register of Historic Places.[6]

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Joseph Iao, “Portion of Hamakualoa & Koolau Maui,” registered map no. 2482, Hawaii Territory Survey (1909).

3 U.S. Geological Survey, ed., *Haiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

4 Davianna Pomaikai McGregor, Ph. D., *Na Kuaʻaina: Living Hawaiian Culture* (Honolulu: University of Hawaii Press, 2007).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

6 Hana Belt Road, National Register of Historic Places #20010615 (May 2001).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear, No yield • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • None
	East Bridge Approach • Yield Sign (Worn out) w/ To Oncoming Traffic Sign (Worn out) (R1-2, R1-2a) • Right Object Markers (Vandalized, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.82 • Operating Rating = 1.06
Condition	Functionally Obsolete

Civil & Traffic

Haipuaena Stream Bridge is located at mile point 11.42 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 14.44 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively poor condition. Currently, there is no apron at either entrance of the bridge and there are no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way Maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 25, 2013. The overall condition rating of the bridge at the time of inspection was fair.[7] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in poor condition. The upstream and downstream parapets had a height of 30 inches and 35 inches, respectively. Although the heights of the upstream and downstream parapets are adequate for a TL-2 rating, neither parapet is crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.82 and the operating rating is 1.06.

The current curb-to-curb dimension is 12.80 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

7 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Haipuaena Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 25, 2013, record drawings,[8, 9] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Haipuaena Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Haipuaena Stream Bridge currently does not meet the minimum standard width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the upstream side of the bridge. There are also no recommendations for adding a pedestrian or bicycle access route.

Special attention should be paid to removing excessive asphalt overlay at the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration,

8 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

9 Maui Loan Fund Commission, Territory of Hawaii, Haipuaena Bridge, Koolau, Maui (July 5, 1911).

suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and upstream and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining downstream Kahului approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Parapet cap detail; scrape mark damage across interior face of parapet
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream

Inappropriate parapet end repair
Courtesy of FAI

Damaged parapet cap with portion missing
Courtesy of FAI

Pier footing detail
Courtesy of NOEI

Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to replace the parapets on the upstream and downstream sides with a similarly designed reinforced concrete parapet. For this purpose, it is recommended to use a vertical wall type SBC01c concrete parapet which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The existing deck does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapets will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash-tested railing design height can be changed to match existing conditions, have an exterior panel detail and a sloped top cap appearance.

Foundations, Piers, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the concrete abutments, pier wall, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete pier wall is a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier wall, it is recommended to be replaced in-kind with reinforced concrete structures with the exterior surfaces detailed and finished to match existing conditions. If it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with reinforced concrete structures.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete pier wall, which shows evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-2), "To oncoming traffic" sign (R1-2a), yield line, and an object marker (OM3-R) be added to the west bridge approach. It is also recommended that and object marker (OM3-L) to be added to the left side bridge end treatment located at the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Aprons should be added to both approaches in accordance to current standards. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left and Right (OM3-L, OM3-R)

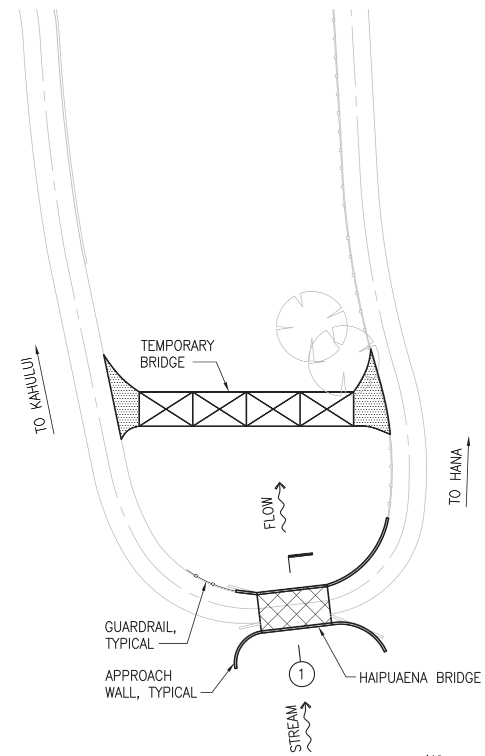
East Bridge Approach

- Replace Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add and replace Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Haipuaena Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



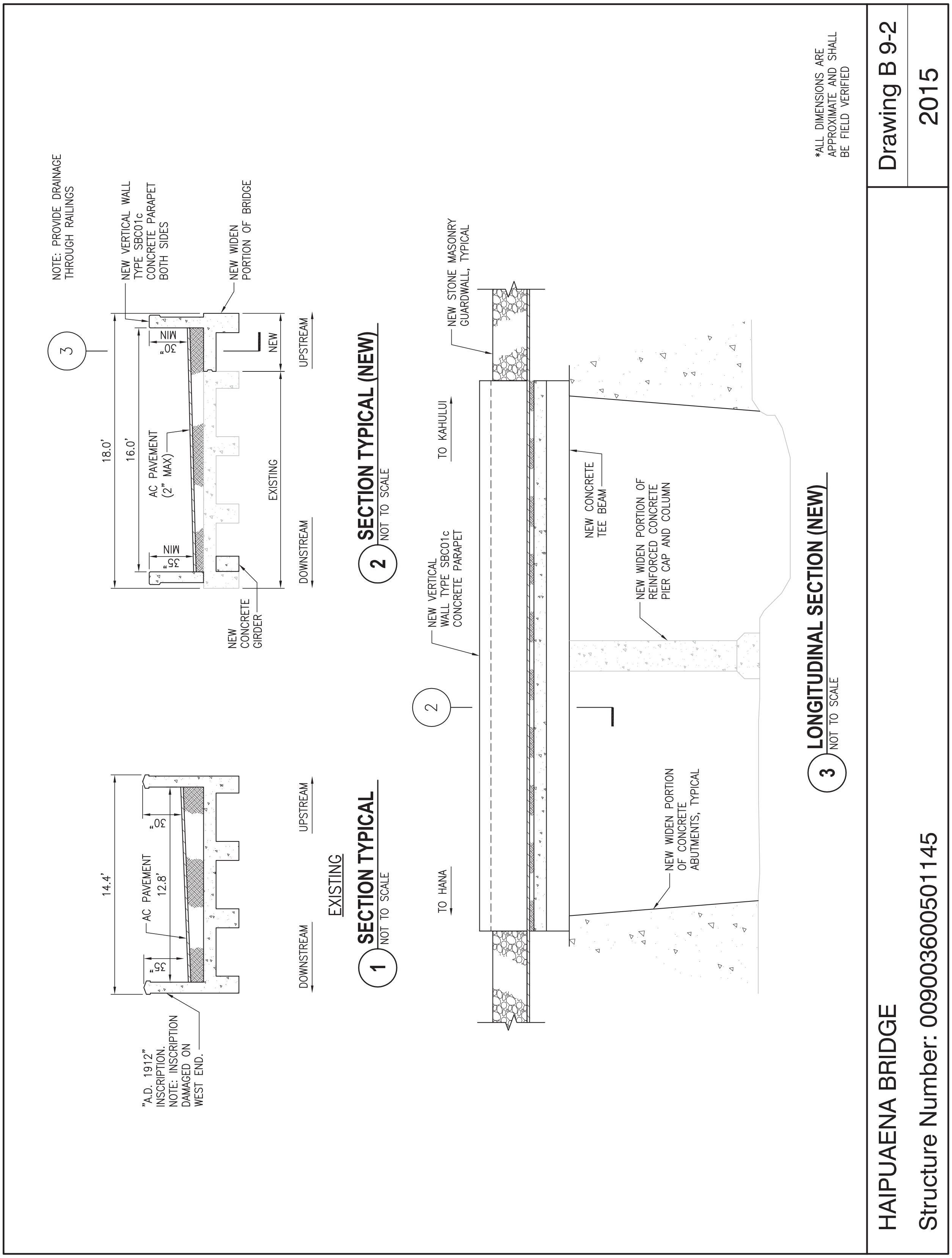
A ROADWAY PLAN
NOT TO SCALE

NOTE:
ROADWAY PLAN IS PRELIMINARY AND NOT FOR CONSTRUCTION PURPOSES. TEMPORARY BRIDGE LOCATION IS CONCEPTUAL AND THE EXACT LOCATION SHALL BE DETERMINED BY FUTURE DESIGN TEAM. THE LOCATION FOR LEAST DISTURBANCE SHALL BE RESEARCHED AND USED.

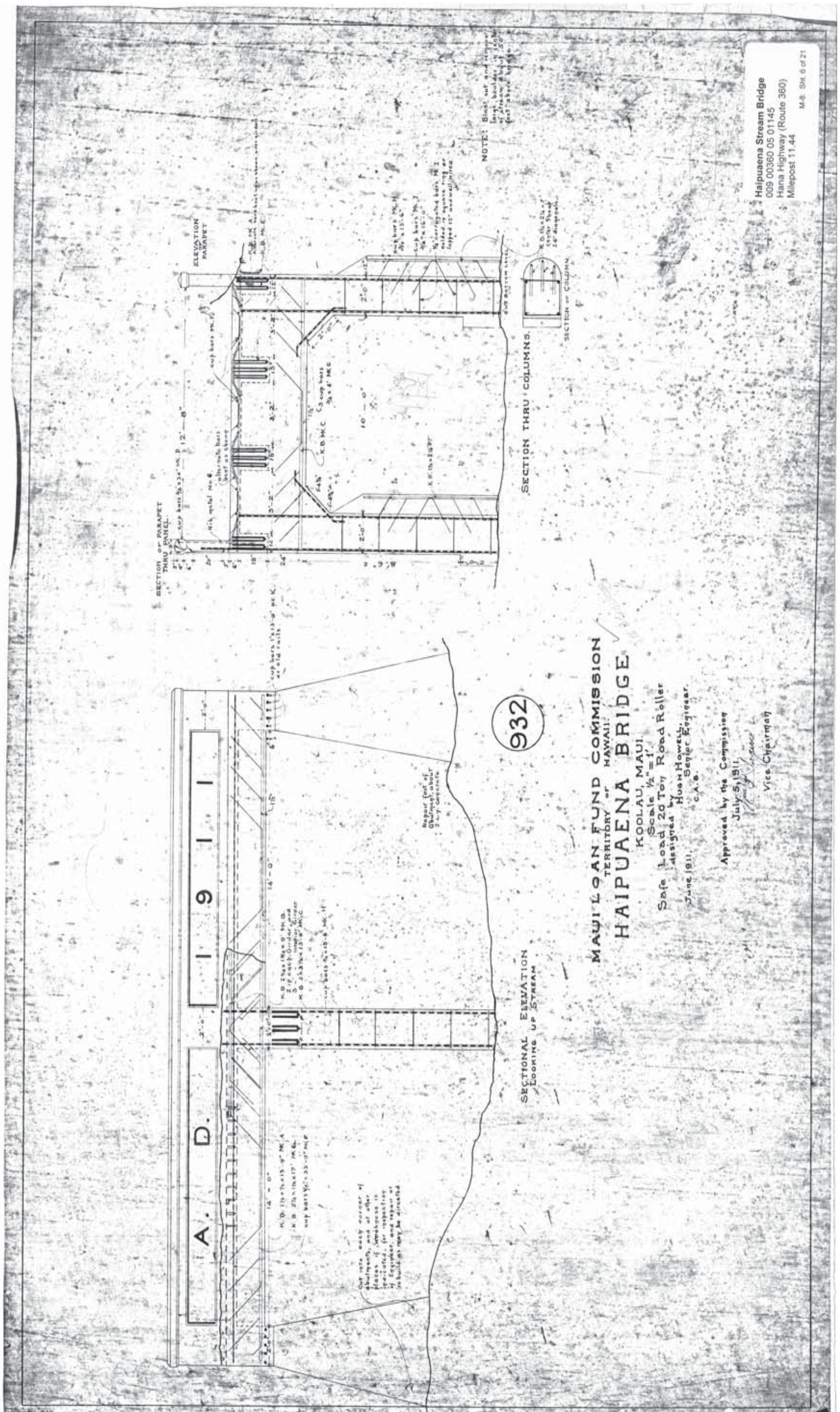
LEGEND:
- EXISTING ELEMENTS
- NEW ELEMENTS
- APPROACH ON/SUPPORTED ON GRADE

HAIPUAENA BRIDGE	Drawing B 9-1
Structure Number: 009003600501145	2015

Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

10 Kolea (Punalau Stream) Bridge

10 KOLEA (PUNALAU STREAM) BRIDGE

Bridge Number	009003600501317			**Island**	Maui		
Date of Construction	1911			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of Google Maps

Location

Latitude	20d 51m 44s
Longitude	156d 10m 12s
Mile Point	13.13
Location	1.03 miles east of Kaumahina State Wayside Park Road
Feature Crossed	Punalau Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	34.12 feet
Number of Spans	1
Maximum Span	29.9 feet
Deck Width	• Curb-to-Curb = 12.80 feet • Out-to-Out = 14.11 feet
Abutment Material	Concrete Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Solid Reinforced Concrete Parapet
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 31 inches • Downstream Railing Height = 32 inches
Parapet / Railing Profile	• No Cap • Thickness = 7 inches
Parapet Inscription	“1911” on downstream face

Bridge Features

Kolea (Punalau Stream) Bridge is a single-span reinforced concrete tee beam bridge built in 1911. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of concrete abutments and CRM wingwalls. The bearings under the abutments are unknown and concealed below grade.

Setting of Kolea (Punalau Stream) Bridge
Courtesy of NOEI

Kolea (Punalau Stream) Bridge downstream elevation with inscription
Courtesy of NOEI

Hana approach to Kolea (Punalau Stream) Bridge toward Kahului
Courtesy of FAI

Kahului approach to Kolea (Punalau Stream) Bridge toward Hana
Courtesy of NOEI

Solid concrete parapet, upstream side
Courtesy of NOEI

Solid concrete parapet, downstream side
Courtesy of NOEI

Bridge date on downstream parapet
Courtesy of FAI

Approach wall, upstream Kahului side
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Concrete abutment, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Honomanu
Designer / Builder	Maui Loan Fund Commission - Hugh Howell, Senior Engineer
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Parapets/Railings
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of four solid parapet bridges with a date inscription on Hana Highway, Route 360; the other three similar bridges are Waikamoi Stream, Puohokamoa Stream, and Haipuaena Stream Bridges • Good intact example of concrete abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Honomanu Valley across Punalau Stream • Heavy, dense vegetation and vines in this open valley; the valley is filled with kukui and African tulip trees, with clusters of palm trees • Quiet area with babbling brook at the base of a gentle slope • Kahului side is hilly • A scenic area with small pull-off area for cars on the Hana approach •There are 4 large boulders on the inner roadside of the Kahului approach • Large boulder on west downstream end appears to have been placed as a guardrail; unique roadside edging
Character Defining Features	• Concrete Tee Beam Bridge • CRM Wingwalls • Concrete Solid Parapets • Raised inscription "1911", downstream parapet
Detracting Features	• Cementitious material obscures the face of CRM wingwalls • Excessive asphalt

Significance & Context

Bridge Site History

In 1911, the Territorial legislature established the LFC for the disbursement of funds for belt road construction in Hawaii. That same year, a record total of 21 bridges were built on Maui, with four new concrete bridges, including Kolea (Punalau) Stream Bridge, constructed on Hana Highway.[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that “very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road.”[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, “and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair.”[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[5] By 1927, the local newspaper *Maui News* observed that “very few wooden structures are left on Maui… concrete bridges have been put in all over the County,”[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 63.

2 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 “Roads and Bridges of County Weather Heavy Rain Storms,” Maui News, April 6, 1927.

Archaeological / Cultural Significance

The place name *Kolea* is defined as, "plover. Land section, Koolau, Maui."[7] *Punalau* is defined as, "many springs."[8] The Kolea Bridge spans Punalau Stream, which empties into Honomanu Bay located in the Honomanu Ahupuaa.[9, 10]

It was noted by McGregor that Native Hawaiian families settled and cultivated gardens in the broad, deep valley of Honomanu. A large Native Hawaiian population constructed terraces deep into Honomanu valley for taro cultivation.[11]

Honomanu Valley is best characterized as a large stream with a broad deep valley and a good beach for fishing canoes. In ancient times, Honomanu was said to have supported a large population. Terrace walls were observed by Handy:

> *….as far as the level land goes – a little less than a mile. Above the valley, on elevated flatlands, there used to be some terraces and houses. These upland slopes were doubtless planted with all the plants that flourish where there is much rain, but they were too wet for sweet potatoes*.[12]

The Koolau Ditch trail at Honomanu was described in 1915 as possessing, "beauty that baffles description, and were its attractions made widely known, tourists in plenty would assuredly visit it to gaze down its two-thousand feet depth."[13] The road to Hana crossed the Honomanu Gulch by way of a serpentine roadway that descended down the side of a steep mountain cliff, through the valley floor, and across several bridges before climbing up another steep cliff to exit the valley.[14]

Refer to Section G, Appendix 1, Section 3.1.2.4 for the regional background of Honomanu, and to Section G, Appendix 1, Figure 6 for nearby archaeological study areas.[15]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of the Kolea (Punalau Stream) Bridge.

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7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

9 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

10 MKE Associates, LLC and Fung Associates, INC., "Hawaii State Historic Bridge Inventory and Evaluation," prepared for the State of Hawaii Department of Transportation Highways Division (Honolulu, 2013).

11 Davianna Pomaikai McGregor, Ph. D., *Na Kua'aina: Living Hawaiian Culture* (Honolulu: University of Hawaii Press, 2007).

12 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

13 Alexander Hume Ford, "Around About Nahiku," *The Mid-Pacific Magazine*, 1915.

14 Dawn E. Duensing, "The Hana Belt Road: Paving the Way for Tourism," *The Hawaiian Journal of History* 41 (Honolulu: Hawaiian Historic Society, 2007).

15 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (Poor Condition, OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (Poor Condition, OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.42 • Operating Rating = 0.46
Condition	Structurally Deficient

Civil & Traffic

Kolea (Punalau Stream) Bridge is located at mile point 13.13 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 14.11 feet that has no bicycle or pedestrian access routes. The signage and striping at the east and west bridge approach includes a “Yield” sign (R1-1), a “To Oncoming Traffic” sign (R1-2a), a yield line, and an object markers (OM3-L & OM3-R) on the bridge end treatments. Visibility of oncoming traffic is clear of any obstructions while stopped at both bridge approaches. Currently, there is no apron at either entrance of the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way Maps or any easements in this area.

The Kolea (Punalau Stream) Bridge has been known to have a history of ponding and flooding. Since the parapet railing design does not have any openings or scuppers along its length, runoff is forced to accumulate at the center of the bridge (local low point) which leads to ponding and flooding.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 11, 2013. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[16] This one-lane bridge is *structurally deficient* due to a rating of 4 for the deck and superstructure. This bridge is also *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 32 inches. Although the heights of the upstream and downstream parapets are adequate for a TL-2 rating, neither parapet is crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.42 and operating rating is 0.46.

The current curb-to-curb dimension is 12.80 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

16 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kolea (Punalau Stream) Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 11, 2013, record drawings,[1] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kolea (Punalau Stream) Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

In order to improve the existing drainage conditions, a more detailed drainage study (with the aid of a topographic survey) should be conducted by the design engineer to analyze the magnitude of potential flooding. Drainage solutions may consist of multiple spillways or a drain inlet system that empties back into the stream under the appropriate and current water quality standards.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck & Superstructure

The Kolea (Punalau Stream) Bridge currently does not meet the minimum standard width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the bridge. Widening is preferred on the upstream side of the bridge as to preserve the historic inscription on the downstream parapet.

1 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

There are also no recommendations for adding a pedestrian or bicycle access route.

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

The bridge deck and superstructure are structurally deficient. Repairs to the deck and superstructure shall include, but not be limited to, epoxy injection crack repairs, chipping out and replacing exposed severely corroded reinforcing, and chipping out and patching delaminated and spalled areas with an epoxy non-shrink grout. Finish of the repaired area shall match the original condition of the bridge. Sprayed shotcrete finish shall not be permitted.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

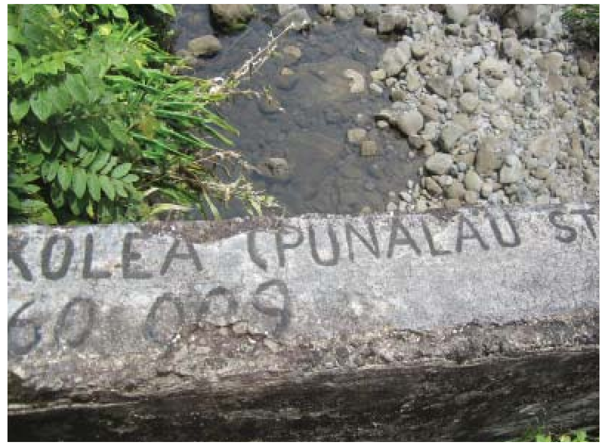
Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Hana approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining three approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Parapet without cap profile
Courtesy of FAI

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.



Spalling at top of parapet wall
Courtesy of FAI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to preserve the historic inscriptions on the downstream parapet by constructing a crash-tested railing in front it. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical concrete barrier rail (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The existing deck does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapets will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions and have a straight exterior surface.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Aprons should be added to both approaches in accordance with current standards. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Replace Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

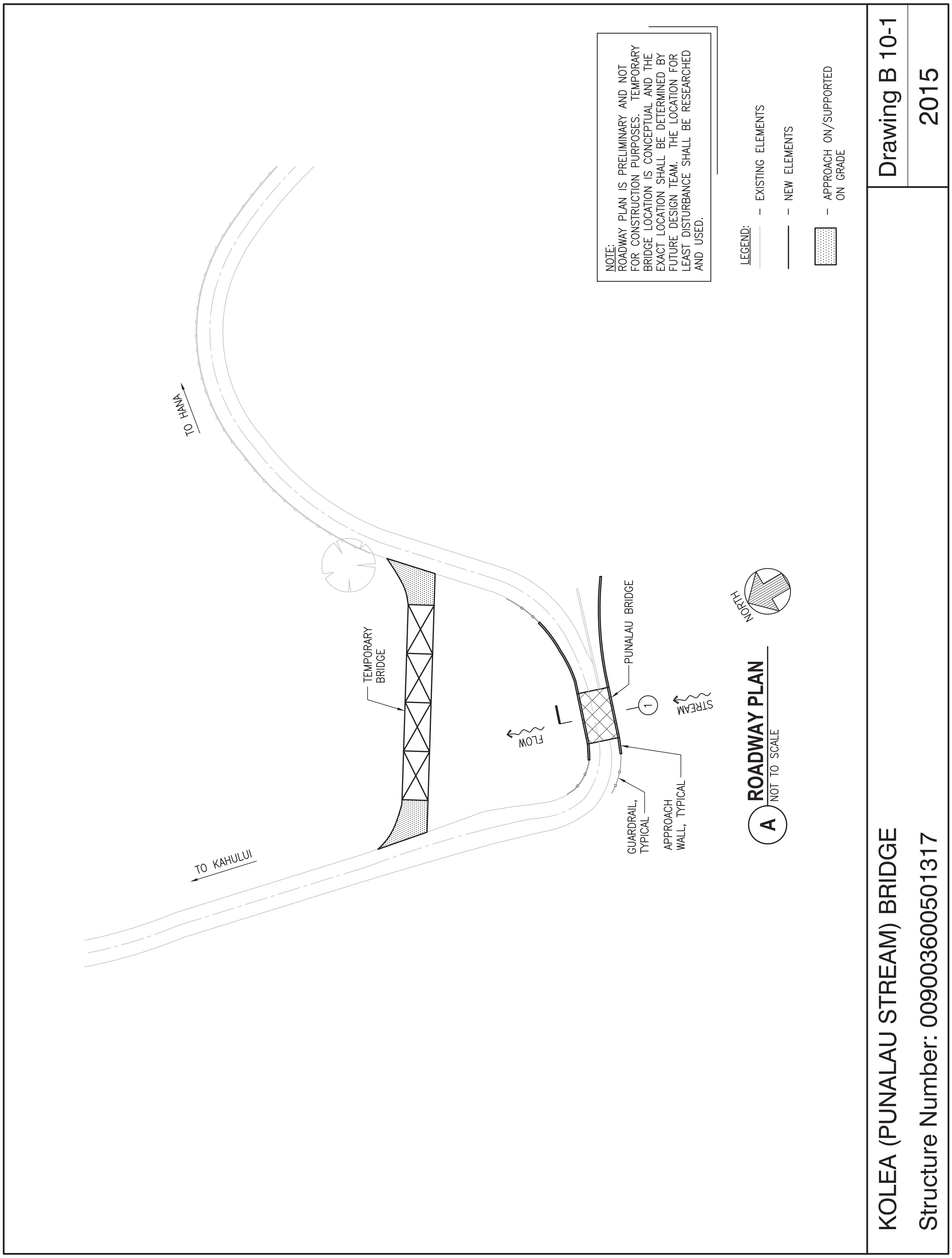
East Bridge Approach

- Replace Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

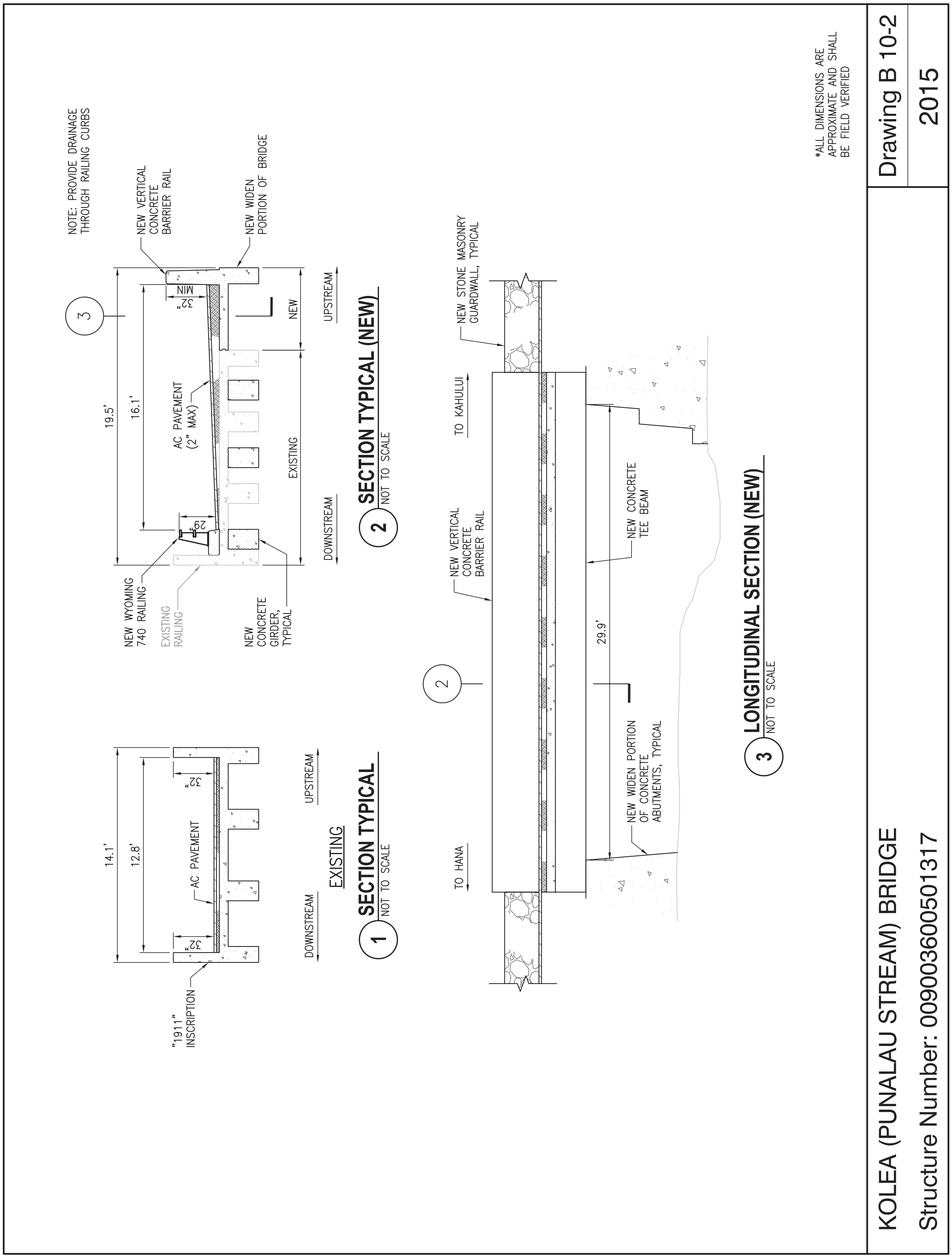
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

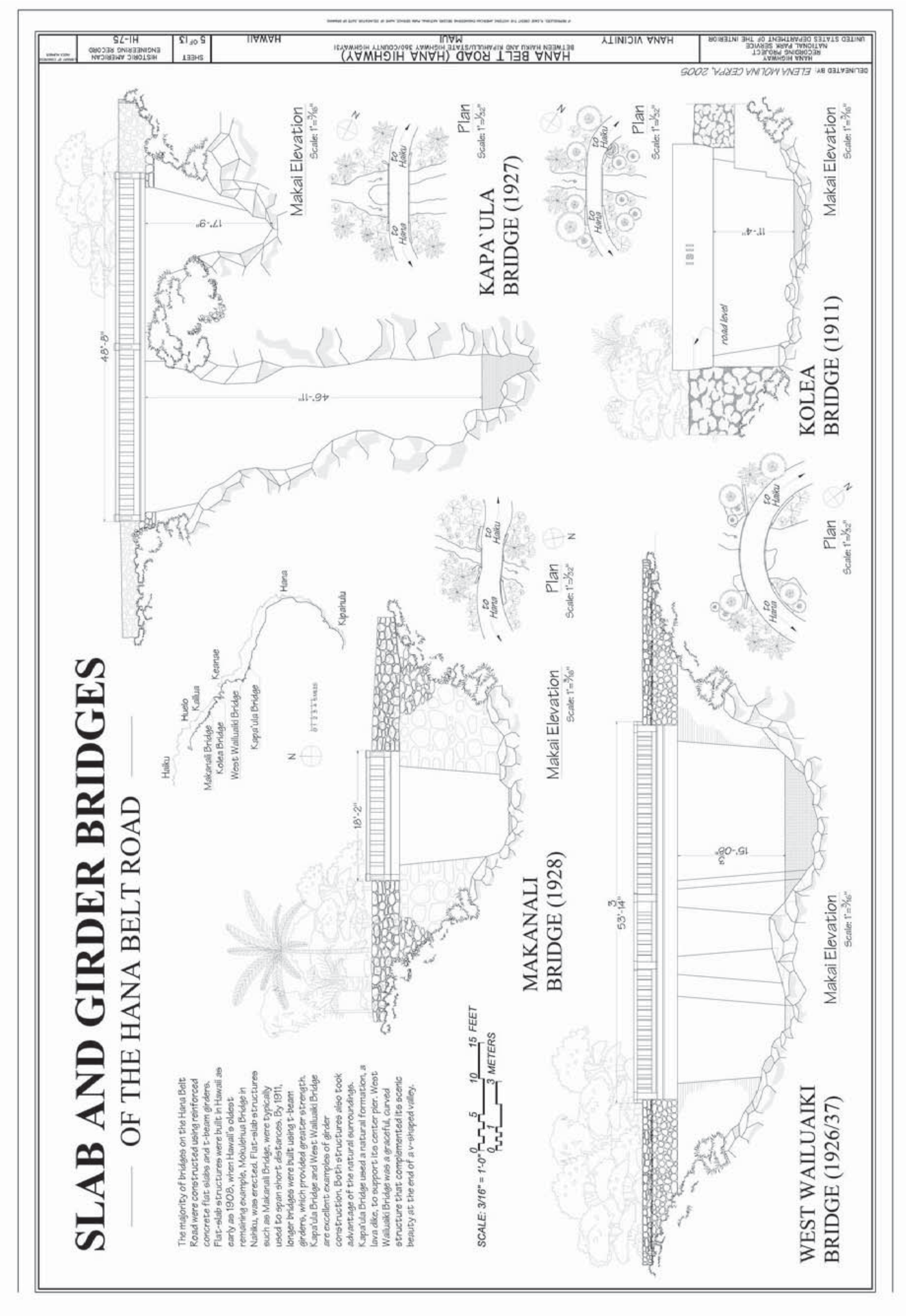
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Kolea (Punalau Stream) Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of HAER HI-75

11

Honomanu Stream Bridge

11 HONOMANU STREAM BRIDGE

Bridge Number	009003600501372			**Island**	Maui		
Date of Construction	1911			**Route**	Hana Highway		
Treatment Recommendation		Preservation		Rehabilitation		Restoration	X	Replacement

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 51m 19s
Longitude	156d 10m 11s
Mile Point	13.68
Location	1.58 miles east of Kaumahina State Wayside Park Road
Feature Crossed	Honomanu Stream

Bridge Features

Bridge Type	Concrete Tee Beam and Pre-cast Pre-stressed Planks
Total Length	47.90 feet
Number of Spans	2
Maximum Span	23.0 feet
Deck Width	• Curb-to-Curb = 12.47 feet • Out-to-Out = 14.11 feet
Abutment Material	• Concrete Abutments • Concrete Pier Wall
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Solid Reinforced Concrete Parapet
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 26 inches • Downstream Railing Height = 26 inches
Parapet / Railing Profile	• Rounded cap • Thickness = 9 inches
Parapet Inscription	None

Bridge Features

Honomanu Stream Bridge was originally built in 1911 as a double-span reinforced concrete tee beam bridge. According to 1978 record drawings, the original bridge was left in place and pre-cast pre-stressed planks with an AC overlay were placed over the existing deck. The top of the existing bridge deck cannot be seen due to the AC overlay; therefore, only the concrete slab which is supported on a superstructure of four concrete tee beams in each span, can be observed from the underside of the bridge deck. The substructure consists of concrete abutments, concrete pier wall, and CRM wingwalls. The bearings under the abutments and pier wall are unknown and covered by stream flow.

Setting of Honomanu Stream Bridge
Courtesy of FAI

Honomanu Stream Bridge downstream elevation
Courtesy of FAI

Hana approach to Honomanu Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Honomanu Stream Bridge toward Hana
Courtesy of NOEI

Solid concrete parapet, upstream side
Courtesy of NOEI

Solid concrete parapet, downstream side
Courtesy of NOEI

CRM wingwall, downstream Kahului side
Courtesy of NOEI

Concrete pier wall with cutwater
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Concrete abutment resting on CRM base, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Honomanu
Designer / Builder	Maui Loan Fund Commission - Hugh Howell, Senior Engineer
Historic Drawings	None
Alterations	1978 - Rehabilitation
Replacement	None
Preservation Priority	Contributing Bridge: Solid Parapet
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of concrete pier wall on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Lush vegetation in this quiet, cool, and shaded wooded area • Located at base of Honomanu Valley • Quiet, shallow and clear creek surrounded by fern groundcover and dense undergrowth
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Abutments with CRM Base • CRM Wingwalls • Concrete Pier Wall with Board-Formed Texture • Concrete Solid Parapets with Board-Formed Texture
Detracting Features	• Cementitious material obscures the face of CRM wingwalls • Excessive asphalt

Significance & Context

Bridge Site History

In 1911, the Territorial Legislature established the LFC for the disbursement of funds for belt road construction in Hawaii. That same year, a record total of 21 bridges were built on Maui, with four new concrete bridges, including Honomanu Stream Bridge, constructed on Hana Highway.[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that “very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road.”[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, “and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair.”[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[5] By 1927, the local newspaper *Maui News* observed that “very few wooden structures are left on Maui… concrete bridges have been put in all over the County,”[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

Archaeological / Cultural Significance

The place name *Honomanu* is defined as, “shoulders puffed with fatness. Land section, Koolau, Maui.”[7] The Honomanu Stream Bridge spans Honomanu Stream, located in the Honomanu Ahupuaa.[8]

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1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 63.

2 Ibid, 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 “Roads and Bridges of County Weather Heavy Rain Storms,” Maui News, April 6, 1927.

7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990).

Honomanu Valley is best characterized as a large stream with a broad deep valley and a good beach for fishing canoes. In ancient times, Honomanu was said to have supported a large population,[9] and families settled and cultivated gardens in the narrow valleys fed by small streams in the region.[10] Terrace walls were observed by Handy:

> *….as far as the level land goes – a little less than a mile. Above the valley, on elevated flatlands, there used to be some terraces and houses. These upland slopes were doubtless planted with all the plants that flourish where there is much rain, but they were too wet for sweet potatoes*.[11]

In 1828, Protestant missionaries made a tour of the island of Maui, and described a traveling to Honomanu:[12]

> *In the vallies [sic] there ran brooks, some of them of considerable size. Several miles of our way lay through a wood. The soil was exceedingly rich; the trees, many of which were large, were covered with vines, of a most luxuriant growth; be we looked in vain for the "fruit of the vine," which, weary and hungry as we were, would have been exceedingly refreshing. About five o'clock, P.M., we reached Honomanu, where we examined a small school. Here the princess concluded to spend the Sabbath.*[13]

The Koolau Ditch trail at Honomanu was described in 1915 as possessing, "beauty that baffles description, and were its attractions made widely known, tourists in plenty would assuredly visit it to gaze down its two-thousand feet depth."[14] The road to Hana crossed the Honomanu Gulch by way of a serpentine roadway that descended down the side of a steep mountain cliff, through the valley floor, and across several bridges before climbing up another steep cliff to exit the valley.[15] During the period of road construction to Hana, the road crew led by John Wilson that constructed the portion of the Hana highway between Kailua and Keanae in 1904, constructed a workers camp at Honomanu Valley.[16]

Refer to Section G, Appendix 1, Section 3.1.1.1.3 for a detailed account by the Protestant missionaries traveling through the Hamakualoa District; Sections 3.1.2.3 and 3.1.2.4 for a regional history of Kolea and Honomanu; and Section G, Appendix 1, Figure 6 for nearby archaeological study areas.[17]

9 William Richards, Lorrin Andrews, and Jonathan Green, "A Tour of Maui," *The Missionary Herald, containing Proceedings of The American Board of Commissioners for Foreign Missions with a View of Other Benevolent Operations for the year 1829* (Boston: Crocker and Brewster for A.B.C.F.M., 1829)

10 Davianna Pomaikai McGregor, Ph. D., *Na Kua'aina: Living Hawaiian Culture* (Honolulu: University of Hawaii Press, 2007).

11 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

12 William Richards, Lorrin Andrews, and Jonathan Green, "A Tour of Maui," *The Missionary Herald, containing Proceedings of The American Board of Commissioners for Foreign Missions with a View of Other Benevolent Operations for the year 1829* (Boston: Crocker and Brewster for A.B.C.F.M., 1829).

13 Ibid, 249.

14 Alexander Hume Ford, "Around About Nahiku," *The Mid-Pacific Magazine*, 1915.

15 Dawn E. Duensing, "The Hana Belt Road: Paving the Way for Tourism," *The Hawaiian Journal of History* 41 (Honolulu: Hawaiian Historic Society, 2007).

16 Bob Krauss, *Johnny Wilson: First Hawaiian Democrat* (Honolulu: University of Hawaii Press, 1994).

17 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of the Honomanu Stream Bridge.

Walker Site 89, the Puuo Kohola Heiau, was listed by Walker as destroyed, but as having once been located at Honomanu. Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway.

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (Poor Condition, OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Right Object Markers (Poor Condition, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.63 • Operating Rating = 0.81
Condition	Structurally Deficient

Civil & Traffic

Honomanu Stream Bridge is located at mile point 13.68 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 14.11 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently obstructed by large trees causing poor visibility of oncoming traffic. The signs in this area are in relatively poor condition. Currently, there is no apron at either entrance of the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way Maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 11, 2013. This bridge is a one-lane bridge. CRM walls are located at each corner of the approaches to the bridge.

The overall condition rating of the bridge at the time of inspection varied between poor and fair[1] and was limited to the exposed portions of the bridge. This bridge is currently rated as *structurally deficient* due to a rating of 4 for the original 1911 deck and superstructure, but this may be incorrect. The 1978 pre-cast pre-stressed planks were not visible for inspection and therefore, are not incorporated into the condition rating of the bridge. The pre-cast pre-stressed planks span between the abutments and pier and appear to be designed to carry the designed load without assistance from the original 1911 bridge. The original 1911 bridge appears to be left in-place for ease of construction. This bridge is also *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*.

At the time of inspection, the concrete parapets were in poor condition. The upstream and downstream parapets had a height of 26 inches. Neither parapet has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.63 and the operating rating is 0.81.

The current curb-to-curb dimension is 12.47 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

1 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Honomanu Stream Bridge be replaced. Any replacement or rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 11, 2013, record drawings,[1, 2, 3] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Honomanu Stream Bridge is to be replaced, any replacement work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

In addition to providing a temporary bridge, the location of the entry ways to the temporary bridge will require clearing trees and vegetation in the gulch. At the time of construction, the location of the entry ways will need to be investigated to determine the best location with the least amount of flora and cultural disturbance.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Cracked asphalt surface at deck
Courtesy of NOEI

1 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

2 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

3 State of Hawaii, Department of Transportation, Land Transportation Facilities Division, "As-Built" Plans for Hana Highway Honomanu Bridge Repair, Project No. 360AB-02-78 (April 1978).

Recommendations have been identified per bridge component, as follows:

Deck & Superstructure

The Honomanu Stream Bridge currently does not meet the minimum standard width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the bridge on the downstream side. There are also no recommendations for adding a pedestrian or bicycle access route.

Replacement of the deck and superstructure is recommended since the condition of the pre-cast pre-stressed planks cannot be confirmed through visual inspection and there is a significant amount of water stains and patching to the bridge deck and girders. Also, the existing bridge deck and girders are structurally deficient.

The new concrete deck and girder components will be designed to meet current codes, a minimum clear curb-to-curb width of 16 feet, and support a 40-ton load carrying capacity.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Deteriorated portion of parapet
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Damaged parapet
Courtesy of FAI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to replace the parapets on the upstream and downstream sides with a similarly designed reinforced concrete parapet. For this purpose, it is recommended to use a vertical wall type SBC01c concrete parapet (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

Pier cutwater detail
Courtesy of NOEI

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, the future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash-tested railing design height and appearance can be changed to match original as-built (pre-1978 rehabilitation) conditions.

Staining and growth at bridge girders
Courtesy of NOEI

Foundations, Piers, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Spalled concrete and exposed re-bar at bridge substructure
Courtesy of NOEI

It is recommended to investigate the current material composition of the concrete abutments, pier wall, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete pier wall is a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier wall, it is recommended to be replaced in-kind with reinforced concrete structures with the exterior surfaces detailed and finished to match existing conditions. If it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with reinforced concrete structures.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete pier wall, which shows evidence of historic craftsmanship, is strongly recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and a bridge load posting of 30-tons was recommended. Although this recommended posting is higher than the 10-tons general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3), it is still under the recommended design criteria of 40-tons. Therefore, it is recommended to design the new bridge superstructure to support a load carrying capacity of 40-tons. Also, the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that an object marker (OM3-L) is placed on the left side bridge end treatment at the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Aprons should be added to both approaches in accordance to current standards. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Replace Object Marker Type 3 - Left and Right (OM3-L, OM3-R)

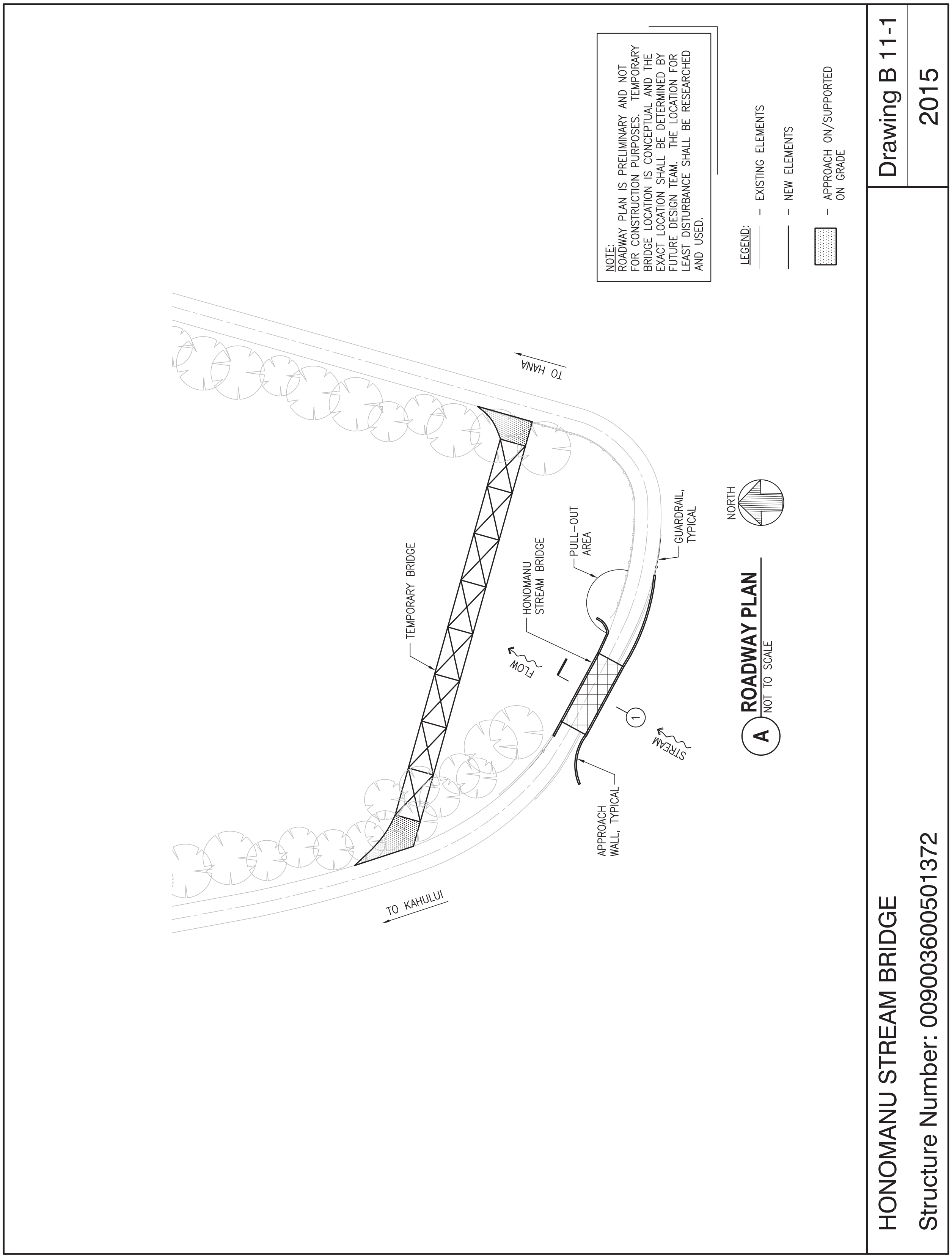
East Bridge Approach

- Add Object Marker Type 3 - Left (OM3-L)
- Replace Object Marker Type 3 - Right (OM3-R)

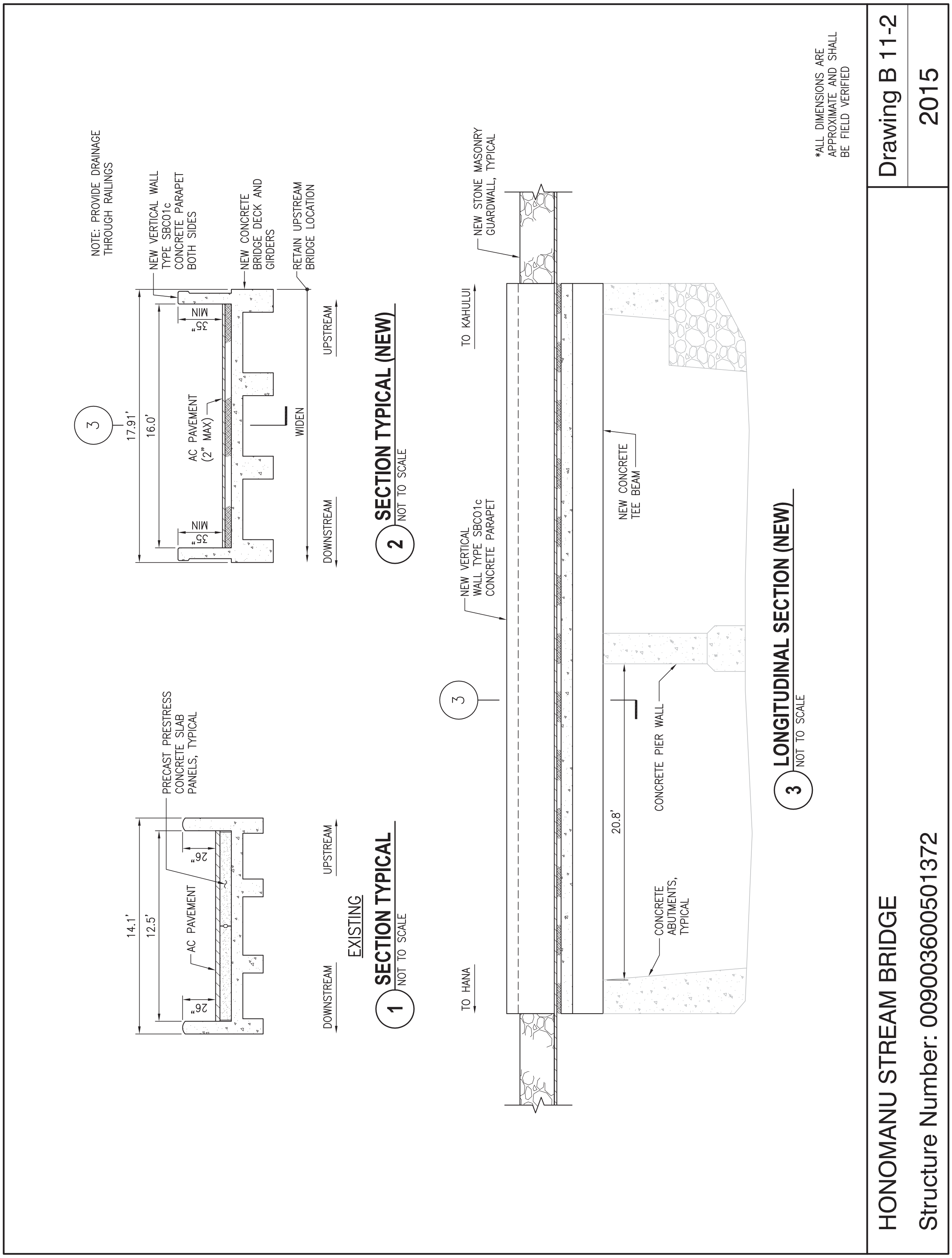
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Honomanu Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

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12

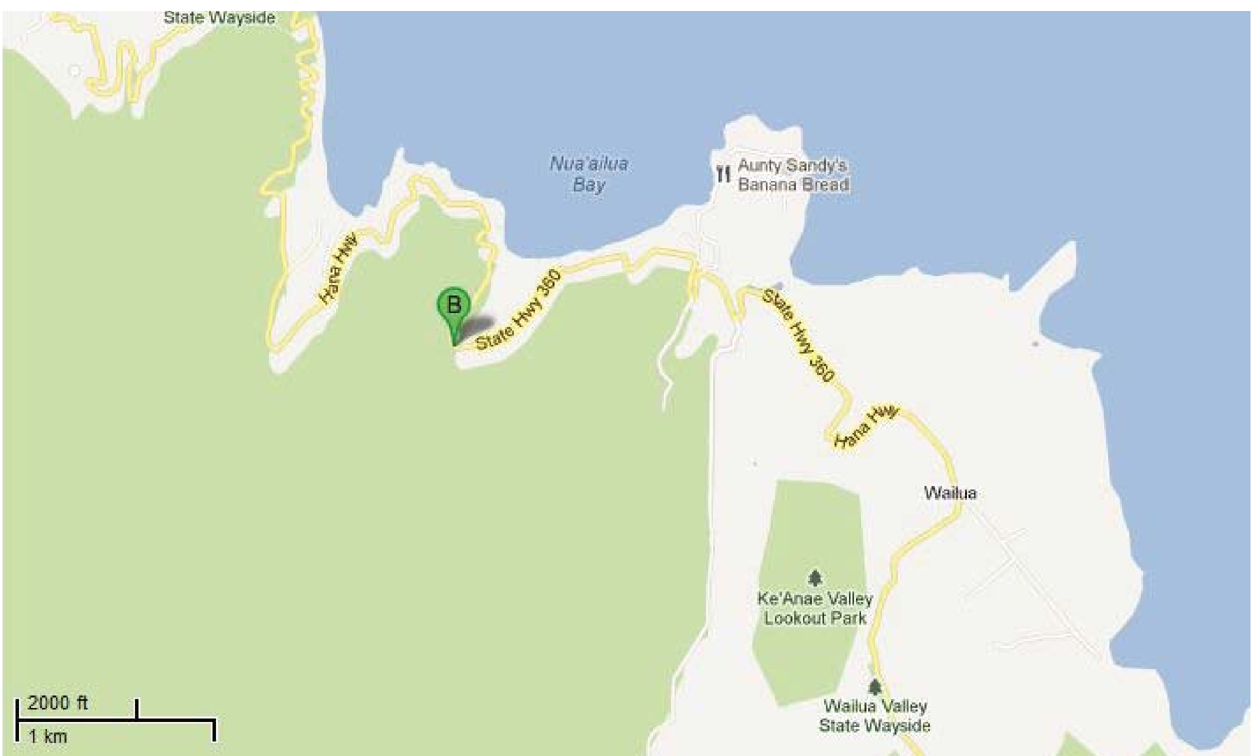
Nuaailua Stream Bridge

12

NUAAILUA STREAM BRIDGE

Bridge Number	009003600501540			Island		Maui	
Date of Construction	1911			Route		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of FAI



Courtesy of Google Maps

Location

Latitude	20d 51m 19s
Longitude	156d 09m 38s
Mile Point	15.34
Location	1.16 miles west of Keanae Homestead Road
Feature Crossed	Nuaailua Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	35.10 feet
Number of Spans	1
Maximum Span	29.9 feet
Deck Width	• Curb-to-Curb = 21.00 min - 35.80 max feet (varies) • Out-to-Out = 23.10 min - 37.90 max feet (varies)
Abutment Material	Concrete Abutments with CRM Base
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	• Solid Reinforced Concrete Parapet (upstream) • Concrete Open Vertical (downstream)
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 42 inches • Downstream Railing Height = 40 inches
Baluster Dimensions (downstream)	• Posts = 6 inches x 6 inches • Posts spaced approx. = 16 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Cap Profile (downstream)	• Rectangular cap • Railing cap = 6 inches x 8 inches
Parapet / Railing Profile (upstream)	• No cap • Thickness = 8 inches
Parapet Inscription (upstream)	None

Bridge Features

Nuaailua Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1911 and widened in 1940. The superstructure consists of a concrete deck slab with AC pavement overlay supported on eight concrete tee beams. The substructure consists of concrete abutments supported on CRM bases and CRM wingwalls. The inspection report mentioned that the abutments are bearing directly on natural rock formations.

Setting of Nuaailua Stream Bridge
Courtesy of FAI

Nuaailua Stream Bridge downstream elevation
Courtesy of FAI

Hana approach to Nuaailua Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Nuaailua Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of FAI

Solid concrete parapet, upstream side
Courtesy of FAI

Underside of bridge deck structure
Courtesy of NOEI

Concrete girders
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Concrete abutment resting on CRM base, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Keanae and Honomanu
Designer / Builder	County Engineer's Department - "Y.T.", Designer Plans approved by Joseph Matson, Jr., County Engineer
Historic Drawings	July 1940
Alterations	1940 - Bridge widened and downstream railing replaced
Replacement	None
Preservation Priority	Contributing Bridge: Solid Parapet
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of five bridges with curved parapets on Hana Highway, Route 360 • Good intact example of concrete abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Located in Honomanu Valley • Remote, grassy shoulder area • The stream is not readily visible until one is immediately above, on the bridge • Dense, lush ferns and vegetation surrounded by colorful flowering trees
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Abutments with CRM Base • CRM Wingwalls • Concrete Open Vertical Railings, curved (downstream) • Concrete Solid Parapet, original (upstream) • Alignment: On curve
Detracting Features	• Cementitious material obscures the face of CRM wingwalls

Significance & Context

Bridge Site History

In 1911, the Territorial legislature established the LFC for the disbursement of funds for belt road construction in Hawaii. That same year, a record total of 21 bridges were built on Maui, with four new concrete bridges, including Nuaailua Stream Bridge, constructed on Hana Highway.[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout the County of Maui.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

Based on historic drawings, it appears that an original, narrow bridge may have been widened in the downstream direction.[7] An original solid parapet remains on the upstream side; however, a newer, open picket railing matching the design of similar bridges has been constructed on the downstream side.

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1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 63.

2 Ibid., 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

7 County Engineer's Department, "Nuaailua Bridge," Hana Belt Road Unit #6, Job No. 215-B, Historic Drawings, April 1939, September 1939, and July 1940.

Archaeological / Cultural Significance

The place name *Nuaailua* is defined as, "Stream and point, Ke-anae qd., East Maui."[8] Nuaailua Stream Bridge spans the Nuaailua Stream, which forms the border of Honomanu and Keanae Ahupuaa.[9, 10]

It appears there are three distinctly different ways to spell Nuaailua. Topographic and boundary maps show the spelling as "Nuaailua,"[11] Fornander uses "Nuailua,"[12] and Handy uses "Nuuailua."[13]

Of the region of Kalaloa Point at Nuailua Bay, a *moolelo* reference was found in Fornander as a prominent place name of East Maui.[14]

Nuuailua in pre-contact times was a flat-bottomed valley, like Honomanu, but smaller. Handy states that terraces once covered the flatlands and much taro was formerly raised. However, Handy's conclusion is that the valley had long been uninhabited, or cultivated. He stated that upland taro should have flourished there.[15]

Refer to Section G, Appendix 1, Section 3.1.2.5.1 for the regional history in the vicinity of Nuaailua Stream Bridge, and to Section G, Appendix 1, Figure 8 for nearby archaeological study areas.[16]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of the Nuaailua Stream Bridge.

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8 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

9 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990).

10 R. Jr. Lane, "Hawaii Territory Survey: Koolau Forest Reserve Hana and Makawao Districts," registered map no. 2891 (1932).

11 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

12 Abraham Fornander, "Story of Lonoikamakahiki," *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians' Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, first series, trans. Thomas G. Thrum, vol. 4 of *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1916-1917).

13 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

14 Abraham Fornander, "Story of Lonoikamakahiki," *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians' Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, first series, trans. Thomas G. Thrum, vol. 4 of *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1916-1917).

15 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

16 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by brush and trees • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.84 • Operating Rating = 1.08
Condition	Functionally Obsolete

Civil & Traffic

The Nuaailua Stream Bridge is located at mile point 15.34 along Hana Highway and its existing conditions are as follows. This bridge is a two-lane bridge with an out-to-out width varying between 23.10 - 37.90 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently obstructed by brush and trees causing poor visibility of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 11, 2013. The overall condition rating of the bridge at the time of inspection was fair.[17] This two-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and a rating of 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the upstream concrete parapet and downstream concrete railing was in fair condition. The upstream parapet and downstream railing had a height of 42 inches and 40 inches, respectively. Although the heights of the upstream parapet and downstream railing are adequate for a TL-2 rating, neither is crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.84 and the operating rating is 1.08.

The bridge is on a skew and the minimum curb-to-curb dimension is 21.00 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

17 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Nuaailua Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 11, 2013, record drawings,[18, 19, 20] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Nuaailua Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Nuaailua Stream Bridge currently does not meet the minimum standard width of 24 feet for a two-lane bridge; therefore, it is recommended to widen the upstream side of the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

18 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

19 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

20 County Engineer's Department, "Nuaailua Bridge," Hana Belt Road Unit #6, Job No. 215-B, Historic Drawings, April 1939, September 1939, and July 1940.

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining downstream approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts.

Inappropriate repair at CRM approach wall at Nuaailua Stream Bridge
Courtesy of NOEI

Cracked asphalt at deck surface
Courtesy of NOEI

Upstream parapet, exterior face
Courtesy of NOEI

Detail at base of curved railing
Courtesy of NOEI

Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to replace the parapet on the upstream side and railing on the downstream side with a similarly designed reinforced concrete open vertical railing. Replacement railings should be curved to match those shown in 1940 historic drawings, because these curved railings are a character-defining feature. For this purpose, it is recommended to use a Texas Type C411 concrete railing which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). It is recommended to investigate whether the downstream deck and external girder will need to be rehabilitated to support the additional load of the new railing. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash-tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and can support the 40-ton load carrying capacity.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that an object marker (OM3-L) should be added to the left side end treatment at the east bridge approach. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Prune roadside brush and trees

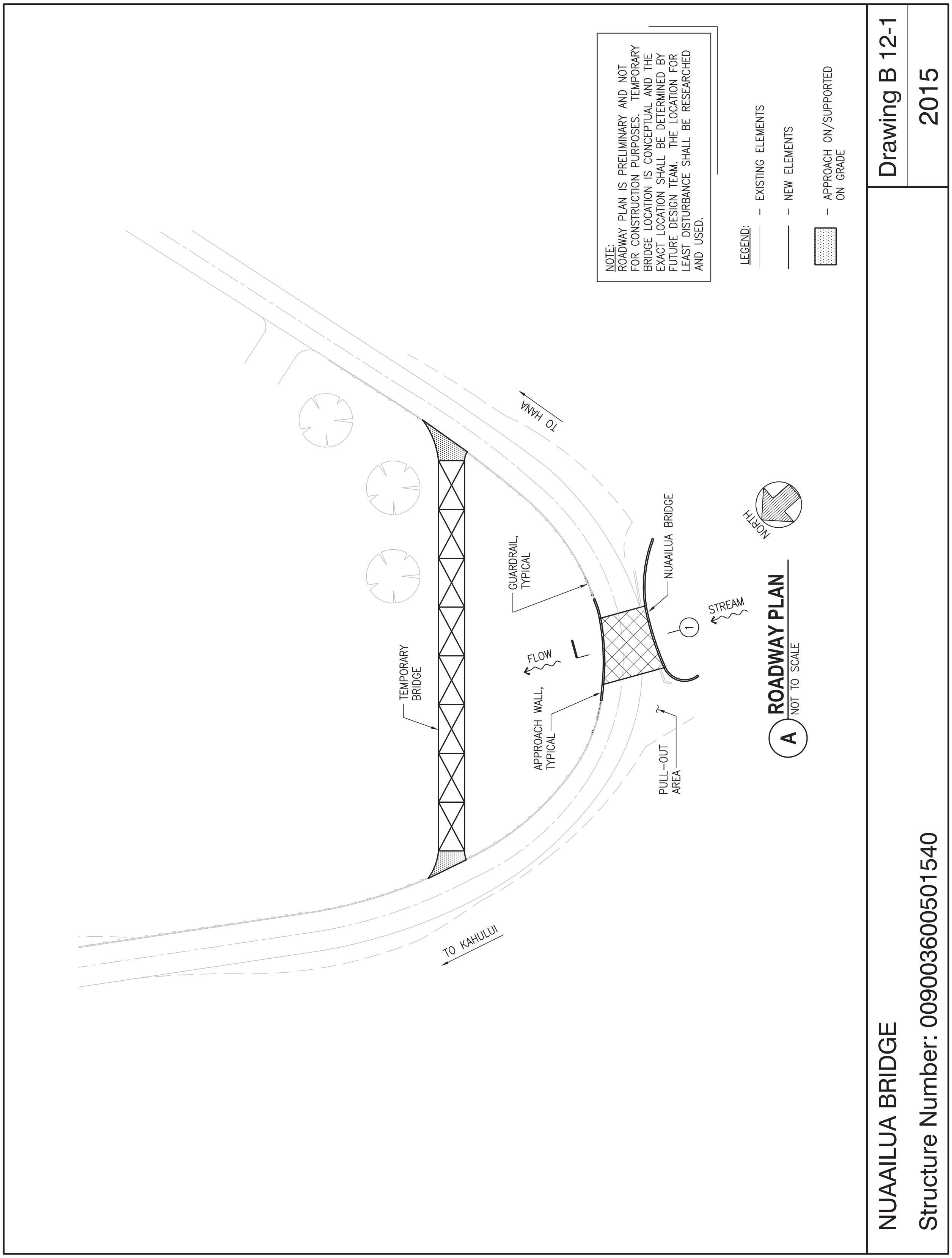
East Bridge Approach

- Prune roadside brush and trees

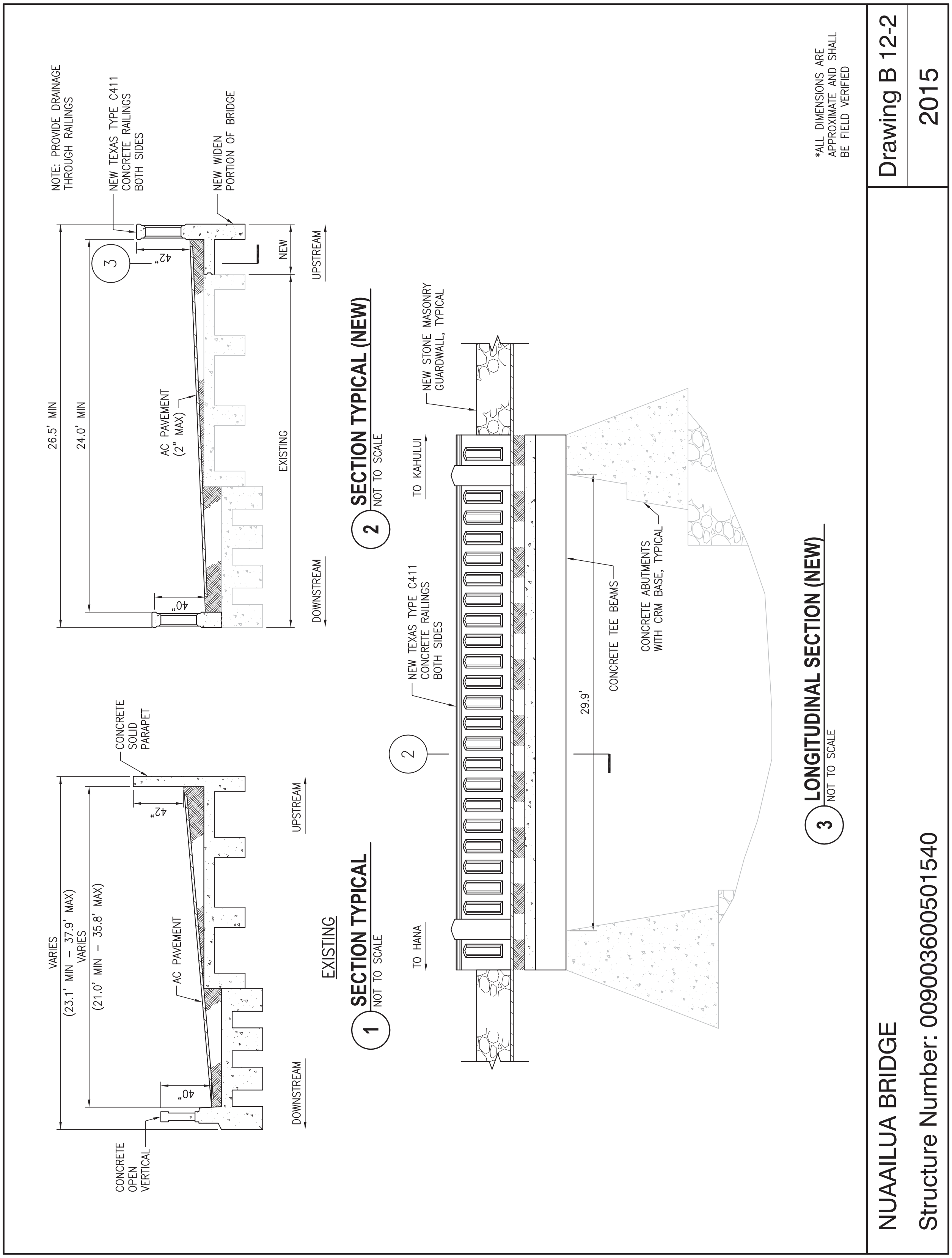
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

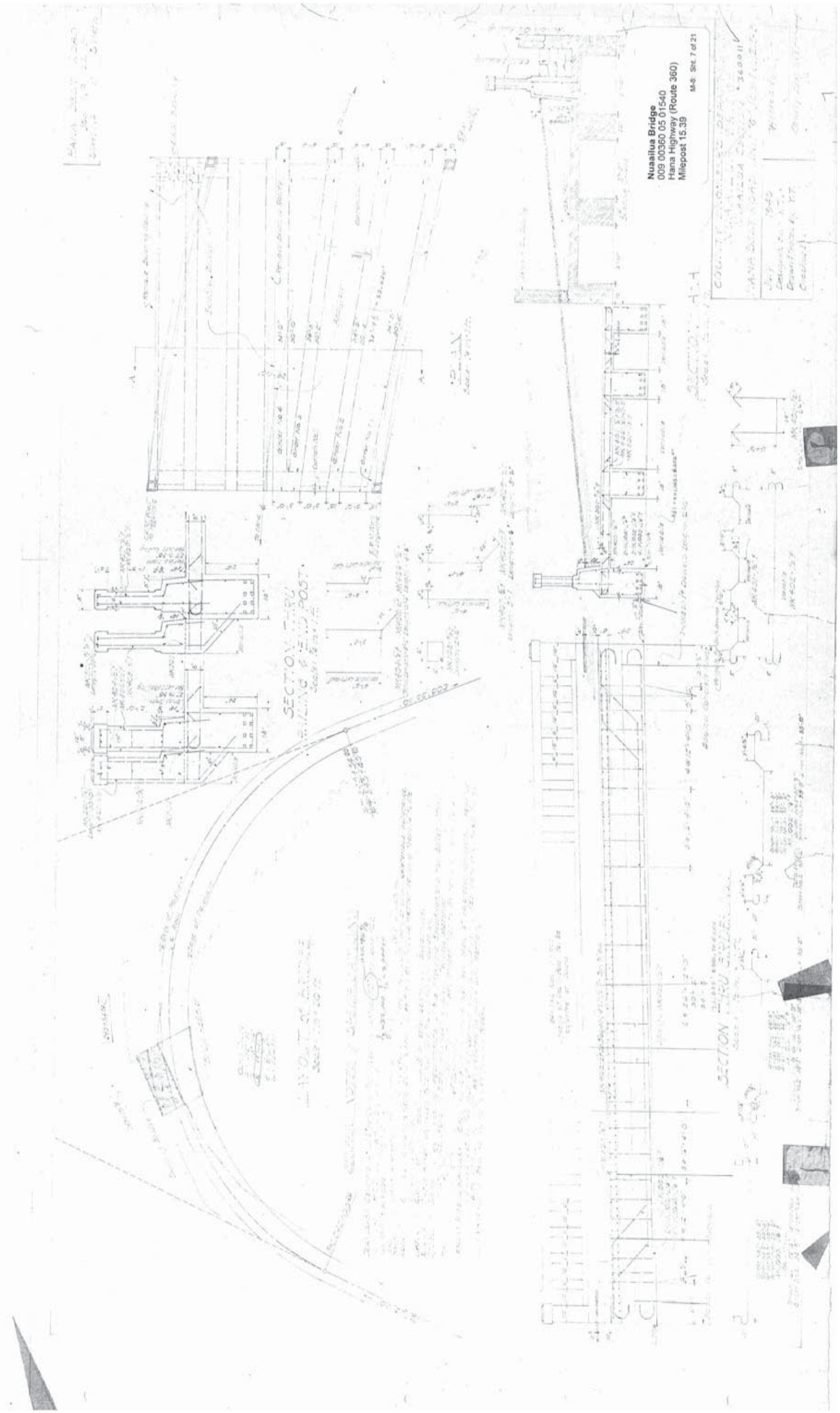
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Nuaailua Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



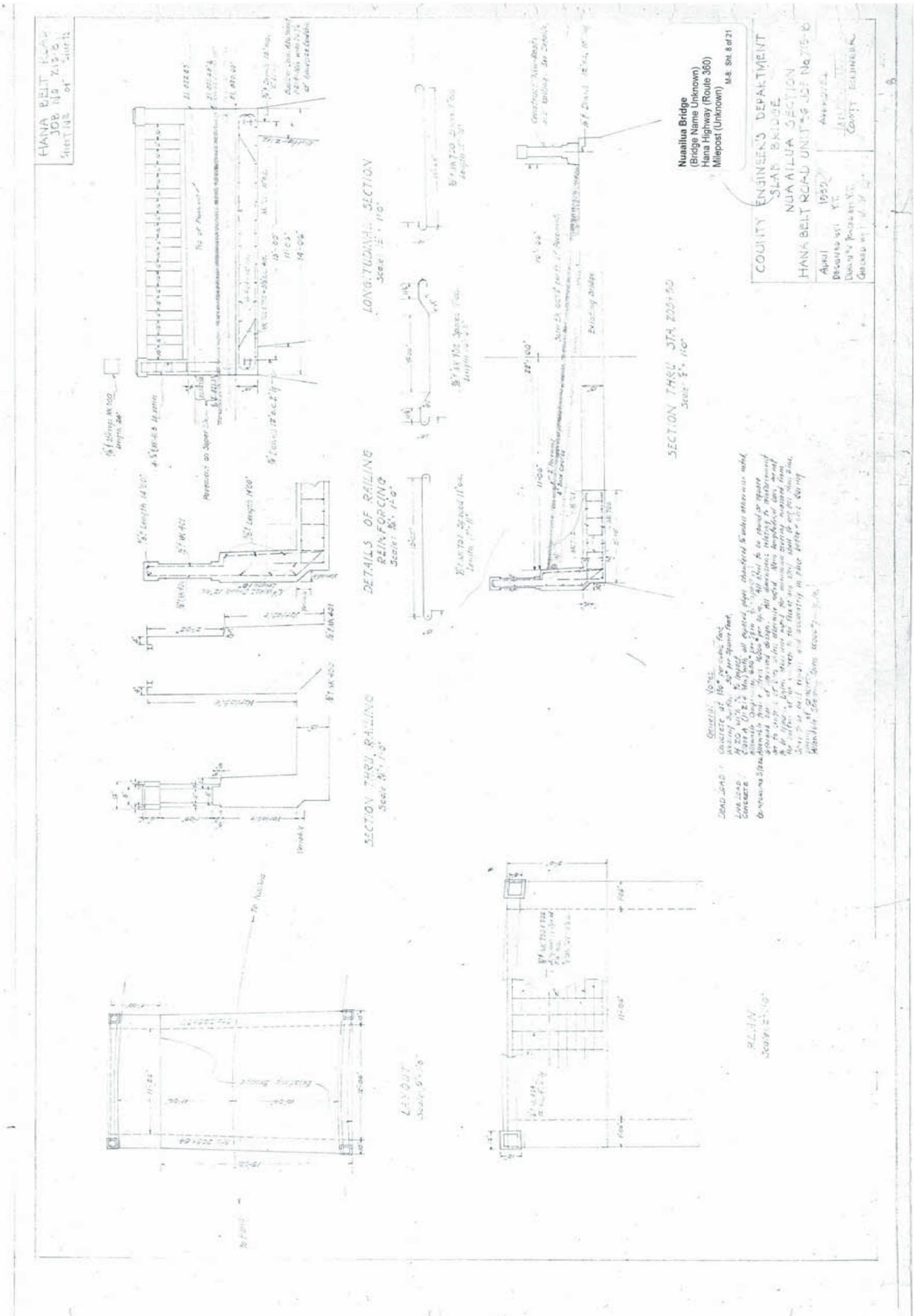
Courtesy of NOEI



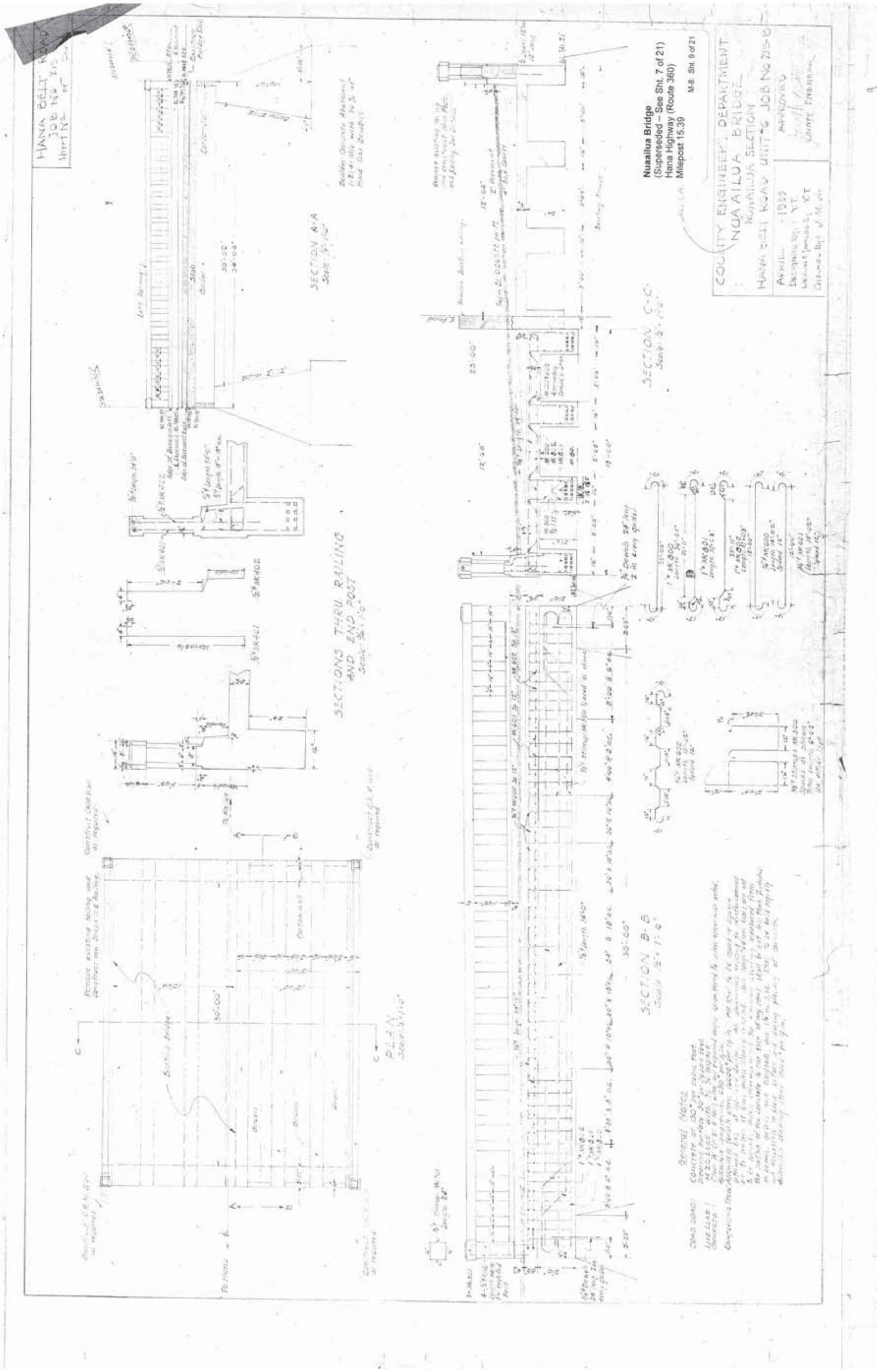
Courtesy of NOEI



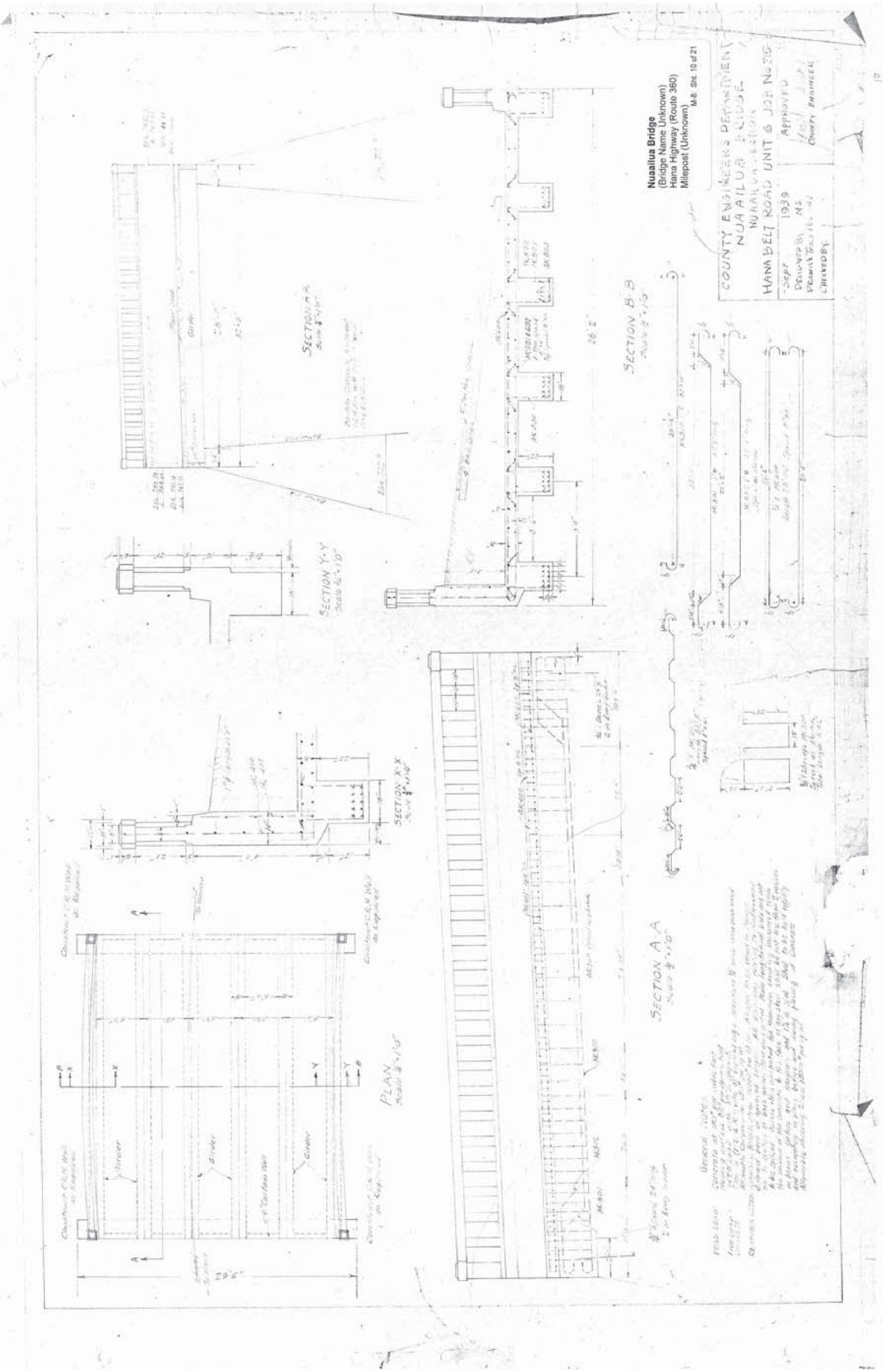
Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation

13

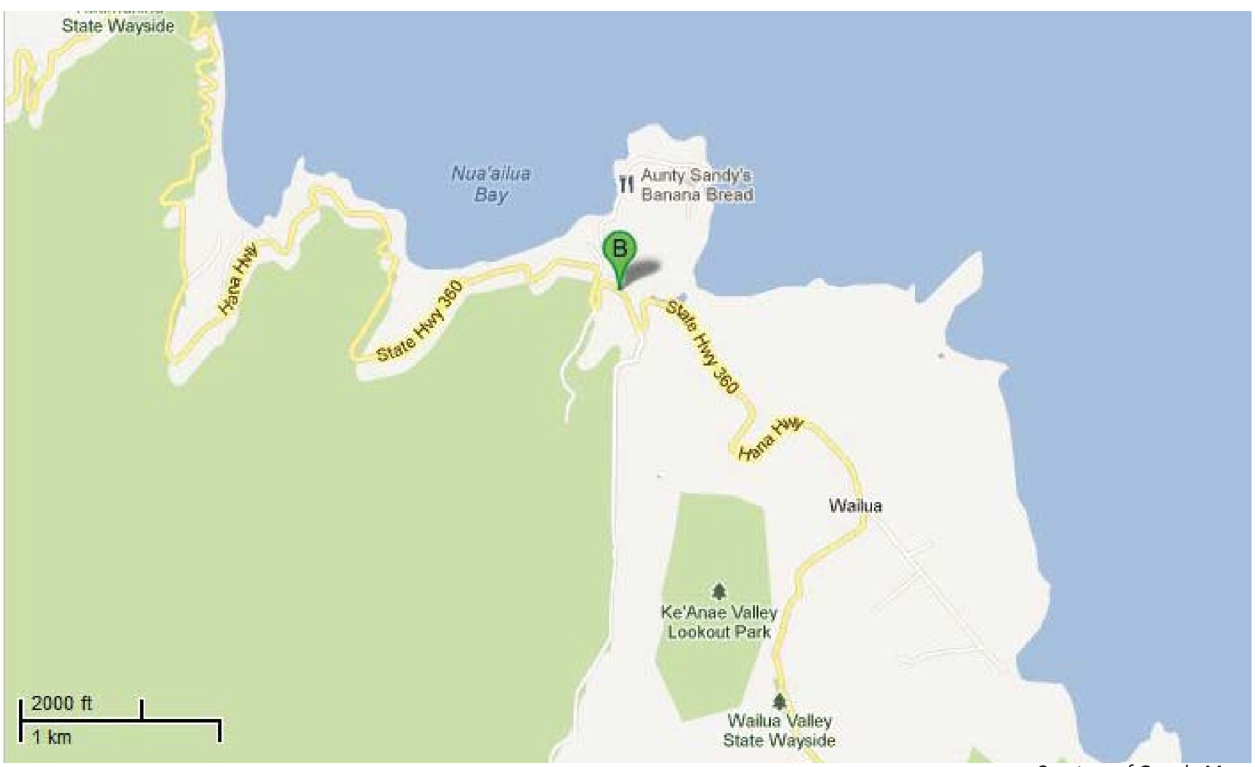
Piinaau Stream Bridge

13

PIINAAU STREAM BRIDGE

Bridge Number	009003600501662				Island	Maui		
Date of Construction	1916				Route	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of HAER HI-75



Courtesy of Google Maps

Location

Latitude	20d 51m 30s
Longitude	156d 08m 53s
Mile Point	16.56
Location	0.04 miles east of Keanae Homestead Road
Feature Crossed	Piinaau Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	27.89 feet
Number of Spans	1
Maximum Span	26.9 feet
Deck Width	• Curb-to-Curb = 19.36 feet • Out-to-Out = 21.25 feet
Abutment Material	Concrete Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 40 inches • Downstream Railing Height = 40 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Piinaau Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1916 and widened in 1940. The superstructure consists of a concrete deck slab with AC pavement overlay supported on seven concrete tee beams. The substructure consists of concrete abutments and CRM wingwalls. The abutments bear directly on natural rock formations.

Setting of Piinaau Stream Bridge
Courtesy of NOEI

Channel at downstream side of Piinaau Stream Bridge
Courtesy of NOEI

Kahului approach to Piinaau Stream Bridge toward Hana
Courtesy of NOEI

Hana approach to Piinaau Stream Bridge toward Kahului
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Downstream CRM wingwall, Hana side
Courtesy of NOEI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

Concrete abutment resting on natural rock, Hana side
Courtesy of NOEI

Concrete abutment resting on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Keanae
Designer / Builder	Unknown
Historic Drawings	None
Alterations	1940 - Rehabilitation
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of typical concrete tee beam bridge with intact concrete open vertical parapets, concrete abutments, and CRM wingwalls • Good intact example of concrete abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Walker Site 84 (a previously destroyed heiau) was located in this vicinity
Geographical Features / Setting	• Rural residental, Y-intersection with Lower Keanae Road • Between bends • Narrow, deep, rock-lined stream with vertical drop at downstream side
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Open Vertical Railings • Concrete Abutments • CRM Wingwalls • Natural Rock Formations
Detracting Features	• Excessive asphalt • Existing waterline at downstream elevation

Significance & Context

Archaeological / Cultural Significance

The Hawaiian word *piinaau* is defined as, "Kind hearted."[1] The Piinaau Stream Bridge spans the Piinaau Stream, which flows through Keanae Ahupuaa.[2, 3]

The Piinaau Stream Bridge is located along the Hana Highway near the entrance to the Keanae Peninsula. According to a State of Hawaii DLNR report for the Piinaau Stream, the stream enters the ocean through the Waialohe Fishpond.[4] The Piinaau Stream is 13.1 miles long and originates in the Waikamoi Forest Reserve. Palauhulu Stream flows parallel to the Piinaau Stream, both of which flow past Keanae Village on their way to the ocean.

Refer to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[5, 6]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Piinaau Stream Bridge.

Walker Site 84, the previous Pakanaloa Heiau, was documented as having been located approximately 20 meters southeast of Piinaau Stream Bridge in Keanae. Thrum says of the site, "The temple of Pakanaloa, has a tradition claiming origin in the worship of the thunder to the effect that its Kahu, Kanehekili, died within its walls, …The people of Hamakualoa wondering at his disappearance searched till they found his body in the temple at Keanae."[7] The *heiau* was not found by Stokes or Walker and assumed to have been previously destroyed.[8, 9]

Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway, and Section G, Appendix 1, Figure 11 for approximate location of Site 84 as recorded by Walker.

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Hawaii Heritage Center, Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990).

3 S. M. Kanakanui, "Hawaii Territory Survey: Keanae Flat," registered map no. 2238 (1903).

4 "Instream Flow Standard Assessment Report Island of Maui Hydrologic Unit 6053 Piinaau September 2008 PR-2008-03," State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management, http://files.hawaii.gov/dlnr/cwrm/ifsar/PR200803.pdf (accessed 2013-2015).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

6 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

7 Thomas G. Thrum, "Heiaus and Heiau Sites Throughout the Hawaiian Islands; Omitting Koas, or Places of Offering to Kuula, the Deity of Fisher Folk," *The Hawaiian Annual* (1908), 38-42.

8 Winslow Walker, *Archaeology of Maui*, 1931, manuscripts on file, Bishop Museum Archives, Honolulu.

9 Thomas G. Thrum, "Maui's Heiau's and Heiau Sites Revisited," ed. 1918, Hawaiian Almanac and Annual (Honolulu: 1917).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	West Bound: Asphalt Cement Driveway
Civil Utilities	• Sewer: None • Water: Existing 6-inch waterline at downstream elevation
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	Electrical lines (primary and telephone) located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.35 • Operating Rating = 0.45
Condition	Functionally Obsolete

Civil & Traffic

Piinaau Stream Bridge is located at mile point 16.56 along Hana Highway and its existing conditions are as follows. This bridge is a two-lane bridge with an out-to-out width of 21.25 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition on both approaches to the bridge. Currently, there is no apron at either entrance to the bridge. There are also no sewer utilities in this area but there is an existing 6-inch waterline owned by the County of Maui that runs along the downstream side of the bridge. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

The Piinaau Stream Bridge has been known to overtop in high intensity storms.

Electrical

There are electrical lines (primary and telephone) that are close to the potential area of work.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 11, 2013. The overall condition rating of the bridge at the time of inspection was fair.[10] This two-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and a rating of 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in good condition. The upstream and downstream railings had a height of 40 inches. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

According to the SI&A sheet, load rating for this structure was calculated using LRFR and the inventory rating is 0.35 and the operating rating is 0.45

The current curb-to-curb dimension is 19.36 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Piinaau Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 11, 2013 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Piinaau Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A detailed drainage analysis is recommended for the vicinity of this bridge in order to assess measures to prevent or mitigate runoff from overtopping the bridge.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Piinaau Stream Bridge currently does not meet the minimum standard width of 24 feet for a two-lane bridge. Due to the decreased curb-to-curb width resulting from the installation of interior crash-tested rails, two cars can no longer safely pass by each other on the bridge. Therefore, it is recommended to change the number of striped lanes on the bridge from 2 to 1, in which case, widening the bridge to meet the 24' requirement for a two-lane bridge would no longer be necessary.

Due to the curb-to-curb width and the curvature of the approach to this bridge, it is also recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream and downstream Kahului and upstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining downstream Hana approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM approach wall to parapet connection
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments and CRM wingwalls which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

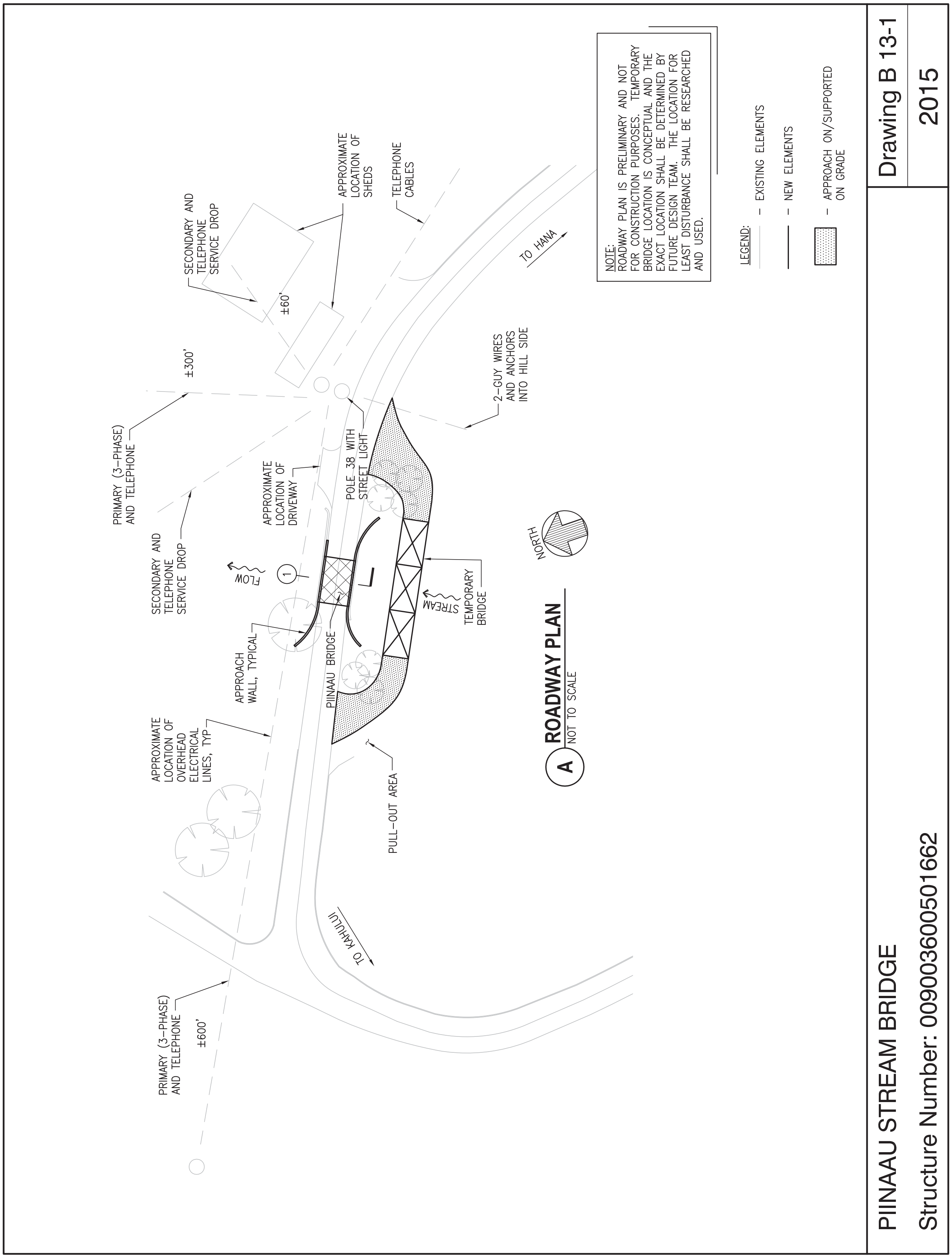
Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Should the bridge be widened on the downstream side, the existing waterline must be relocated and comply with current Maui County Department of Water Supply Standards. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Currently, there are no signage, traffic, and visibility recommendations.

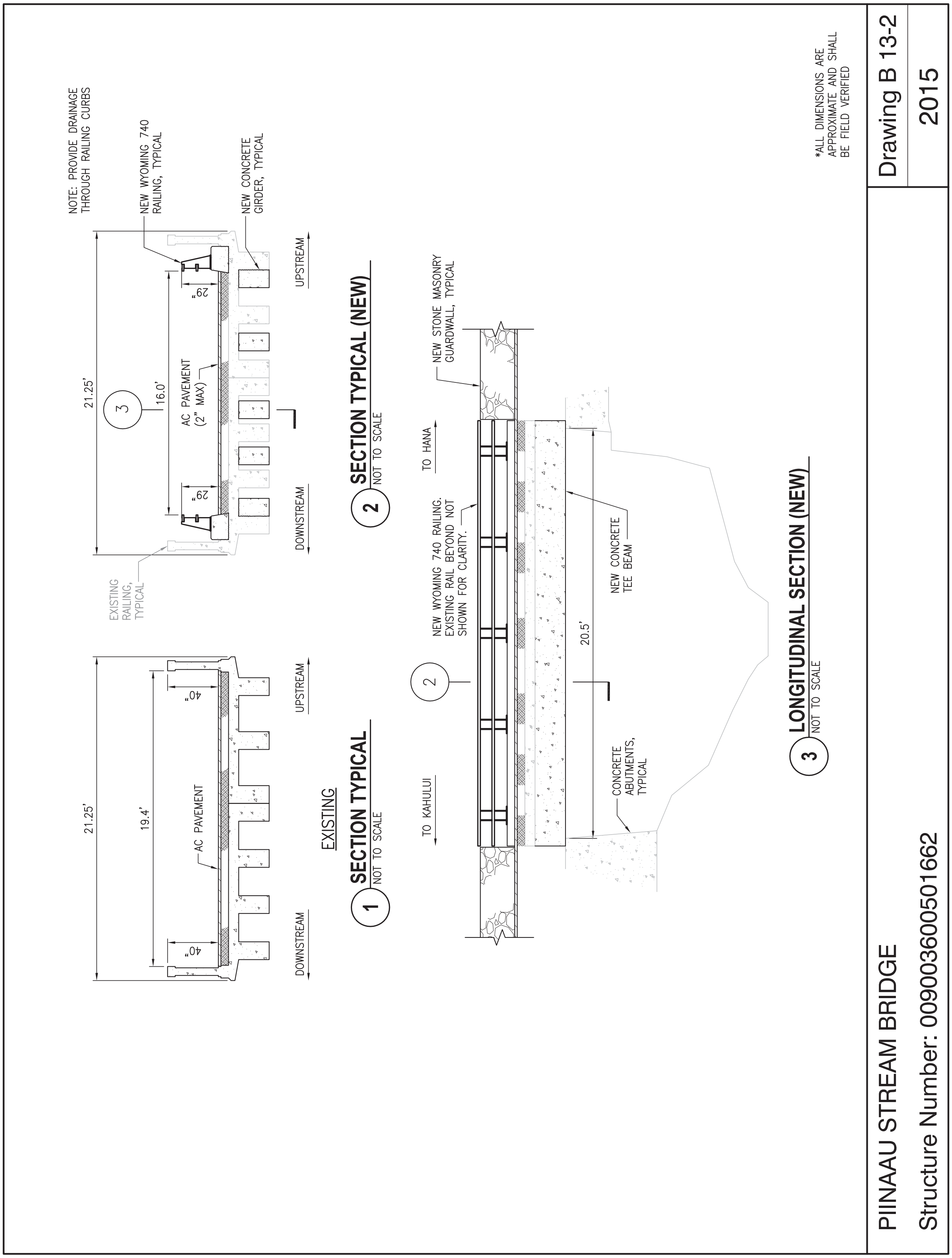
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI

14

Palauhulu Stream Bridge

14

PALAUHULU STREAM BRIDGE

Bridge Number	009003600501679			**Island**	Maui		
Date of Construction	1916			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of HAER HI-75

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 51m 24s
Longitude	156d 08m 48s
Mile Point	16.73
Location	0.21 miles east of Keanae Homestead Road
Feature Crossed	Palauhulu Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	30.84 feet
Number of Spans	1
Maximum Span	29.9 feet
Deck Width	• Curb-to-Curb = 20.34 feet • Out-to-Out = 21.65 feet
Abutment Material	Concrete Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 24 inches • Downstream Railing Height = 33 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap: 6 inches x 8 inches

Bridge Features

Palauhulu Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1916. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of concrete abutments and CRM wingwalls. The abutments bear directly on natural rock formations.

Setting of Palauhulu Stream Bridge
Courtesy of NOEI

Water feature located downstream of Palauhulu Stream Bridge
Courtesy of FAI

Hana approach to Palauhulu Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Palauhulu Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Downstream CRM wingwall, Hana side, and unconnected concrete remnant
Courtesy of NOEI

Downstream Hana side approach wall
Courtesy of NOEI

Concrete abutment resting on natural rock, Hana side
Courtesy of NOEI

Concrete abutment resting on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Keanae and Pahoa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Exceptional Curved Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of five bridges with curved parapets on Hana Highway, Route 360 • Good intact example of concrete abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Exemplary example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential, popular swimming hole below bridge • Open with mature trees on upstream side and swimming hole below on downstream side • Unconnected concrete remnant in streambed, Hana side downstream • Dramatic rushing narrow, rock filled streambed in rainy season
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Open Vertical Railings • Concrete Abutments • CRM Wingwalls • Natural Rock Formations • Alignment: On curve
Detracting Features	• Existing waterline at downstream elevation

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[u]ntil a road was constructed through this area in 1916, Keanae valley was accessible only from the sea. Its inhabitants were Hawaiians who followed the traditional Hawaiian customs and activities."[1]

Archaeological / Cultural Significance

The Hawaiian word *palauhulu* is defined as, "Banana-leaf enclosure."[2] The Pauhulu Stream Bridge is located along the Hana Highway near the entrance to the Keanae Peninsula. The Palauhulu Stream Bridge spans the Palauhulu Stream, which forms the border between Pahoa Ahupuaa and Keanae Ahupuaa.[3, 4]

According to a State of Hawaii DLNR report for the Palauhulu Stream, the stream enters the ocean through the Village of Keanae.[5] The Palauhulu Stream originates in the Waikamoi Forest Reserve, from both the Haoli Wahine Stream and Kano Stream tributaries. Palauhulu Stream flows parallel to the Piinaau Stream.

Keanae is described as a unique wet-taro growing *ahupuaa* developed by the early inhabitants for irrigated taro with a *loi* complex that covered the peninsula. In traditional times, Polaukulu [Palauhulu] Stream brought an abundant supply of water to the taro patches, which are still used for raising wet taro today.[6] The Native Hawaiian mythology states that the god Kane accompanied by Kanaloa, thrust his *kauila* staff into solid rock and water gushed forth. Additionally, Ashdown stated that the Lualailua fishponds were located at Keanae, and that they were considered sacred, or *wahi pana*.[7]

The initial occupation of this portion of Maui first occurred along the coastal region about A. D. 1200.[8] The accepted pre-contact settlement pattern for the region of Keanae/Wailuanui centers on the series of occupational episodes that utilized the Palauhulu Stream for taro (*Colocasia esculenta*) cultivation.

John Clark, in his book *The Beaches of Maui County*, described the Palauhulu area:

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 83.

2 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

3 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990).

4 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

5 "Instream Flow Standard Assessment Report Island of Maui Hydrologic Unit 6053 Piinaau September 2008 PR-2008-03," State of Hawaii Department of Land and Natural Resources Commission on Water Resource Management, http://files.hawaii.gov/dlnr/cwrm/ifsar/PR200803.pdf (accessed 2013-2015).

6 Kepa Maly and Onaona Maly, *He Moʻolelo No Maui Hikina – Kalialinui I Uka A Me Na ʻAina O Lalo A Cultural – Historical Study of East Maui – The Uplands of Kalialinui, and the Lands that Lie Below, Island of Maui "The Waikamoi Preserve",* prepared for The Nature Conservancy of Hawaii (Hilo: Kumu Pono Associates LLC, 2006).

7 Inez MacPhee Ashdown, *Ke Alaloa O Maui – Authentic History and Legends of the Valley Isle* (Wailuku: Kamaʻaina Historians, Inc., 1971).

8 Alan E. Haun, David Henry, and Maria Orr, "Archaeological Inventory Survey, Waiʻānapanapa State Park, Lands of Honokalani, Wākiu and Kawaipapa, Hāna District, Island of Maui," Haun & Associates (Keaau: 2004).

> *Keanae is a low fan of lava that extends about half a mile into the ocean from the sea cliffs on the shoreline. In former times Keanae was famed for its taro patches, and the name Keanae "the mullet" is said to have been originally the name of the royal taro patch*.[9]

Refer to Section G, Appendix 1, Section 3.1.2.5 for the regional history of Keanae in the vicinity of the Palauhulu Stream Bridge; Section 3.3.2 for the settlement pattern along Palauhulu Stream; and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[10, 11]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Palauhulu Stream Bridge.

9 John R. K. Clark, *The Beaches of Maui County* (Honolulu: University of Hawaii Press, 1989).

10 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

11 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • None
	East Bridge Approach • None
Apron	None
Civil Utilities	• Sewer: None • Water: Existing 6-inch waterline at downstream elevation
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.35 • Operating Rating = 0.45
Condition	Functionally Obsolete

Civil & Traffic

Palauhulu Stream Bridge is located at mile point 16.73 along Hana Highway and its existing conditions are as follows. This bridge is a two-lane bridge with an out-to-out width of 21.65 feet that has no bicycle or pedestrian access routes. Signage and striping for the west bridge approach includes and object marker (OM3-L) on the left side bridge end treatment. Currently, there is no apron at either entrance to the bridge. There are also no sewer utilities in this area but there is an existing 6-inch waterline that runs along the downstream side of the bridge. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on November 11, 2013. The overall condition rating of the bridge at the time of inspection was fair.[12] This two-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and a rating of 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in good condition. The upstream and downstream railings had a height of 24 inches and 33 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.35 and operating rating is 0.45.

The current curb-to-curb dimension is 20.34 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

12 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Palauhulu Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated November 11, 2013 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Palauhulu Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Palauhulu Stream Bridge currently does not meet the minimum standard width of 24 feet for a two-lane bridge. Due to the decreased curb-to-curb width resulting from the installation of interior crash-tested rails, two cars can no longer safely pass by each other on the bridge. Therefore, it is recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining three approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges:

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM apprach wall connection to metal thrie beam and open picket railing
Courtesy of NOEI

#19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Curb base of open picket railing obscured by excessive asphalt
Courtesy of NOEI

Damage at end post cap
Courtesy of NOEI

Foundations, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments and CRM wingwalls which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

The natural rock foundations of this bridge are unique in the bridge's construction and contribute to the overall setting of the bridge. Therefore, all efforts should be made to preserve the appearance of the natural rock during bridge rehabilitation work. Documentation of the existing foundations is strongly recommended if it is not feasible to retain the natural rock foundations in future projects.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that object markers are to be added to both end treatments at both bridge approaches. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left and Right (OM3-L, OM3-R)

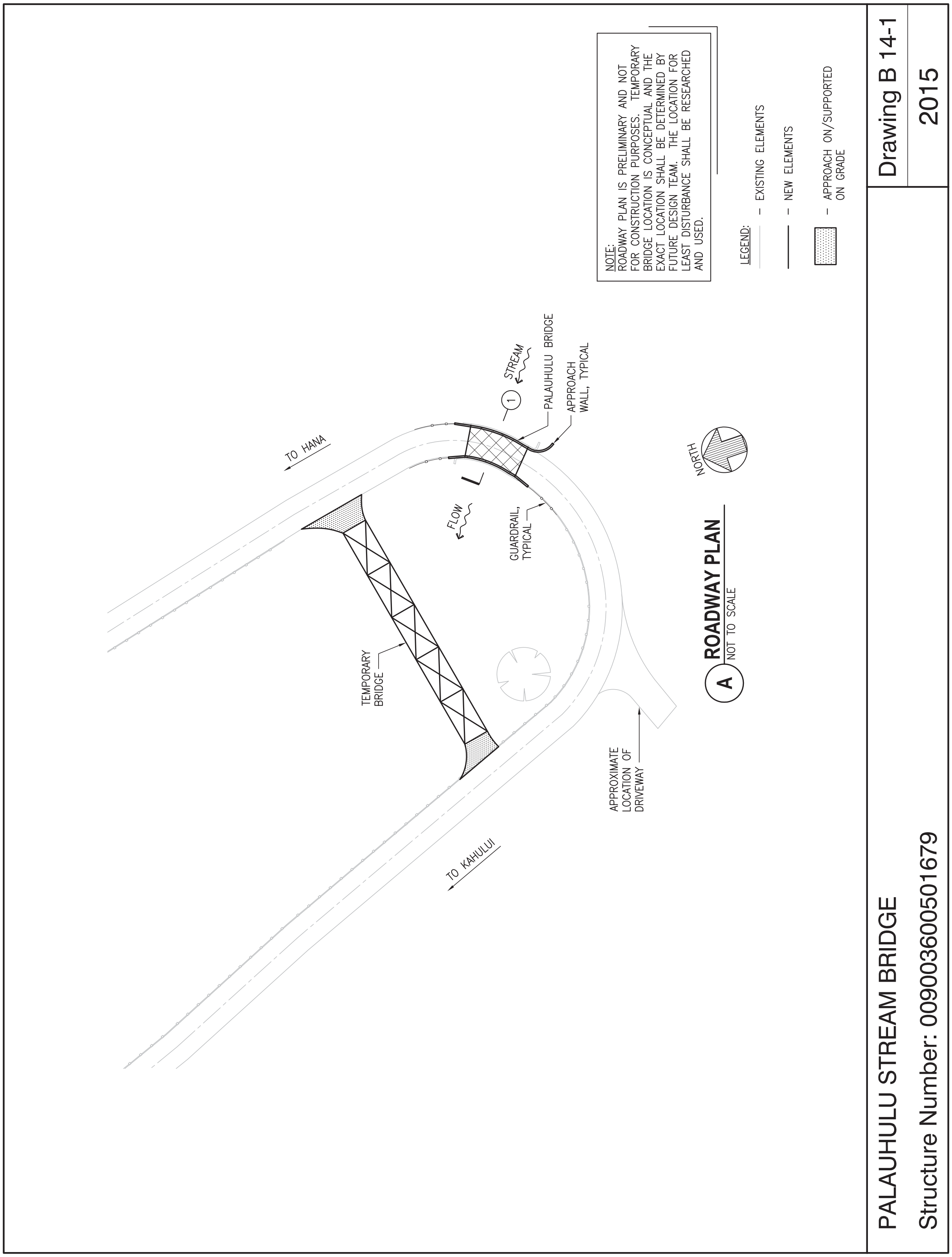
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

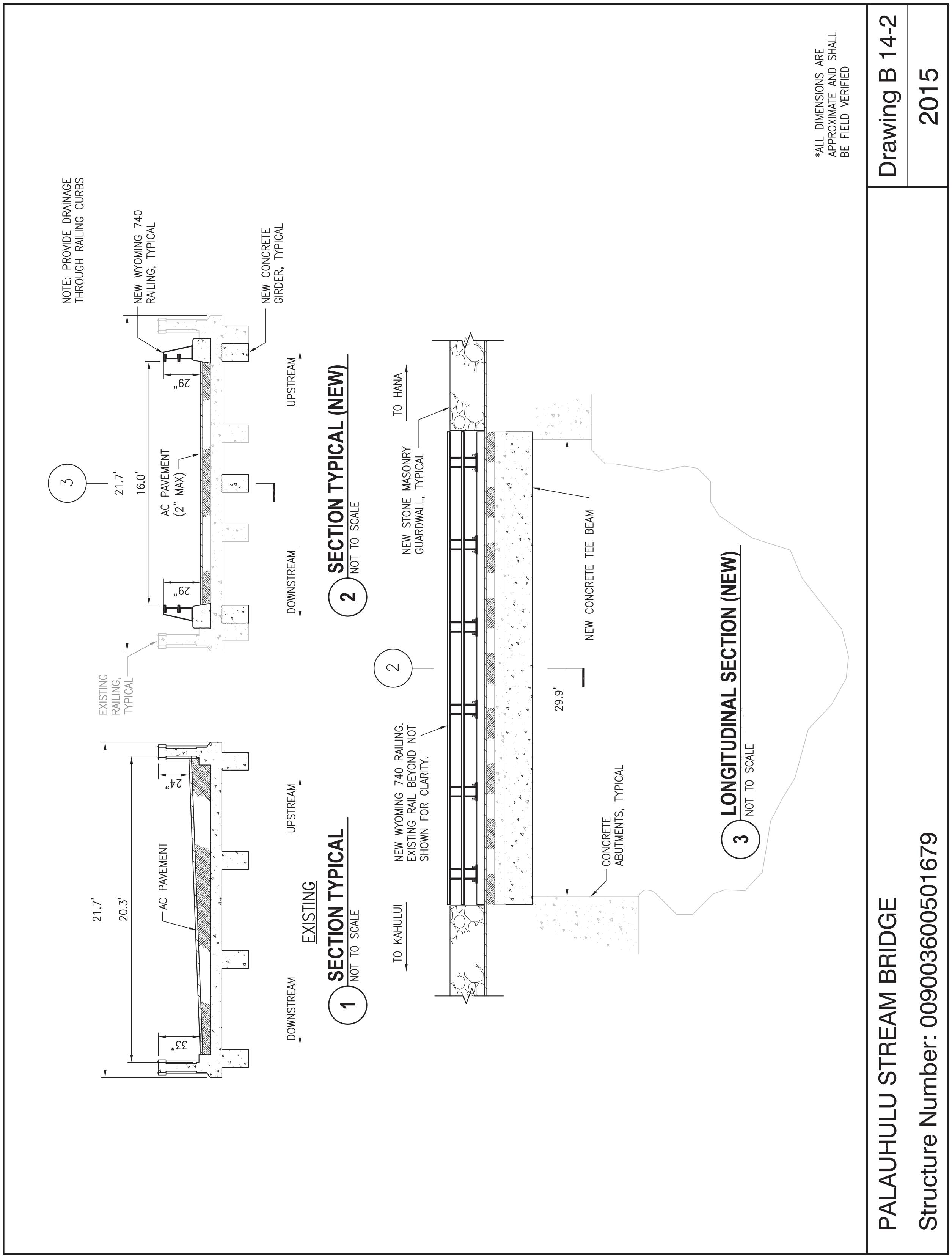
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Palauhulu Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

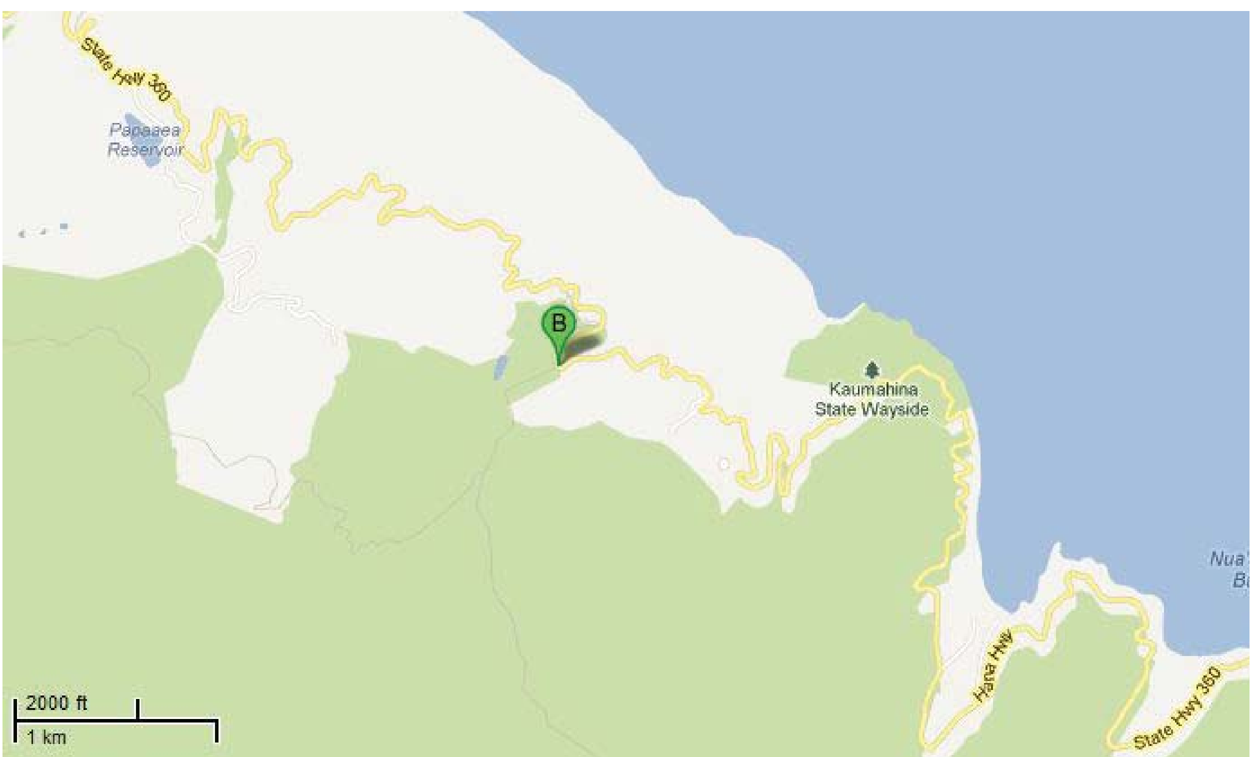
15 Waiokamilo Stream Bridge

15

WAIOKAMILO STREAM BRIDGE

Bridge Number	009003600501811			**Island**	Maui		
Date of Construction	1921			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 50m 56s
Longitude	156d 08m 10s
Mile Point	18.03
Location	0.02 miles west of Wailua Homestead Road
Feature Crossed	Waiokamilo Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	23.95 feet
Number of Spans	1
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 22.75 feet • Out-to-Out = 26.25 feet
Abutment Material	Concrete Abutment
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Greek Cross
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 24 inches (minimum), 43.5 inches (mid-height) • Downstream Railing Height = 24 inches (minimum), 44.5 inches (mid-height)
Baluster Dimensions	• Posts = 6 inches x 6 inches • Decorative Panels = 1 foot 7 inches (height) x 1 foot (width) • Posts and Panels spaced approx. 1 foot 6 inches on-center • End posts = 1 foot 9 inches x 1 foot 9inches
Parapet / Railing Profile	• Stepped cap • Railing cap = 6 inches x 12 inches

Bridge Features

Waiokamilo Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1921 and widened in 1937. The superstructure consists of a concrete deck slab with AC pavement overlay supported on a total of eight concrete tee beams. The substructure consists of concrete abutments and CRM wingwalls. The abutments are bear directly on natural rock formations.

Setting of Waiokamilo Stream Bridge
Courtesy of FAI

Waiokamilo Stream
Courtesy of NOEI

Hana approach to Waiokamilo Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Waiokamilo Stream Bridge toward Hana
Courtesy of NOEI

Greek cross parapet, upstream side
Courtesy of FAI

Greek cross parapet, downstream side
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Downstream CRM wingwall, Kahului side
Courtesy of NOEI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

Upstream abutment on natural rock formations, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Pauwalu and Wailuanui
Designer / Builder	County Engineer's Department - D. K. Kapohakimohewa, Designer Plans approved by Joseph Matson, Jr., County Engineer (1937 alteration plan)
Historic Drawings	November 1937
Alterations	Widened and installed new parapets in 1937
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Parapets/Railings
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of two structures with open Greek cross parapets on Hana Highway, Route 360 • Good intact example of concrete abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• SIHP - 5237 located within 200 meters south-southwest • Walker Site 88 (previously destroyed heiau) located within 200 meters south-southwest
Geographical Features / Setting	• Rural residential • Adjacent to snack shops • Open clearing with dense vegetation around stream • Adjacent to "Y" intersection with Lower Wailua Road • Waiokamilo Culvert, same design (but shorter and wider) is directly to the east of this bridge
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Abutments • CRM Wingwalls • Concrete Open Greek Cross Railings (built as a set with Waiokamilo Culvert) • Stepped railing cap
Detracting Features	• Refractors signs on the end posts • Existing waterline at upstream elevation • Hana downstream side of wingwall is obscured by cementitious material

Significance & Context

Archaeological / Cultural Significance

The place name *Waiokamilo* is defined as, "Kamilo's water. Stream. Koolau. Maui."[1] The Waiokamilo Stream Bridge is located near the village of Wailua. The Waiokamilo Stream Bridge spans the Waiokamilo Stream, which divides Pauwalu Ahupuaa and Wailuanui Ahupuaa.[2, 3]

According to a State of Hawaii DLNR report for the Waiokamilo Stream, the stream enters the ocean in the region of the Village of Wailua.[4] The Waiokamilo Stream originates in a narrow watershed, with its stream water directed to taro patches (*loi*) in Wailua for over one hundred years.

A cultural landscape study recorded the intensive use of the Keanae and Wailuanui region for taro, identified three separate field systems, and noted the processes by which community cooperation led to the field system operation.[5] According to Maly, water from the Waiokamilo Stream enters the Lakini *auwai* system of taro *loi* that includes *loi* above the Hana Highway and some 339 *loi* west of Wailua Nui Stream.[6]

Evidence of a cohesive population is perhaps best described by the first Europeans to visit Keanae. From the journal of William Richards, a Protestant missionary, comes information that the region between Honomanu and Wailua was densely populated:

> *We went on board the canoe, and rowed a few miles, avoiding some difficult paries [steep cliffs]. After landing, we walked a few miles further, to Wailua, where we put up for the Sabbath. Very early the morning [of the Sabbath], the horns, summoning the people to the house of God, were heard in every direction; and we soon perceived that the call had not been heard with indifference. At the early hour, the house was thronged with attentive worshippers. [The next day] we examined the schools, which were large. About 10 o'clocko'clock, A.M., the princess [Nahienaena] arrived, and addressed the people; after which, we proceeded on our way [to Hana].*[7]

1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Hawaii Heritage Center, Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990).

3 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

4 State of Hawaii, Division of Aquatic Resources, *Report on Waiokamilo Stream, Maui, Hawaii, prepared for the State of Hawaii*, Commission on Water Resource Management, Department of Land and Natural Resources (2008).

5 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

6 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

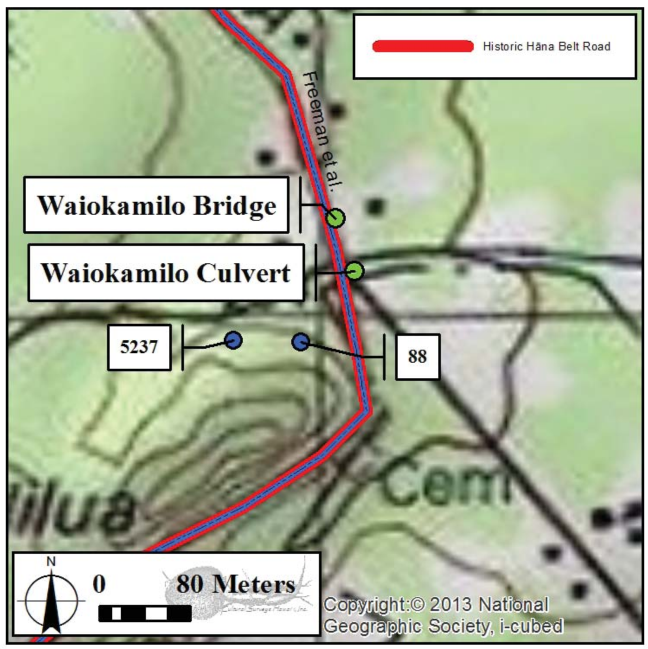
7 William Richards, Lorrin Andrews, and Jonathan Green, "A Tour of Maui," *The Missionary Herald, containing Proceedings of The American Board of Commissioners for Foreign Missions with a View of Other Benevolent Operations for the year 1829* (Boston: Crocker and Brewster for A.B.C.F.M., 1829).

According to the Group 70 International, Inc. *et al*. cultural landscape study, over 490 Land Commission Awards (LCA) claimed taro patches of various sizes at Keanae and Wailuanui during the time of the Great Mahele [beginning in 1848].[8] Several LCAs included claims for pools and fishponds. In addition, evidence of densely-grouped regional *heiau* and smaller shrines was the subject of specialized studies dating from the turn of the 20th century to more recent work by Maria E. Orr.[9, 10]

Background research into the land use patterns of the surrounding vicinity indicated that the area was intensively used for pre-contact agricultural pursuits, permanent and temporary habitation and traditional ceremony, as well as historic-era agriculture represented by taro *loi*, sweet potato, rice, and other staple crop cultivation. Early settlement patterns for the area seem to have focused primarily on valley and gulch lands, from river mouths to *mauka* lands. In the river gulches, it is expected that the soils are rich and fertile and conducive to agriculture. In addition, the constant supply of fresh water would have supported fairly intense agricultural pursuits. Within these valleys intensive agriculture would have likely been taking place in association with habitation activities. Toward the river mouths, the widening gulches would have provided ample areas for small communities and access to marine resources, as well as additional *loi*.

Based on available archaeological evidence and interpretations, it is possible that historically significant subsurface cultural deposits representing both traditional and historic agriculture, as well as midden and other cultural material concentrations representing both traditional and historic habitation may occur within the area.

Refer to Section G, Appendix 1, Section 3.3.2, for the Settlement Pattern of the Koolau District in the Keanae and Wailuanui vicinity, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[11, 12, 13]



8 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

9 Maria E. Orr, "A Preliminary Report on the Heiau of Hana and Their Significance, Past and Present," Department of Anthropology, University of Hawaii (Honolulu: 1990).

10 Thomas G. Thrum, "Heiaus and Heiau Sites Throughout the Hawaiian Islands; Omitting Koas, or Places of Offering to Kuula, the Deity of Fisher Folk," The Hawaiian Annual (1908).

11 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

12 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

13 Alan E. Haun and Jack D. Henry, "Archaeological Inventory Survey TMK: 1-1-008:015, 023, Land of Pauwalu, Hana District, Island of Maui," inventory survey, Haun & Associates (Keaau: 2003).

Adjacent Cultural Sites

Walker Site 88, the former Kamokukupeu Heiau, was documented as having been located approximately 113 meter south-southwest of Waiokamilo Bridge, but was recorded as destroyed by Walker.[14] Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway, and to figure below for approximate location in relation to Waiokamilo Stream Bridge.

Haun and Henry conducted an archaeological inventory survey of approximately 4 acres at Pauwalu in Wailuanui Ahupuaa.[15] The inventory survey resulted in the identification of one historic property,

SIHP -5237, consisting of an overhang (Feature A)* and trail (Feature B)* located approximately 140 meters southwest of Waiokamilo Stream Bridge (see previous page). The overhang was interpreted as a pre-contact temporary habitation shelter that was occupied between AD 1420-1650 and the trail as a transportation route. Refer to Section G, Appendix 1, Table 2: Previous archaeological studies conducted along Hana Highway, Route 360.

*Indicate the SHIP-5237 has two contributing features, Feature A and B.

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14 Winslow Walker, *Archaeology of Maui*, 1931, manuscripts on file, Bishop Museum Archives, Honolulu.

15 Alan E. Haun and David Henry, "Archaeological Inventory Survey TMK: 1-1-008:015, 023, Land of Pauwalu, Hana District, Island of Maui," inventory survey, Haun & Associates (Keaau: 2003).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: Existing 6-inch waterline at upstream elevation
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 1.07 • Operating Rating = 1.38
Condition	Bridge is not Functionally Obsolete or Structurally Deficient.

Civil & Traffic

Waiokamilo Stream Bridge is located at mile point 18.03 along Hana Highway and its existing conditions are as follows. This bridge is a two-lane bridge with an out-to-out width of 26.25 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge. There are also no sewer utilities in this area but there is an existing 6-inch waterline that runs along the upstream side of the bridge. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are primary and secondary overhead lines located on the downstream side of the bridge. Overhead telephone lines pass directly over the length of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 17, 2013. The overall condition rating of the bridge at the time of inspection varied between fair and good.[16] This two-lane bridge is not *functionally obsolete* or *structurally deficient*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in good condition. The upstream and downstream railings had a minimum height of 24 inches. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 1.07 and the operating rating is 1.38.

The current curb-to-curb dimension is 22.75 feet, which for a two-lane bridge does not meet the design criteria of minimum of 24 feet.

16 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Waiokamilo Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 17, 2013, record drawings,[17,18,19] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Waiokamilo Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 2 for Hana Belt Road National Register Nomination Form). In addition, undocumented burial mounds have been reported to Maui SHPD assistant archaeologist Jenny Pickett by Dr. Melissa Kirkendall. Precise location information is unavailable at this time; however, the mounds are reported to be located along the upstream side of Hana Highway between TMK (2) 1-1-08:002 and 004, approximately 200-500 meters south to southwest of the bridge. These mounds were recommended for further investigation and recording during the Environmental Assessment phase for Waiokamilo Bridge and/or Culvert. Due to the sensitive nature of these site types, it is also recommended that confidentiality of the site location should be respected.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

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17 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

18 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

19 County Engineer's Department, "Waiokamilo Stream," Hana Belt Road, Job No. 215, Historic Drawings, November 1937.

Recommendations have been identified per bridge component, as follows:

Deck

The Waiokamilo Stream Bridge currently does not meets the standard width for a two-lane bridge. Due to the curb-to-curb width and the historic railings on this bridge, it is recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other bridges along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining three approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Existing natural rock foundation
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Refer to current drawing for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship on Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are good intact examples of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments and CRM wingwalls which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted. After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

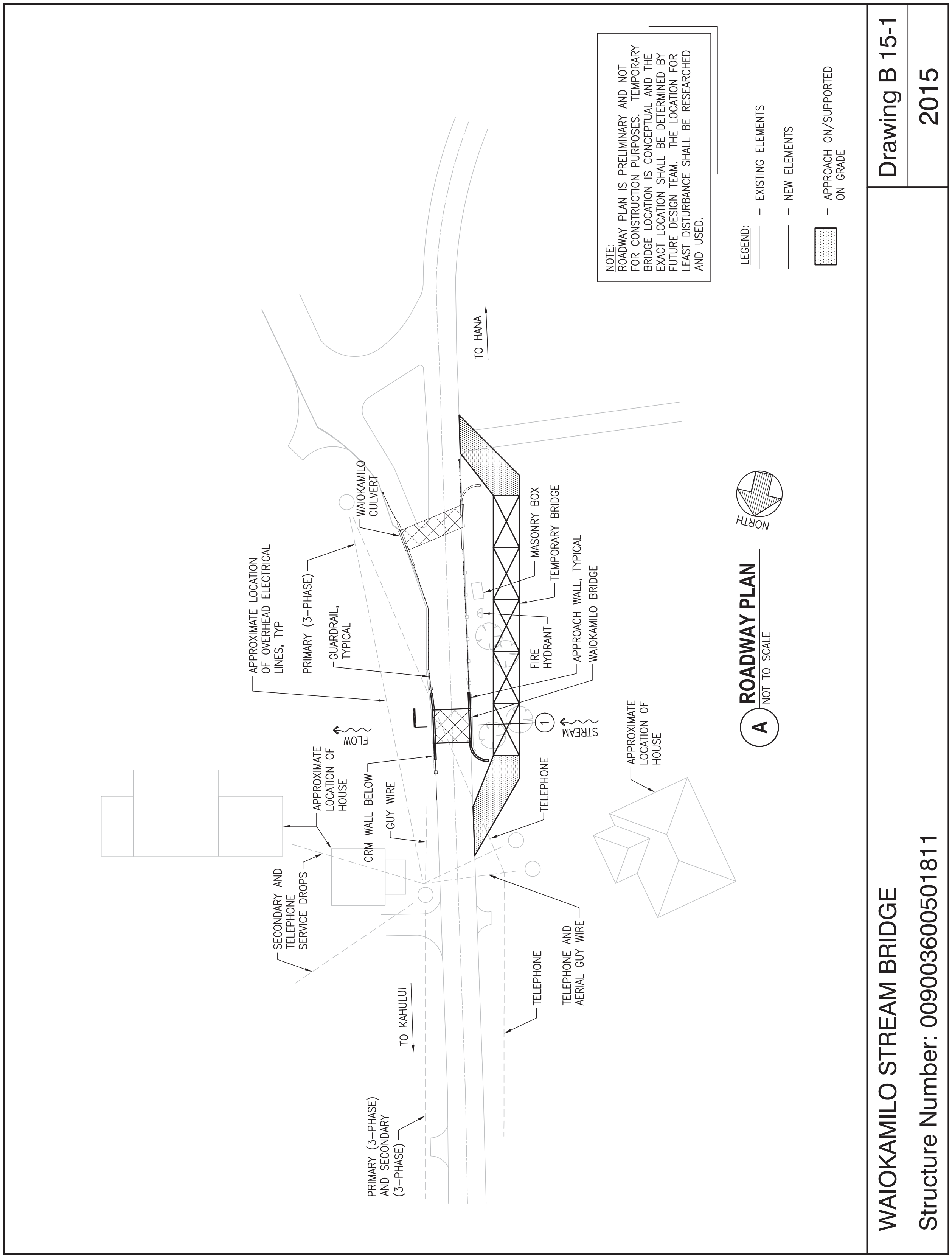
Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Device for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Currently, there are no signage, traffic, and visibility recommendations.

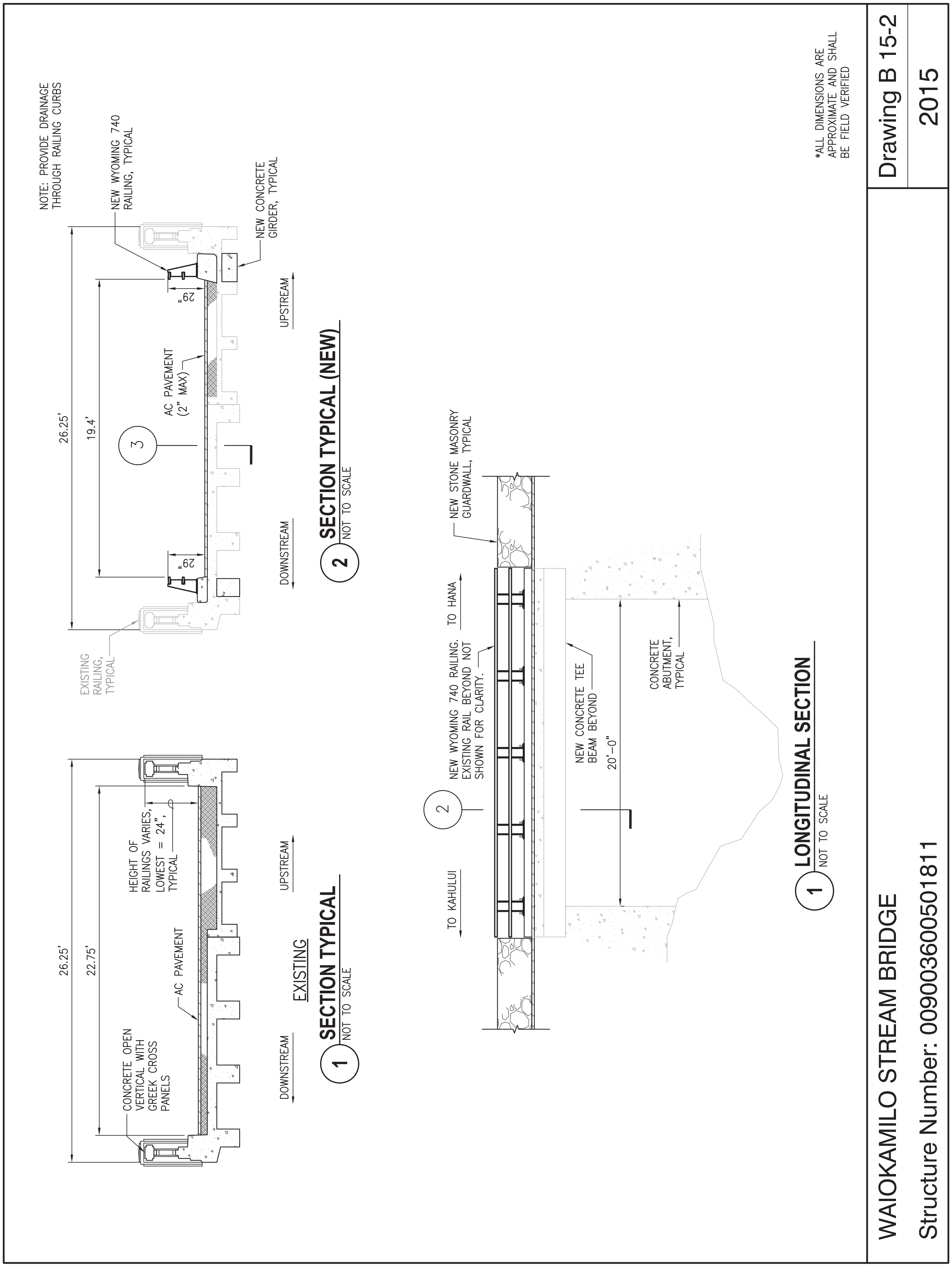
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

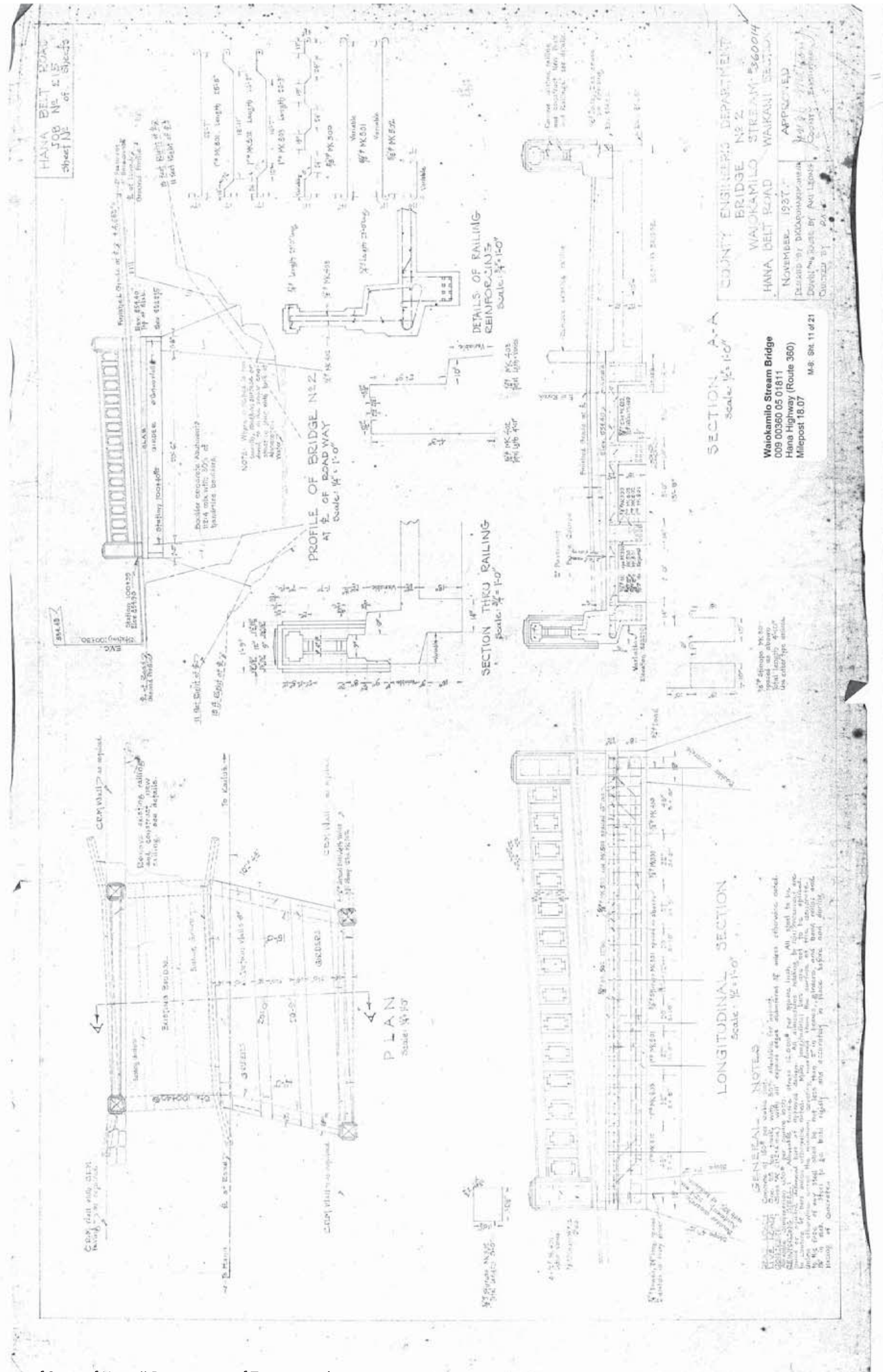
The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



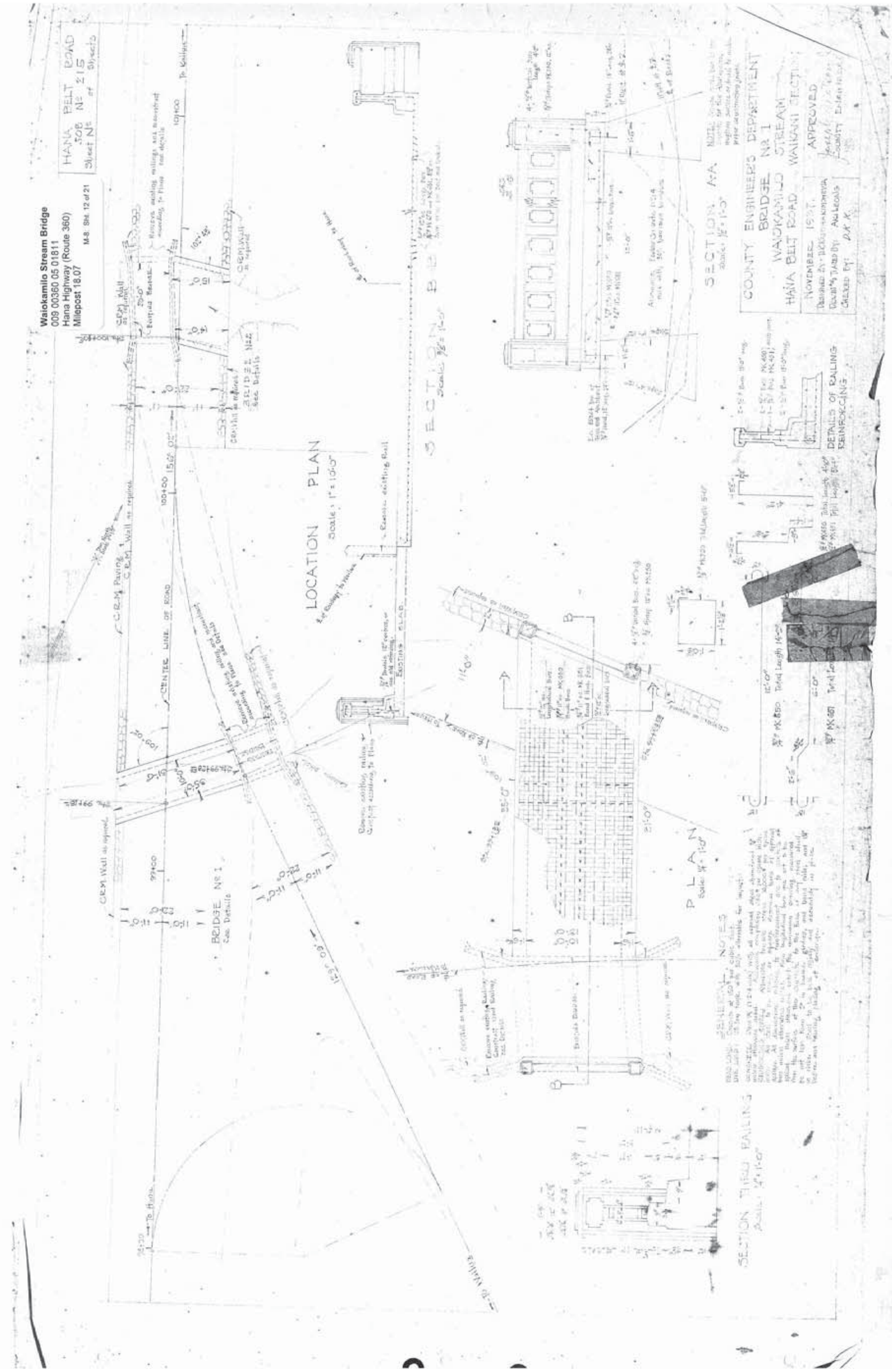
Courtesy of NOEI



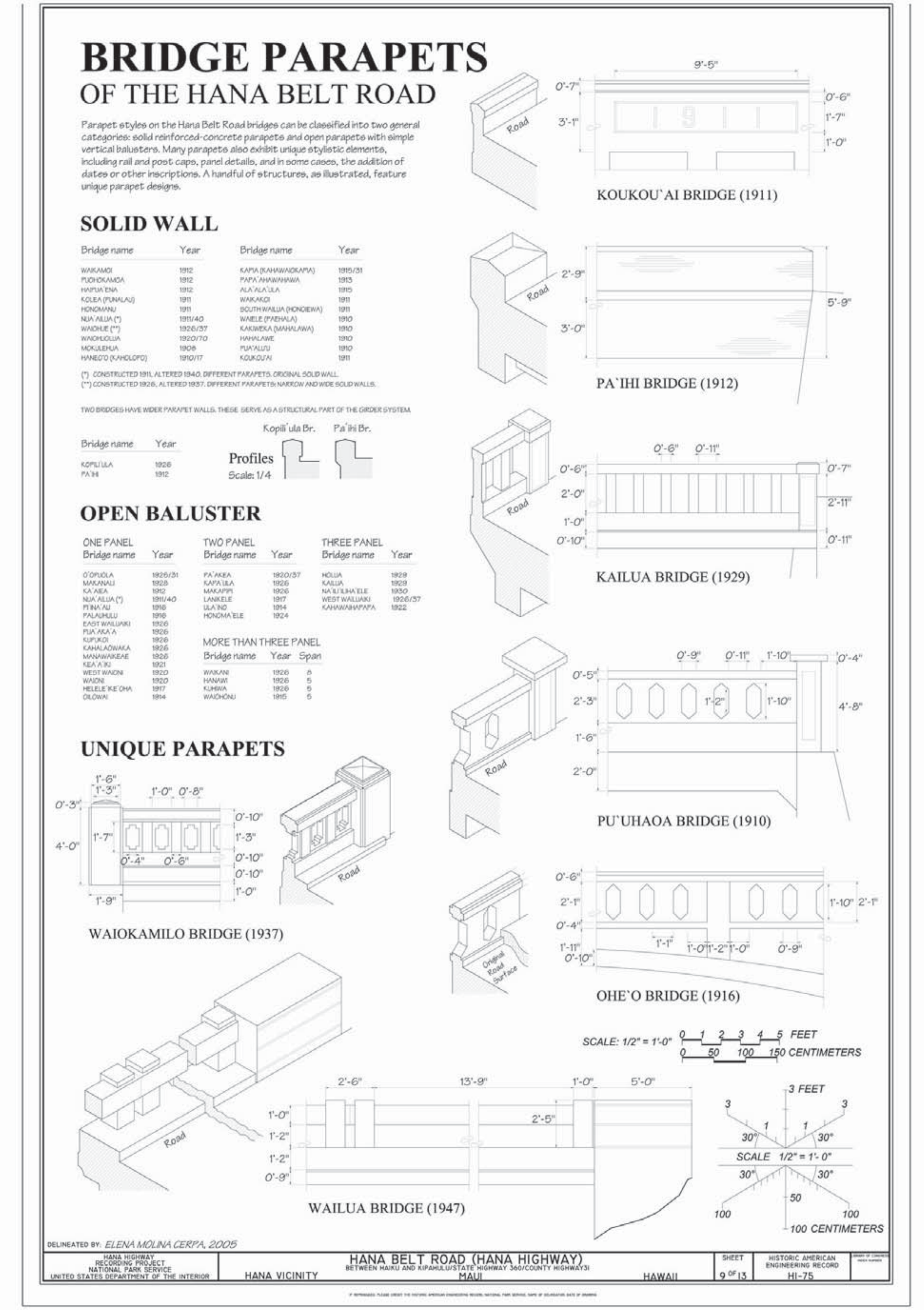
Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation



Courtesy of HAER HI-75

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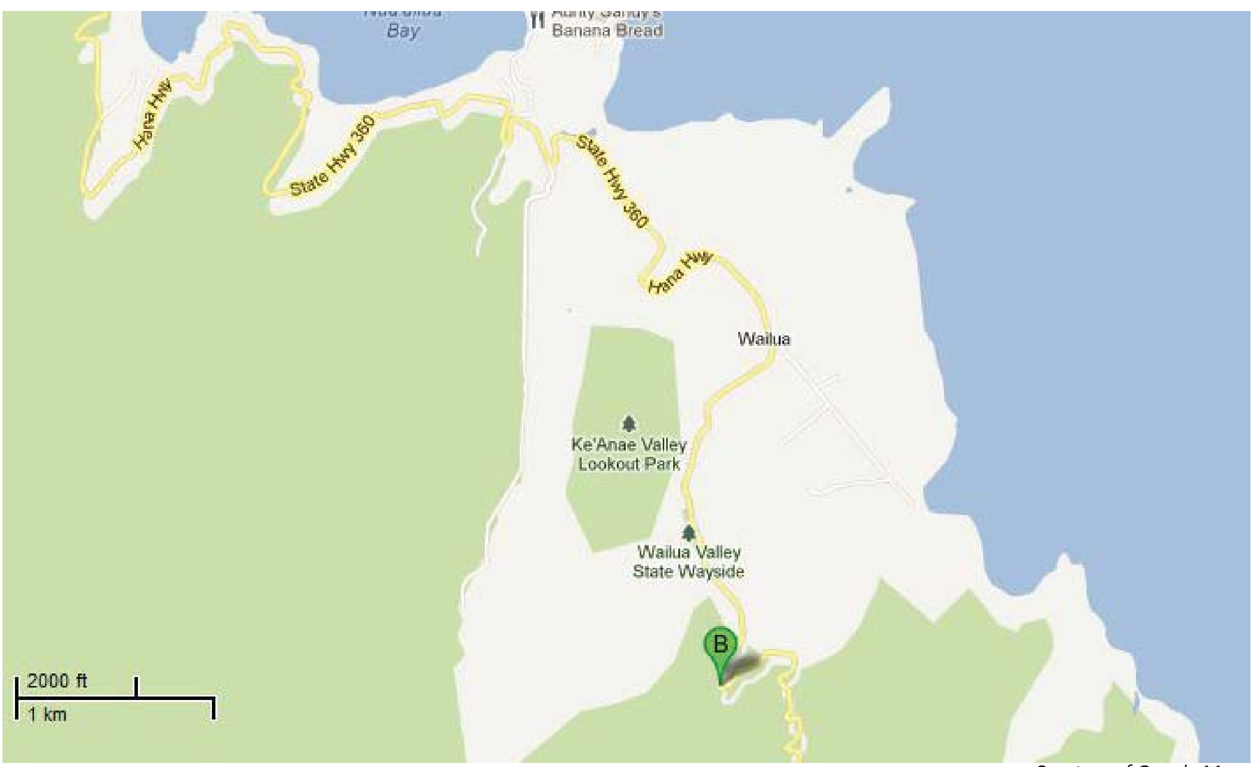
16

Waikani Stream Bridge

16 WAIKANI STREAM BRIDGE

Bridge Number	009003600501942			**Island**	Maui		
Date of Construction	1926			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 49m 58s
Longitude	156d 08m 19s
Mile Point	19.35
Location	0.33 miles east of Wailua Valley Lookout
Feature Crossed	Wailua Nui Stream

Bridge Features

Bridge Type	Reinforced Concrete Open Spandrel Arch Bridge
Total Length	107.94 feet
Number of Spans	1
Maximum Span	83.0 feet
Deck Width	• Curb-to-Curb = 17.10 feet • Out-to-Out = 20.01 feet
Abutment Material	Concrete Abutments
Wingwall Material	Concrete Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	10
Parapet / Railing Height	• Upstream Railing Height = 29 inches • Downstream Railing Height = 33 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17.75 inches on-center • Intermediate posts = 10 inches x 10 inches • End posts = 10 inches x 10 inches (round on downstream side)
Parapet / Railing Cap Profile	• Saddle coping cap • Railing cap = 7 inches x 10 inches

Bridge Features

Waikani Stream Bridge is a single-span reinforced concrete open spandrel arch bridge built in 1926. The structure consists of a concrete slab with AC pavement overlay supported by reinforced concrete spandrel bents, which are comprised of beams and columns, reinforced concrete struts, and two reinforced concrete arch ribs. At each end of the slab are concrete abutments and CRM wingwalls. The abutments and arch ribs bear directly on natural rock formations.

Setting of Waikani Stream Bridge
Courtesy of NOEI

Waikani Waterfall
Courtesy of FAI

Hana approach to Waikani Stream Bridge toward Kahului
Courtesy of FAI

Kahului approach to Waikani Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of FAI

Partially repaired concrete open vertical railing, downstream side
Courtesy of FAI

Concrete spandrel bents
Courtesy of NOEI

Concrete arch rib
Courtesy of NOEI

Concrete struts
Courtesy of NOEI

Abutment on natural rock formations, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Wailuanui
Designer / Builder	William D'Esmond and A. H. Wong, Designers Moses Akiona Company, Builder Plans approved by A. P. Low, County Engineer and Lyman H. Bigelow, Superintendent of Public Works
Historic Drawings	January 1926
Alterations	None
Replacement	None
Preservation Priority	Exceptional Arched Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Arch bridges are an uncommon bridge type • Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • One of the most scenic bridges on Hana Highway, Route 360 • Constructed by prominent native Hawaiian contractor Moses Akiona and skilled builders • Exceptional example of concrete open spandrel arch bridge on Hana Highway, Route 360 • Good intact example of concrete abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Bridge spans a deep gorge and provides view to a waterfall upstream • Multiple waterfalls in the immediate area • Lush vegetation
Character Defining Features	• Reinforced Concrete Open Spandrel Arch Bridge • Open Concrete Vertical Railings • End and intermediate post designs, including round starter post • Curved railings at first and last segment on downstream side • Highly visible structural components
Detracting Features	Inappropriate alteration on downstream railings Hana side

Significance & Context

Bridge Site History

> [The bridge was] *designed by architect William D'Esmond in partnership with* [Paul] [A. P.] *Low, constructed by the prominent native Hawaiian contractor Moses Akiona and skilled builders.* [Waikani Bridge] *dramatically crosses a deep gorge at the head of Wailuanui Valley and is located at the end of mile-long ledge over Wailua, which Low had described in May 1926 "without comparison." [The bridge was] major piece of construction remaining to be completed before the Hana Belt Road could be opened to traffic in 1926.*[1]

Archaeological / Cultural Significance

The Hawaiian words *wai* and *kani*, which together form the place name *Waikani*, translate as, "the sound made by water"or, "singing water."[2] The Waikani Bridge spans the Wailua Nui Stream near Waikani Falls, within Wailuanui Ahupuaa.[3,4]

The Wailua Nui Stream is a large stream that flows through Wailua Valley and empties into the ocean on the Hana side of the Keanae peninsula. In ancient times, Handy stated that the two adjacent areas of Keanae and Wailua Nui comprised a major center of population on the island of Maui.[5]

On November 30, 1778, British explorer Cook sailed his ships off to the northeast end of Maui.[6] According to Fornander, a number of canoes approached his ships to trade off the coast of Haaluea, just below Wailua Nui.[7] Kalaniopuu boarded Cooks ship with a group of his paddlers.[8] It was noted by Cook that the following items were traded by the natives of this region of east Maui:

> *Our visitors supplied us with a quantity of cuttle-fish, in exchange for nails and iron. [Expecting the natives would return the next day]….many of them appeared, bringing with them potatoes, taro (sic), bread-fruit, plantains and small pigs.*[9]

In 1860 a Catholic church, "Saint Gabriel's Church," was constructed out of white coral at Wailua Nui. From the archives of correspondence with the Vicariate came a letter dated 1865, in which the full story of the erection of St.

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1 Richard O'Connor, Hana Belt Road HAER HI-75, 2005,43.

2 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

3 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

4 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

5 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

6 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

7 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

8 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

9 Captain James Cook and Captain James King, *A Voyage to the Pacific Ocean; Undertaken by Command of his Majesty, for Making Discoveries in the Northern Hemisphere, Performed Under the Direction of Captains Cook, Clerke and Gore, in the Years 1776, 1777, 1778, 1779, and 1780*, vol. 3 of 4 (London: 1784).

Gabriel's Church, is told. In the words of Father Leonor Fouesnel:

When there was a question as to the building of a new chapel at Wailua Nui (Keanae), our Protestant neighbors had been working for two years on the erection of a new temple. They had a hard time getting the necessary material. There was no beach is this region and consequently no sand. Rocks abound, but the lime-boiled coral – as well as the sand – has to come from the sea. One has to dive for it as deep as six to ten feet. So we gather our neophytes and tell them to get the necessary materials, sand and coral, so as not to delay the work of the two Brothers who will soon arrive to build their church. A day was chosen and set for all to go down together and begin the diving and hauling. But on the appointed day a fierce storm was raging and it was only four days later that the ocean calmed. All of our people went down armed with iron bars to loosen the coral. What a surprise greeted them when, coming to the assigned place, they found the shore heaped with coral.

Of course, they went to work with a will and soon gathered coral enough to take care of the whole building. The Protestants looked on, spellbound, but did not dare take the coral that seemed to belong to the Catholics. However, the next day, they hurried down to gather what we had left behind. But (and I was an eye-witness to this) when they arrived at the shore, all at once the sea took to a sudden swelling and washed away the last vestiges of coral.

The Hawaiians of this district were simply wonderful in this enterprise. They not only gathered coral and sand with their bare hands, but as if in procession, the priest leading, the men with their wives and children went up into the mountains to saw and to carry piece by piece the necessary wood for the construction of their church.

When Brothers Arsene and Charles arrived, it took only a short time to build the church. The new chapel was blessed by Father Modest Favens. This is how Keanae got its stone church, topped by a small square tower.

In Hana, in Kaeleku, there used to be another mission chapel of the Keanae parish. It became relatively important when in 1905 the Hana Plantation was reorganized and its name changed to Kaeleku Sugar Company. The mill was always in Kaeleku, which village was part of the Hana ecclesiastical district until Keanae district was formed in 1940.[10]

10 Robert Schoofs, *Pioneers of the Faith: History of the Catholic mission in Hawaii, 1827-1940* (Honolulu: Louis Boeynaems, 1978).

The section of the Hana Belt Road that was built through the West Wailua Iki Valley from Keanae, took a year of digging through the mountains and blasting through solid rock from both ends of the project. The steam shovels finally met at Waikani Falls in Wailua Nui Valley in August, 1926.[11]

Refer to Section G, Appendix 1, Section 3.1.2.6 for the history of the Wailua Nui Stream vicinity, and to Appendix 1, Page 72, Figure 10 for nearby archaeological study areas.[12, 13]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Waikani Stream Bridge. However, in 1916 Stokes described four *heiau* at Wailua Nui:

> *The informant Kama stated that: heiau Ohia, land of the same name; near house of informant Kama, who called it a Koa ia [fishing shrine]. Built by chief Kaimuki. Previous occupant of place used stones for pig pen and pigs died.*
>
> *Various native informants stated: heiau Kaluanui, land of the same name, below Ohia and one third of a mile from sea; on side of taro patch. Small, 41 x 42. Two sections, enclosure and platform, the latter running into the hill and seeming to have continued up the slope. Said by Mrs. Napihaa to have been for sacrifice, and that the drums were heard.*
>
> *Informant and guide Enos Kapoohiwi stated that: heiau Kukaiapuni, land of Pauwalu; 300 feet south of road, 5-600 feet west of school, cresting top of slope and facing North West by west. Terrace springing from ground level and extending to height of 8 to 12 feet according to undulations of land. Disturbed, no characteristics remaining. Upper surface of platform 42 x 50.*[14]
>
> *The informant Kalo described heiau Makehau, on flat land of same name. Mauka of main lower road, and 150 feet south of Makehau road. Disturbed platform 43 x 72 remaining, and indications that it extended to greater width. Eight coconuts on platform, said to have been planted by Kaniho, who took care of the heiau. Kaniho was remembered as an old man by Kalo the guide and informant.*[15]

Refer to Section G, Appendix 1, Section 3.1.2.6 for the history of the Wailua Nui Stream vicinity.

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11 Dawn E. Duensing, "The Hana Belt Road: Paving the Way for Tourism," *The Hawaiian Journal of History* 41 (Honolulu: Hawaiian Historic Society, 2007).

12 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

13 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

14 John F. G. Stokes, "Maui Heiau," manuscript (Honolulu: Department of Anthropology, Bernice Pauahi Bishop Museum, 1916).

15 Ibid.

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by very tall trees (deep), No yield • West Bound: Obstructed by very tall trees (deep), No yield
Signage (as of September 2014)	West Bridge Approach • None
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.41 • Operating Rating = 0.53
Condition	Functionally Obsolete

Civil & Traffic

Waikani Stream Bridge is located at mile point 19.35 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 20.01 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently obstructed by tall trees causing poor visibility of oncoming traffic. The signs in this area are in relatively poor condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 17, 2013. The overall condition rating of the bridge at the time of inspection was fair.[16] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 29 inches and 33 inches respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.41 and the operating rating is 0.53.

The current curb-to-curb dimension is 17.10 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

16 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Waikani Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 17, 2013, record drawings,[17,18,19] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Waikani Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

The unique design, arched profile, visibility from a distance, large scale and dramatic setting are all combined to make this exceptional bridge.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Waikani Stream Bridge currently exceeds the minimum curb-to-curb width of 16 feet for a one-lane bridge. After installing the Wyoming 740 railing (refer to *Railing/Parapets*), the width does not meet the requirement and it

17 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

18 County Engineer's Office, "Wailuanui Bridge," Kailua-Kopiliula Belt Road, County of Maui, Job No. 9, Historic Drawings, January 1926.

19 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Highway Waikani Bridge Repair, Project No. 360A-01-90M (May 1990).

is recommended that this bridge be exempt from HDOT 16-foot width design criteria due to its exceptional historic significance.

Existing deck
Courtesy of FAI

Replacement of the bridge deck is recommended to increase the load carrying capacity of the bridge and to support the new crash test railings. The new deck will be constructed between the existing longitudinal diaphragm beams. Refer to the following Railings/Parapets and Load Rating sections for more information.

If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

There are no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum.

CRM Approach Walls

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing railings. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the new deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

It is recommended to investigate the current material composition of the concrete wingwalls, concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, they are recommended to be replaced in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions. If it is determined necessary to rehabilitate the concrete wingwalls, they are recommended to be replaced in-kind with reinforced concrete structures.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Additional strengthening may be necessary to account for the additional stresses on the superstructure and substructure caused by construction of the new deck.

Load Rating

Load rating for this bridge was updated with LRFR and a bridge load posting of 11-tons was recommended. Although this recommended posting is higher than the 10-tons general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3), it is still under the recommended design criteria of 40-tons. Therefore, it is recommended to replace the bridge deck to support a load carrying capacity of 40-tons.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility of the oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approval landscape plan. It is recommended that a "Yield" sign (R1-2), a "To Oncoming Traffic" sign (R1-2a), and yield line are added to both bridge approaches. It is also recommended that object makers (OM3-L & OM3-R) are added to the left and right bridge end treatments at both bridge approaches. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left and Right (OM3-L, OM3-R)
- Prune roadside brush and trees

East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Replace Object Marker Type 3 - Left and Right (OM3-L, OM3-R)
- Prune roadside brush and trees

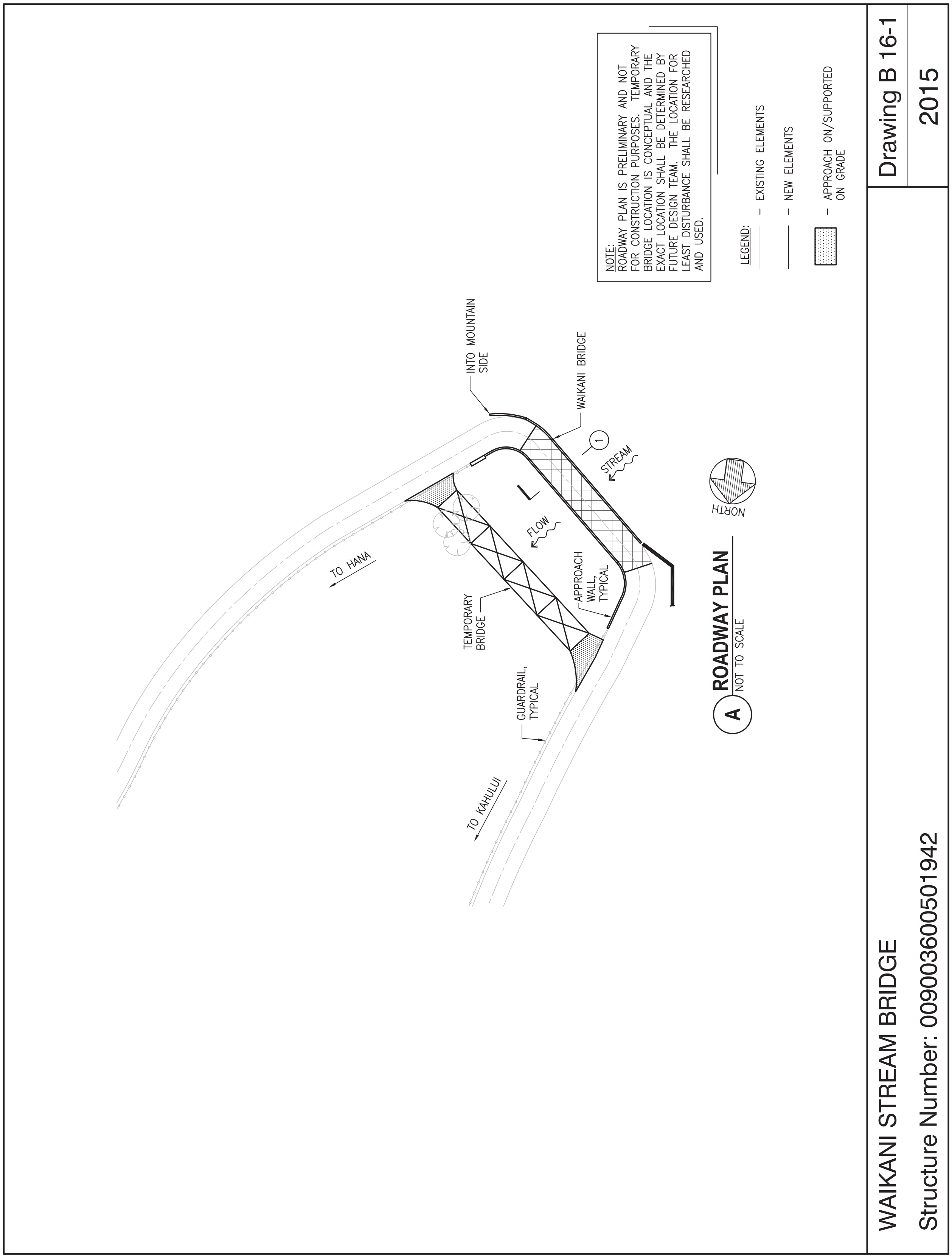
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Waikani Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.

Alternative Option

Due to the bridge width, loading capacity, and traffic issues, an alternate recommendation is to add a new two-lane bridge on the downstream side of the existing bridge and preserve the existing historic bridge as a pedestrian walkway or add a new one-lane bridge and use both existing and new bridges for vehicles. These options are to be further investigated and determined following discussion with community and consulting parties, and are subject to approval by FHWA.



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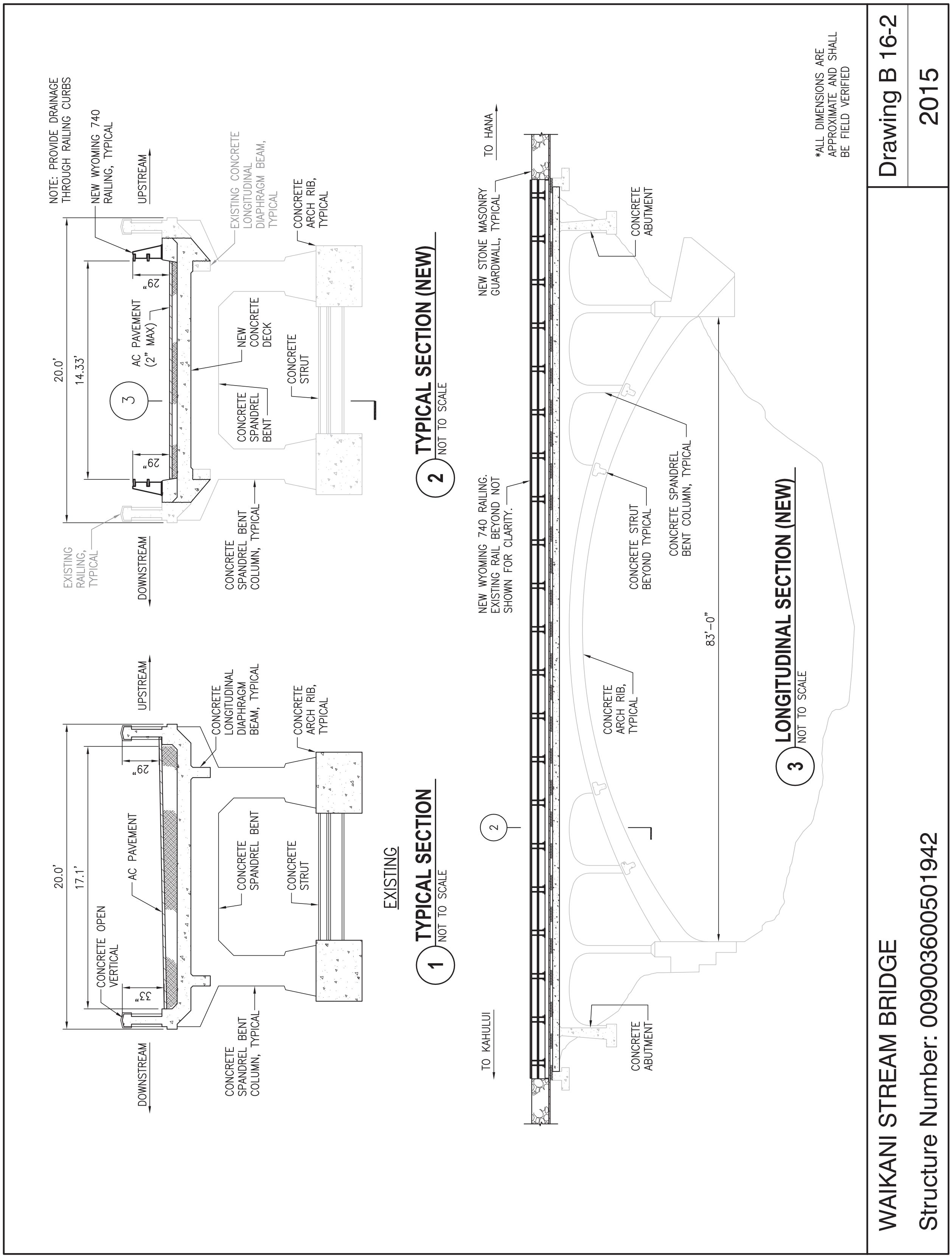

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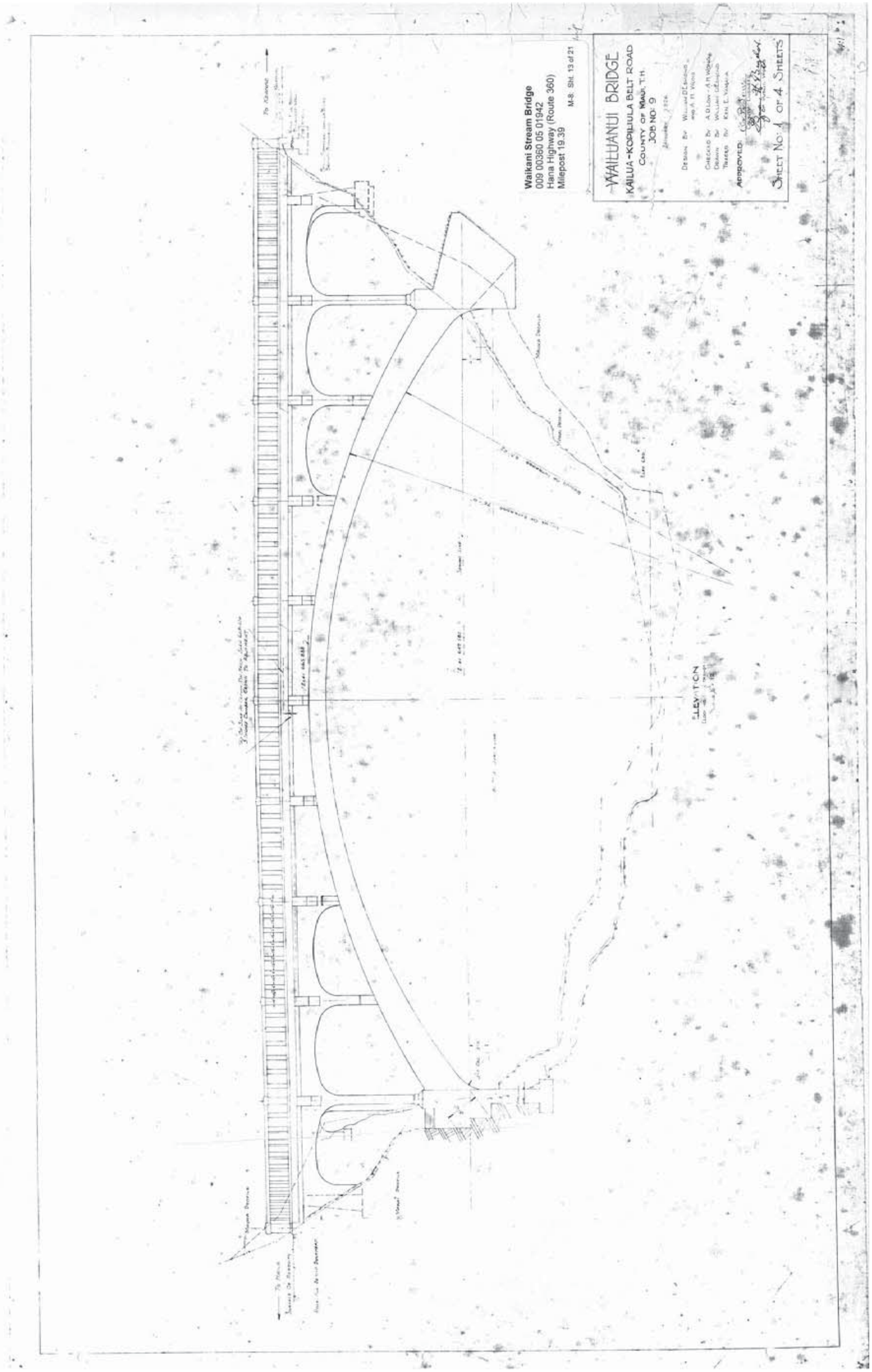

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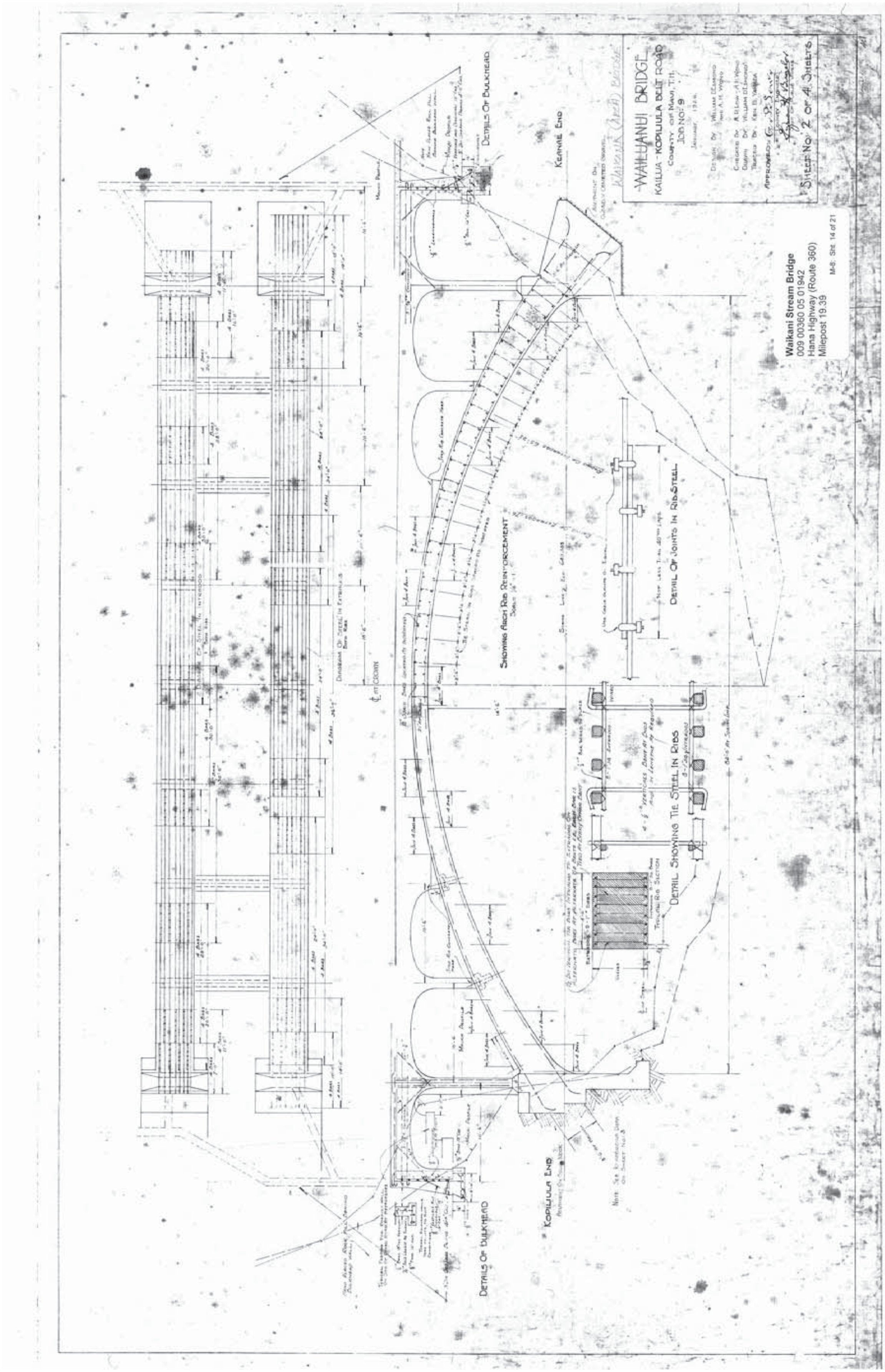

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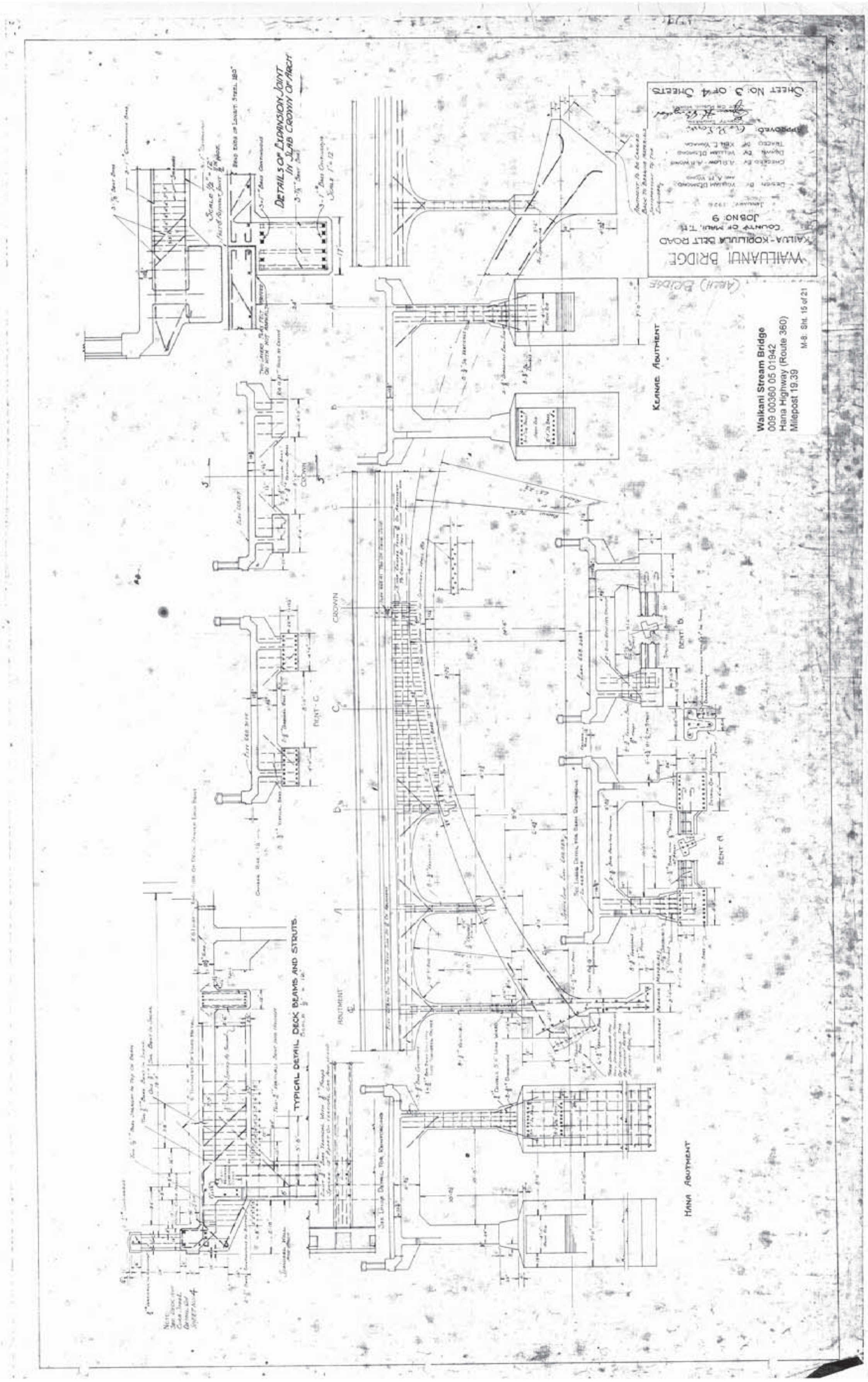

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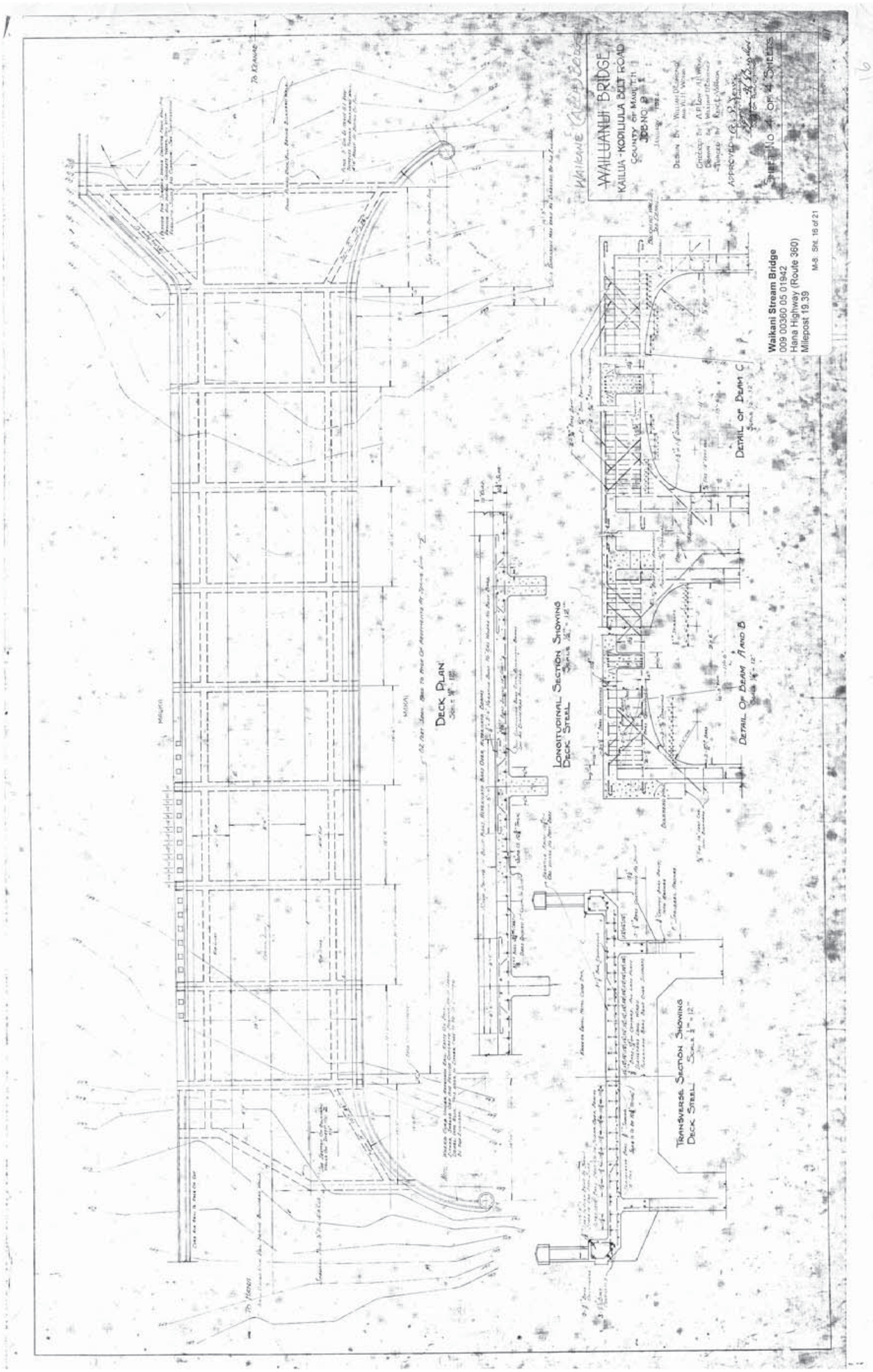

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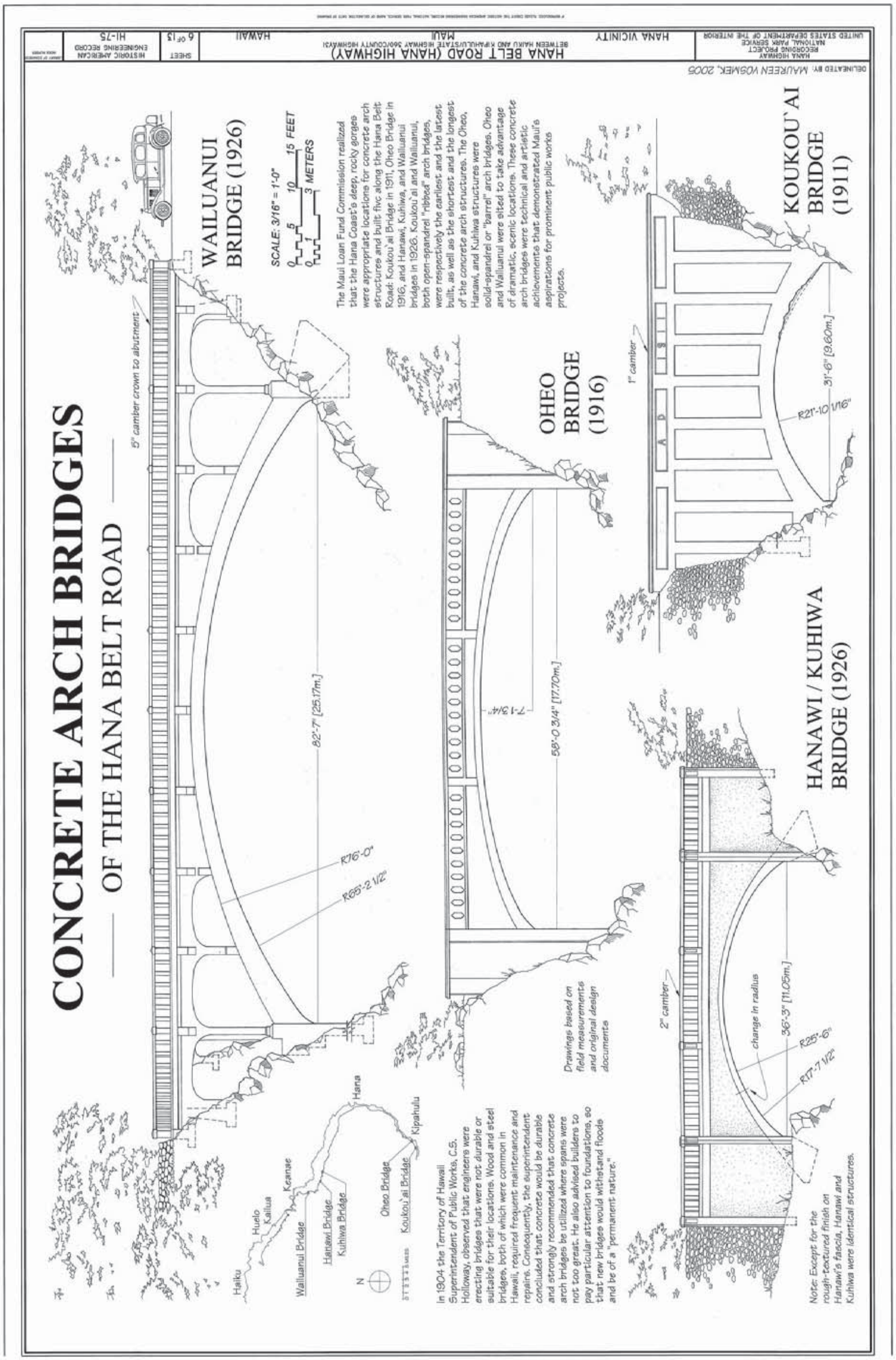
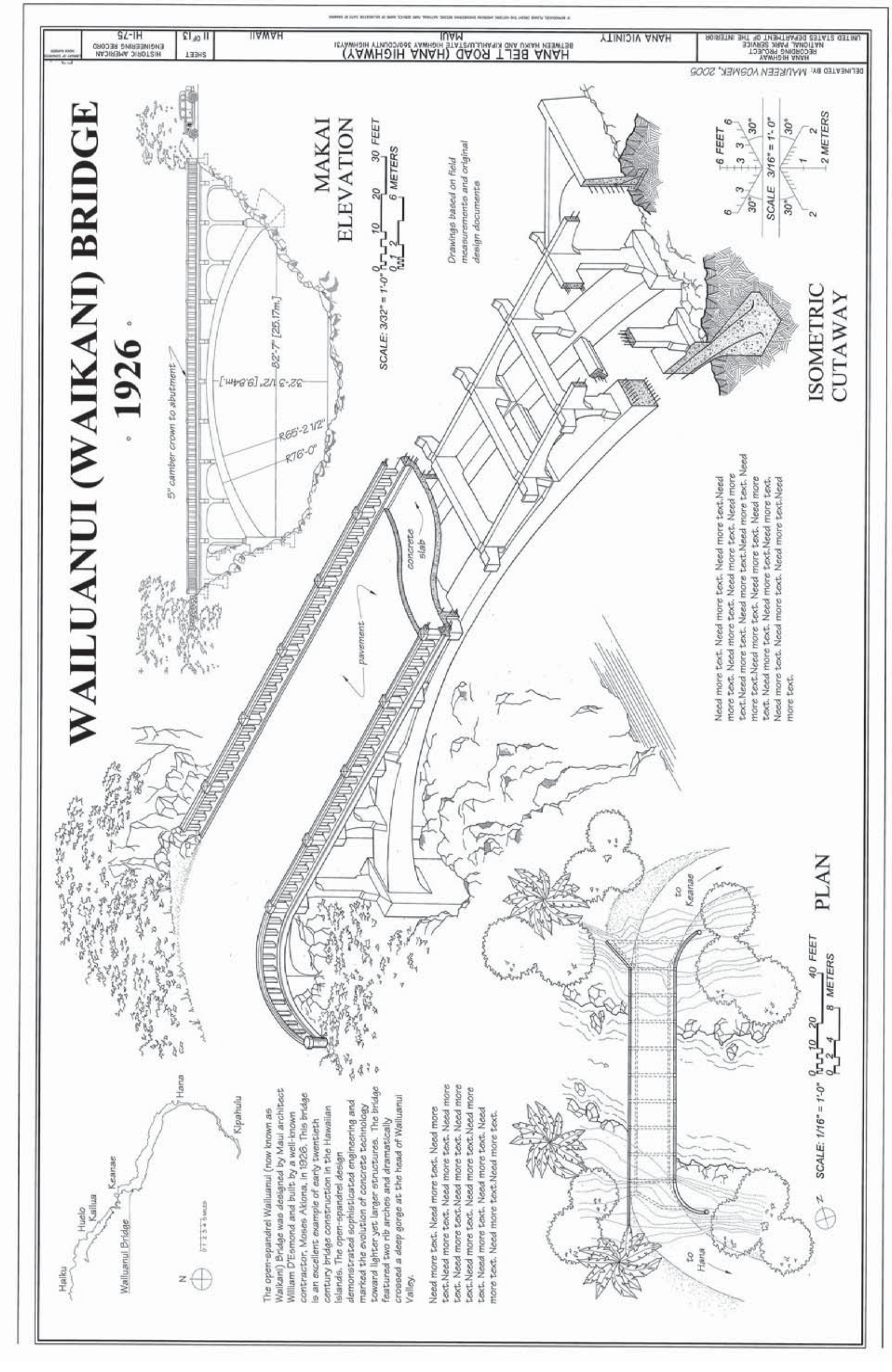


Courtesy of HAER HI-75



Courtesy of HAER HI-75

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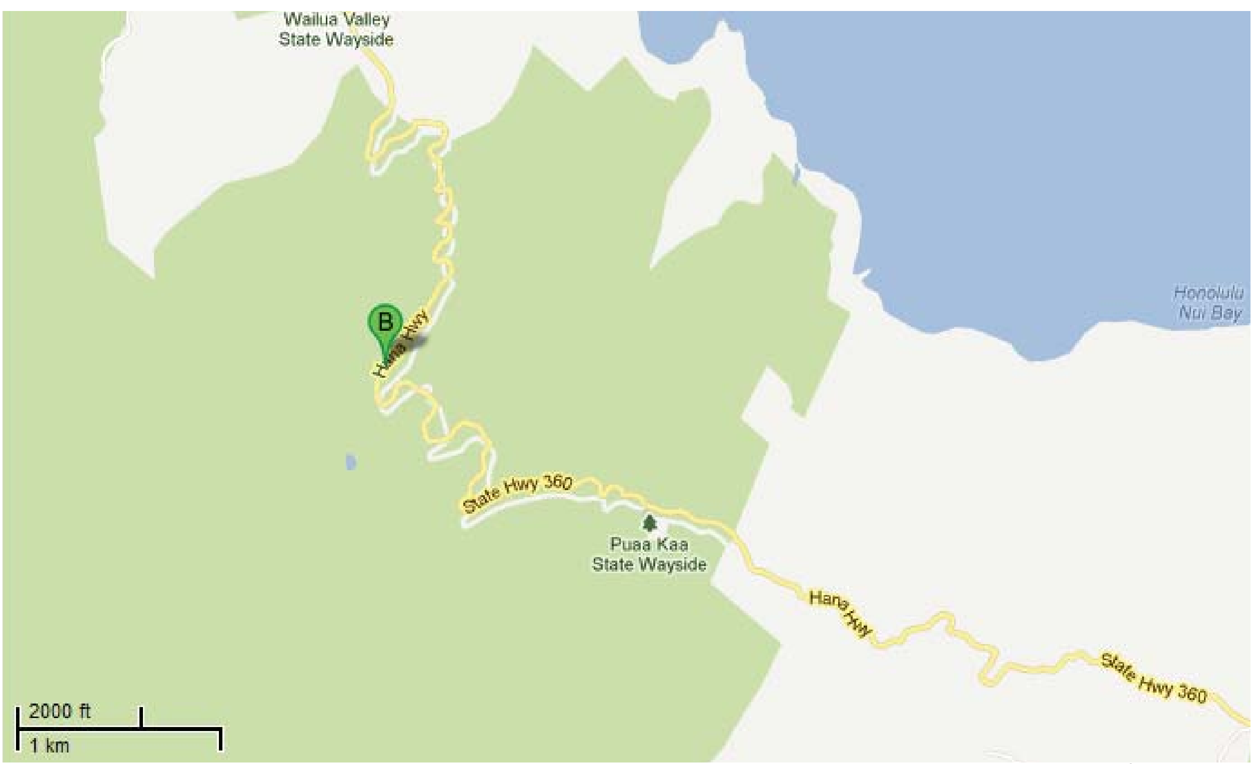
17 West Wailuaiki Stream Bridge

17 WEST WAILUAIKI STREAM BRIDGE

Bridge Number	009003600502086			Island		Maui	
Date of Construction	1926			Route		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 49m 19s
Longitude	156d 08m 17s
Mile Point	20.78
Location	1.77 miles east of Wailua Valley Lookout
Feature Crossed	West Wailuaiki Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	70.87 feet
Number of Spans	3
Maximum Span	28.9 feet
Deck Width	• Curb-to-Curb = 20.01 feet • Out-to-Out = 21.98 feet
Abutment Material	• CRM Abutment (Kahului) • CRM Abutment with Rubble Concrete base (Hana) • Rubble Concrete Pier Walls with Rubble Concrete base
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	3
Parapet / Railing Height	• Upstream Railing Height = 40 inches • Downstream Railing Height = 32 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17 inches on-center • Intermediate posts = 12 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

West Wailuaiki Stream Bridge is a triple-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span, which are spaced approximately 6 feet on-center. The substructure consists of CRM abutments, pier walls, and wingwalls. The abutments and pier bear directly on natural rock formations.

Setting of West Wailuaiki Stream Bridge
Courtesy of NOEI

Natural pond near West Wailuaiki Stream Bridge
Courtesy of NOEI

Hana approach to West Wailuaiki Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to West Wailuaiki Stream Bridge toward Hana
Courtesy of FAI

Concrete open vertical railings, downstream side
Courtesy of FAI

Concrete open vertical railings, upstream side
Courtesy of NOEI

CRM pier walls with concrete façade and rubble concrete base pier
Courtesy of NOEI

Upstream CRM wingwall with concrete façade, Kahului side
Courtesy of NOEI

CRM abutment with concrete façade on natural rock foundation, Kahului side
Courtesy of NOEI

Concrete tee beams
Courtesy of NOEI

Significance & Context

Ahupuaa	Wailua Iki and Wailua Nui
Designer / Builder	County Engineer's Office - A. H. Wong, Designer Plans approved by Lyman H. Bigelow, Superintendent of Public Works
Historic Drawings	December 1925 (approved January 1926)
Alterations	None
Replacement	None
Preservation Priority	Exceptional Curved Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of five bridges with curved parapets on Hana Highway, Route 360 • Good intact example of CRM abutments on Hana Highway • Good intact example of rubble concrete piers on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Wide, Open deep curve with large upstream pond and tall downstream waterfall • Alignment: Curved Bridge, on wide curve • Popular viewing spot with need for safe parking
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutment (Kahului), CRM Abutment with Rubble Concrete base (Hana) • CRM Pier Walls with Rubble Concrete base • CRM Wingwalls • Concrete Open Vertical Railings • Alignment on curve
Detracting Features	• Non-historic cementitious materials on face of CRM abutments and CRM wingwalls

Significance & Context

Archaeological / Cultural Significance

The place name *Wailuaiki* is defined as, "little Wailua. Land section. Koolau, Maui."[1] The West Wailuaiki Stream Bridge spans the West Wailuaiki Stream, which forms the boundary between Wailua Nui Ahupuaa and Wailua Iki Ahupuaa.[2]

Wailua Iki is known in Native Hawaiian legend as the place where Kapo (the elder sister of Hiiaka) saved Pele from Kamapuaa. According to Beckwith, the Maui legend of the hog-man Kamapuaa and the goddess Kapo at Wailua-iki is told this way:

Kamapuaa came to the island of Maui in his fish form and saw a rainbow resting over Kapos house. Her husband was out fishing and she was beating *tapa* when the handsome stranger entered her house. Two men on the cliff signal to her husband and he comes running and hits Kamapuaa with his paddle. Kamapuaa sends the husband flying over the cliff, called today Kuou, and the spot where he fell is seen today in the shape of a huge stone by the roadside. The gap between Wailua and Wailua Iki through which today runs a steep trail, was torn out at the time of this struggle. Kapos house could also be seen. Similar stories of Kamapuaas attack upon Pele are among the popular stories told in this vicinity. In the pursuit Kamapuaa lost his hair at a point called Huluhulu-nui (Many bristles), runs against the cliff at Puaahookui, and finally overcomes Pele at the hill called Kaiwi o Pele (The bones of Pele).[3]

Fornander recorded the mythology surrounding the landmark Kaiwi o Pele (The Bones of Pele) in a story told by the informant John Moo at Lahainaluna School. In the *ahupuaa* of Aleamai, the story begins at a popular surfing spot known as Puhele, at Hana. It was here that Namakaeha, a stranger who came from Kahiki, met Mahinahina from the southern region of Hana. As they walked along a road, Namakaeha saw the goddess Pele digging potatoes. Confronted by Namakaeha as a traveler seeking opponents to fight, Pele battled Namakaeha. They fought until Pele weakened.

The body of Pele was taken and the bones were stripped of flesh and taken and buried in the ground. They were exhumed by dogs, placed in a pile, and that is why this hill is so named, because the bones of Pele were stripped off there.[4]

Famous places were listed on the hill Kaiwi o Pele. At the top, the place where the famous warrior Peapea's bones were burnt; on the eastern side of the same hill are the holes made by the club of Kane and Kanaloa; on the western side were the boys digging potatoes; near that is the fishing *noio* (small black tern).[5] It was from this hill that the

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 Martha W. Beckwith, *Hawaiian Mythology* (Honolulu: University of Hawaii Press, 1970).

4 Abraham Fornander, "The Bones of Pele," *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians' Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, second series, trans. Thomas G. Thrum, vol. 5 of *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1919).

5 Abraham Fornander, "The Bones of Pele," *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians' Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, second series, trans. Thomas G. Thrum, vol. 5 of *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1919).

goddess Hina left the earth to live on the moon.[6]

As with the stories of Pele and her hog-man lover (Kamapuaa), another popular story of the Hana region involves the existence of a shark-man. In Beckwith's story about Pauwalu, which takes place at Wailua, Pauwalu ("eight all killed. Point. Koolau. Maui." [7]) lives at Wailua, Maui. He warns men as they go to the sea that eight will be dead before they return. A shark always kills eight of them as predicted.

Akeake the strong is born beside the stream Hau-ola and while yet a little boy starts about Maui fighting champions. After overcoming Lohelohe, he, with his companion Pakolea, spends the night at a friends' house named Ohia and learns about Pauwalu. The shark man scoffs at so little an antagonist, but *akeake* easily binds him, exposes the sharks' mouth on his back, and casts him into the fire.[8]

Refer to Section G, Appendix 1, Section 3.1.2.7 for the history of the Wailua Iki vicinity, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[9]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the West Wailuaiki Stream Bridge.

6 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 Martha W. Beckwith, *Hawaiian Mythology* (Honolulu: University of Hawaii Press, 1970).

9 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear, No yield • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left Object Marker (Vandalized, OM3-L)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a)
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.65 • Operating Rating = 0.84
Condition	Functionally Obsolete

Civil & Traffic

West Wailuaiki Stream Bridge is located at mile point 20.78 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 21.98 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 17, 2013. The overall condition rating of the bridge at the time of inspection was fair.[10] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 40 inches and 32 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.65 and the operating rating is 0.84.

The current curb-to-curb dimension is 20.01 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of West Wailuaiki Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 17, 2013, record drawings,[11, 12] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If West Wailuaiki Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The West Wailuaiki Stream Bridge currently meets the width standards of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to

11 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

12 County Engineer's Office, "West Wailuaiki Bridge," Kailua-Kopiliula Belt Road, County of Maui, Job No. 8, Historic Drawings, December 22, 1925.

Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Existing concrete façade CRM abutment
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula

Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Existing concrete girders
Courtesy of NOEI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to the current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

According to record drawings, the abutments and pier walls were constructed of CRM material. During site visits to the bridge, no CRM stones were visible, and the façades of the abutments and pier walls appeared to be concrete. Therefore, the existing structural make-up of the abutments and pier walls cannot be verified by visual inspection. It is recommended to investigate the current material composition of the concrete abutments, pier walls, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have core samples extracted. If the core samples show that the abutments and pier walls are concrete structures, then a condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan.

Although the CRM abutments and rubble concrete pier walls are a good intact example of these components along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, if investigations of the material and strength of the abutments and piers yield no substantial results, then it is recommended to replace the substructure completely in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions. If it is determined that the abutments or the pier walls are constructed of CRM material, prior to removal, the future design team shall document the existing appearance, condition, and CRM sublayer.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, CRM wingwalls, and concrete pier walls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and a bridge load posting of 18-tons was recommended. Although this recommended posting is higher than the 10-tons general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3), it is still under the recommended design criteria of 40-tons. Therefore, it is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" Sign (R1-2), a "To Oncoming Traffic" sign (R1-2a), and a yield line are added to both bridge approaches. It is also recommended that object markers (OM3-l & OM3-R) are added to both left and right bridge end treatments at both bridge approaches. In regard to visibility to oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Replace Object Marker Type 3 - Left (OM3-L)
- Add Object Marker Type 3 - Right (OM3-R)

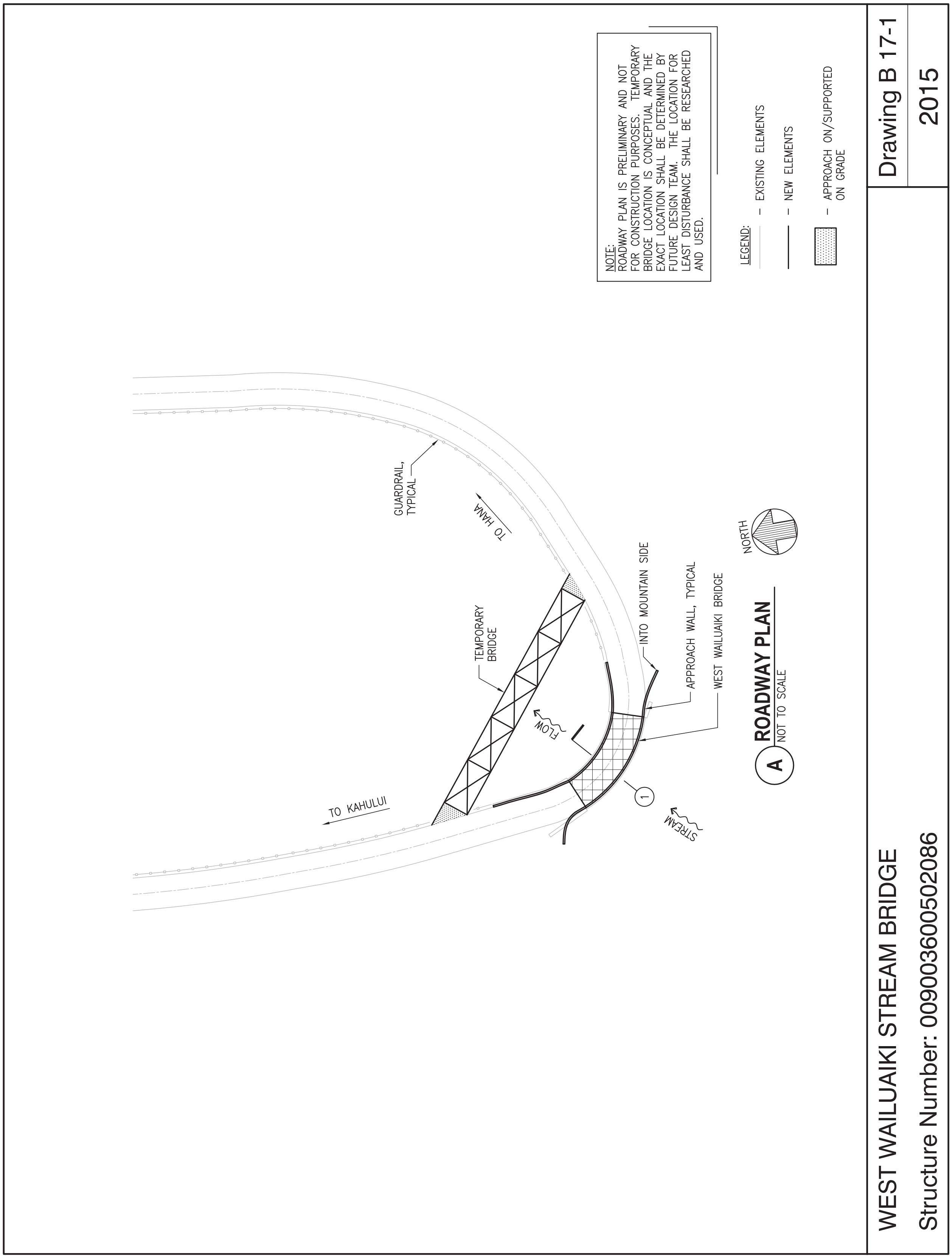
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

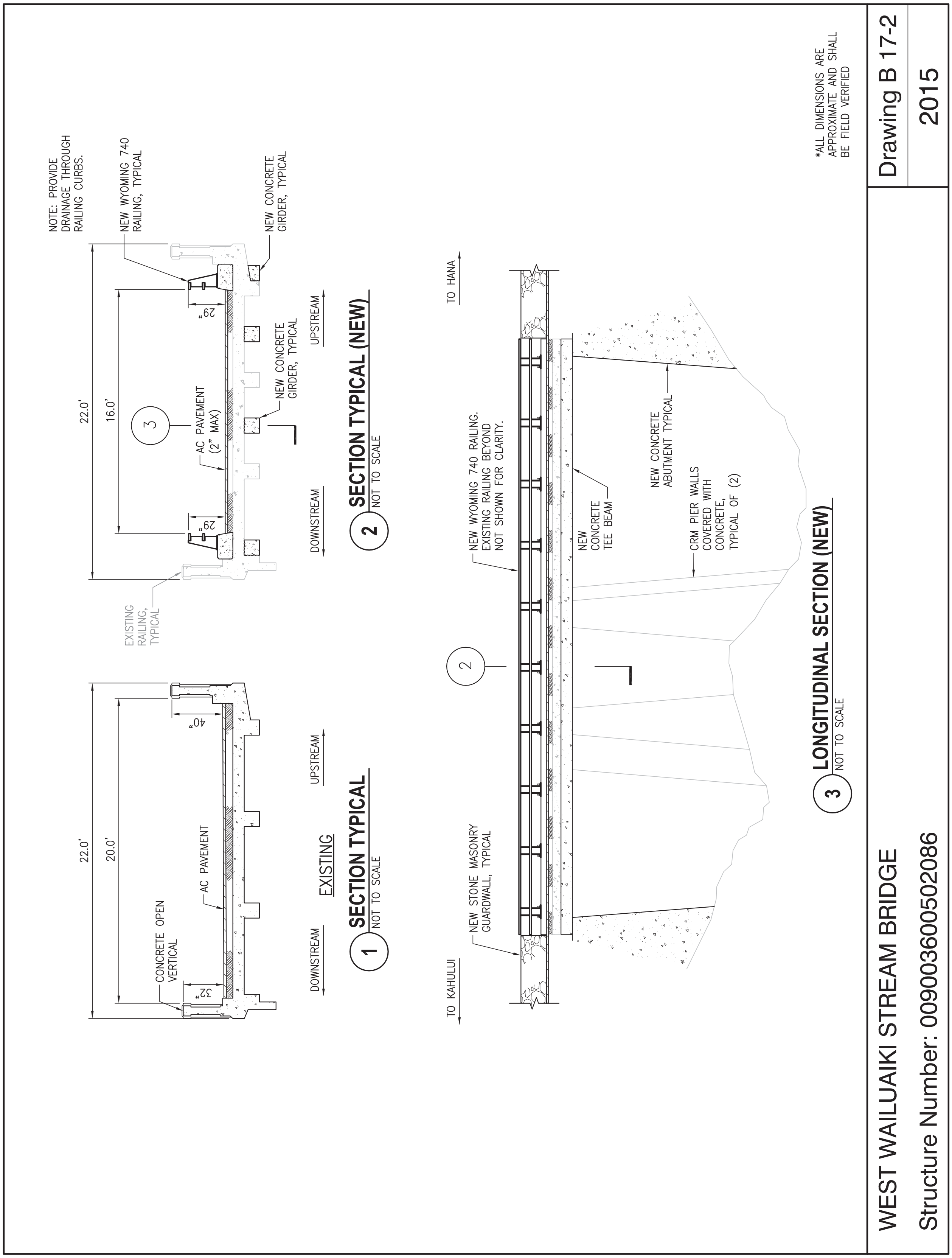
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

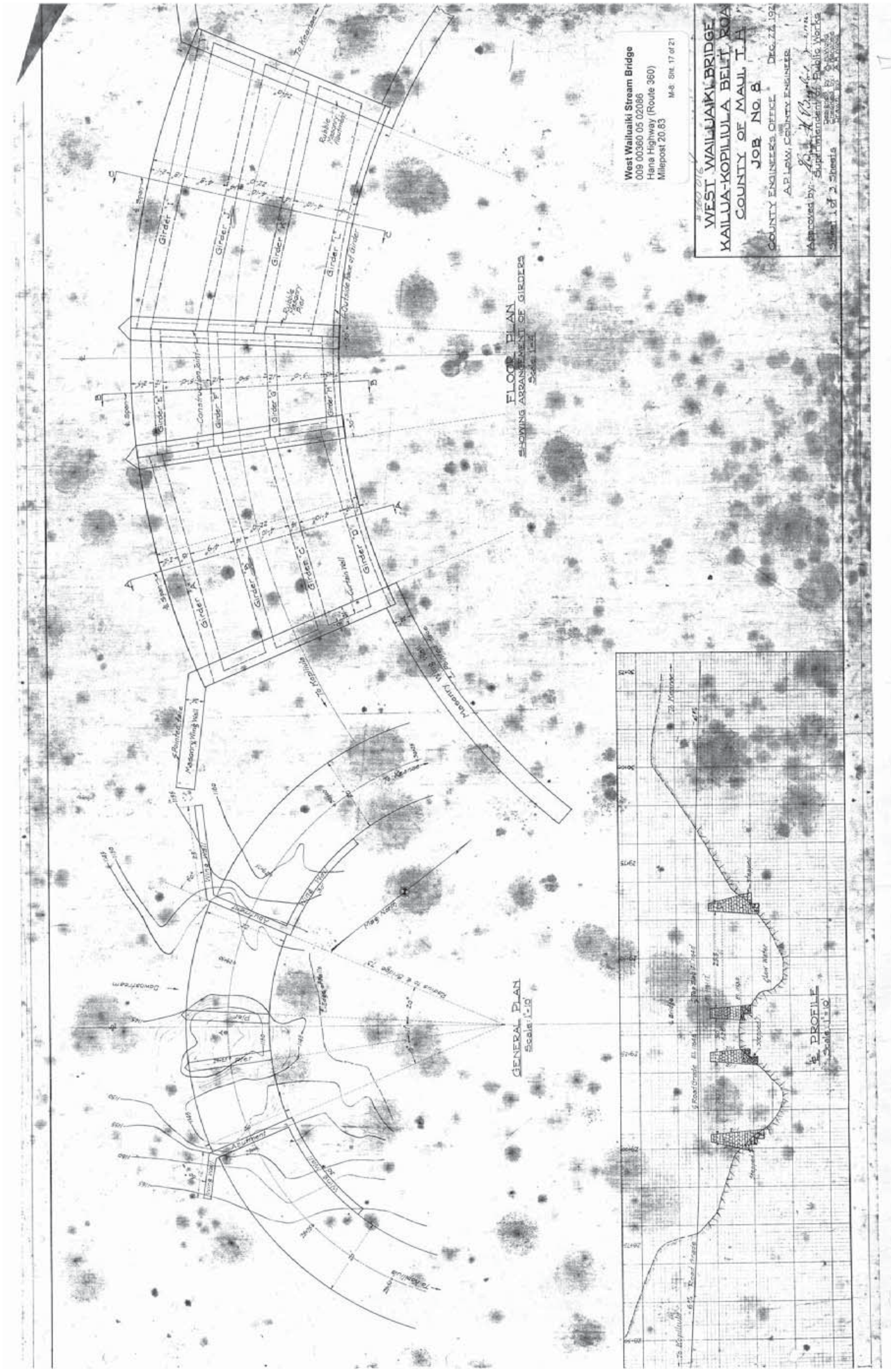
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for West Wailuaiki Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



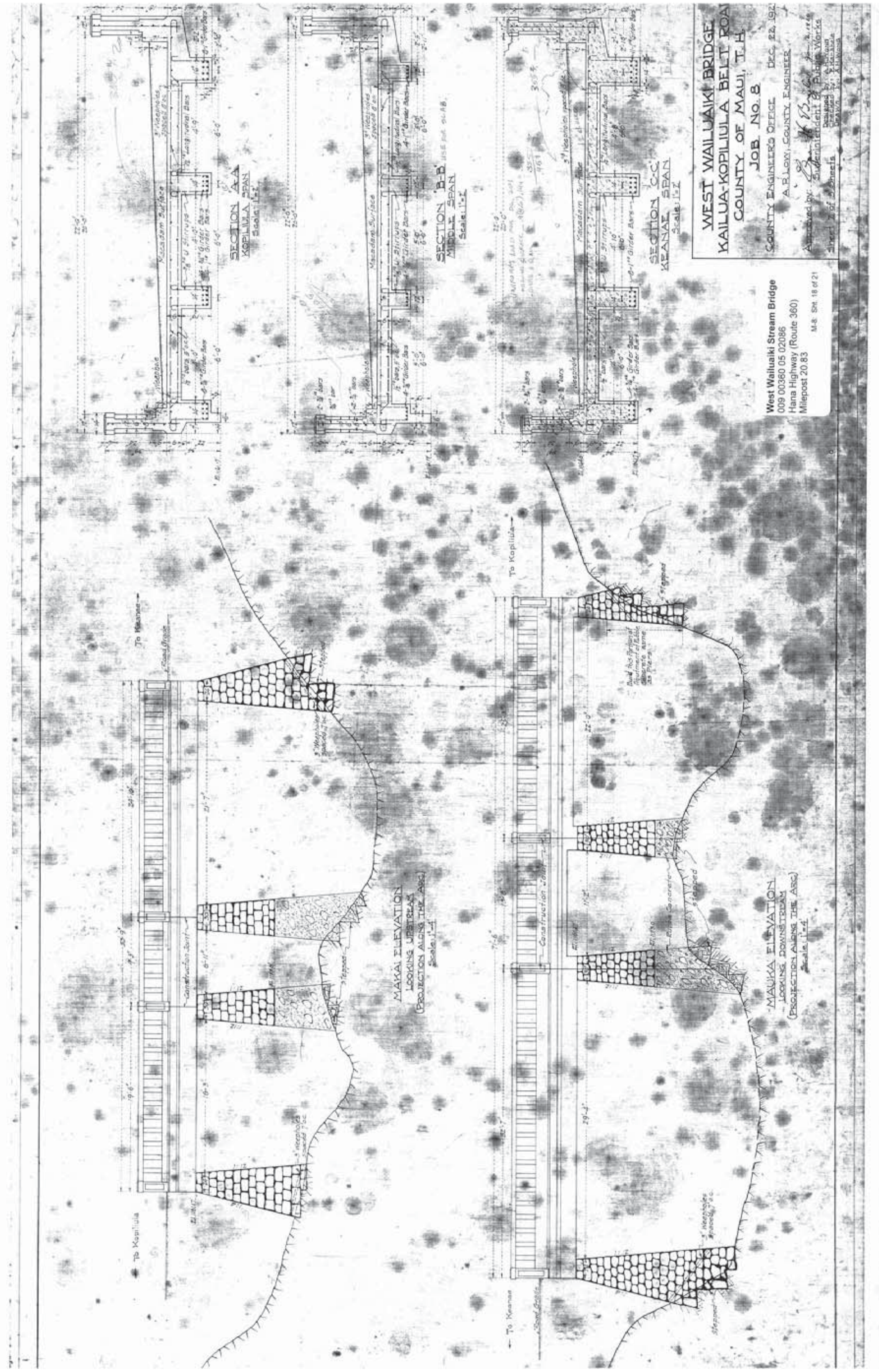
Courtesy of NOEI



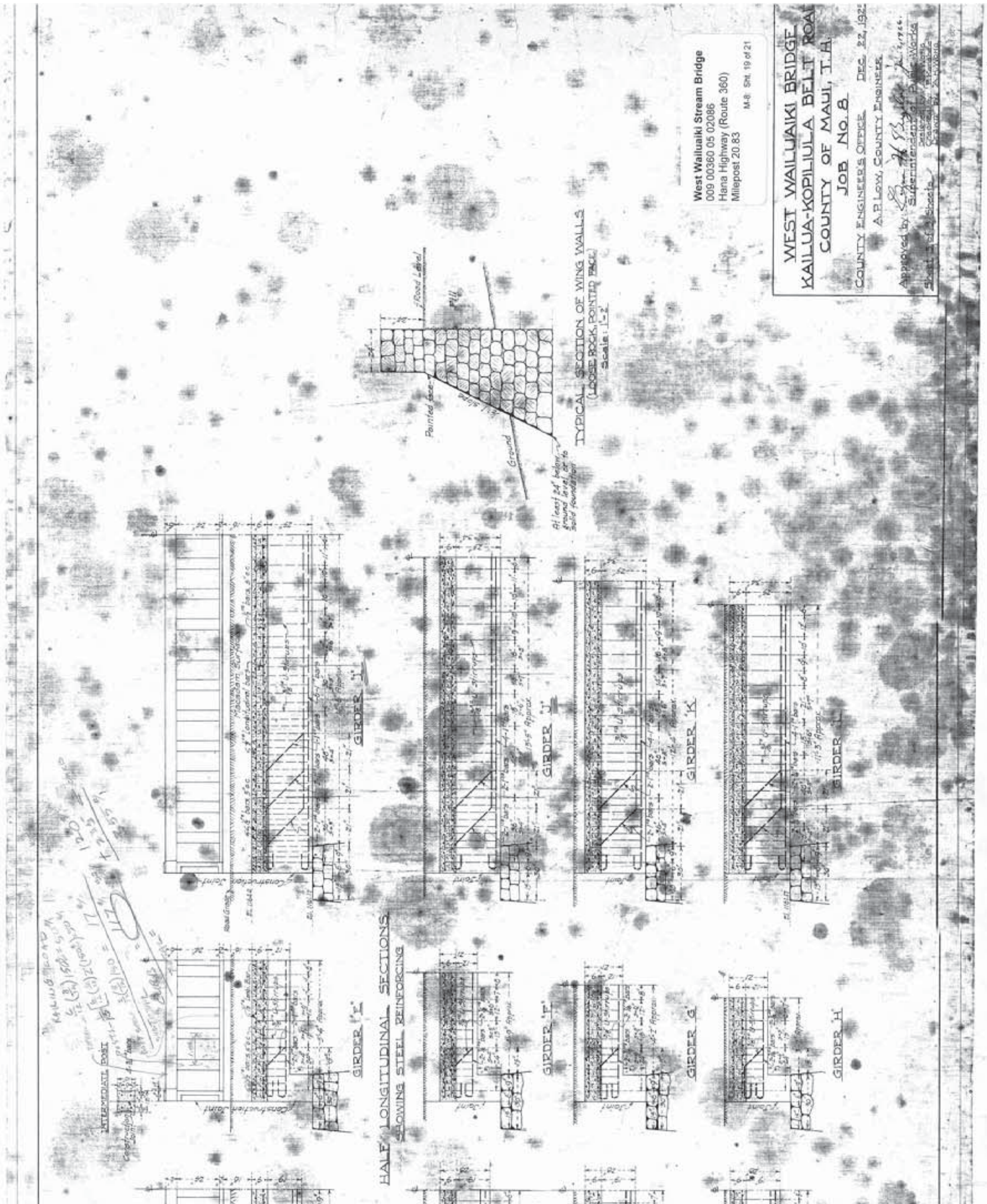
Courtesy of NOEI



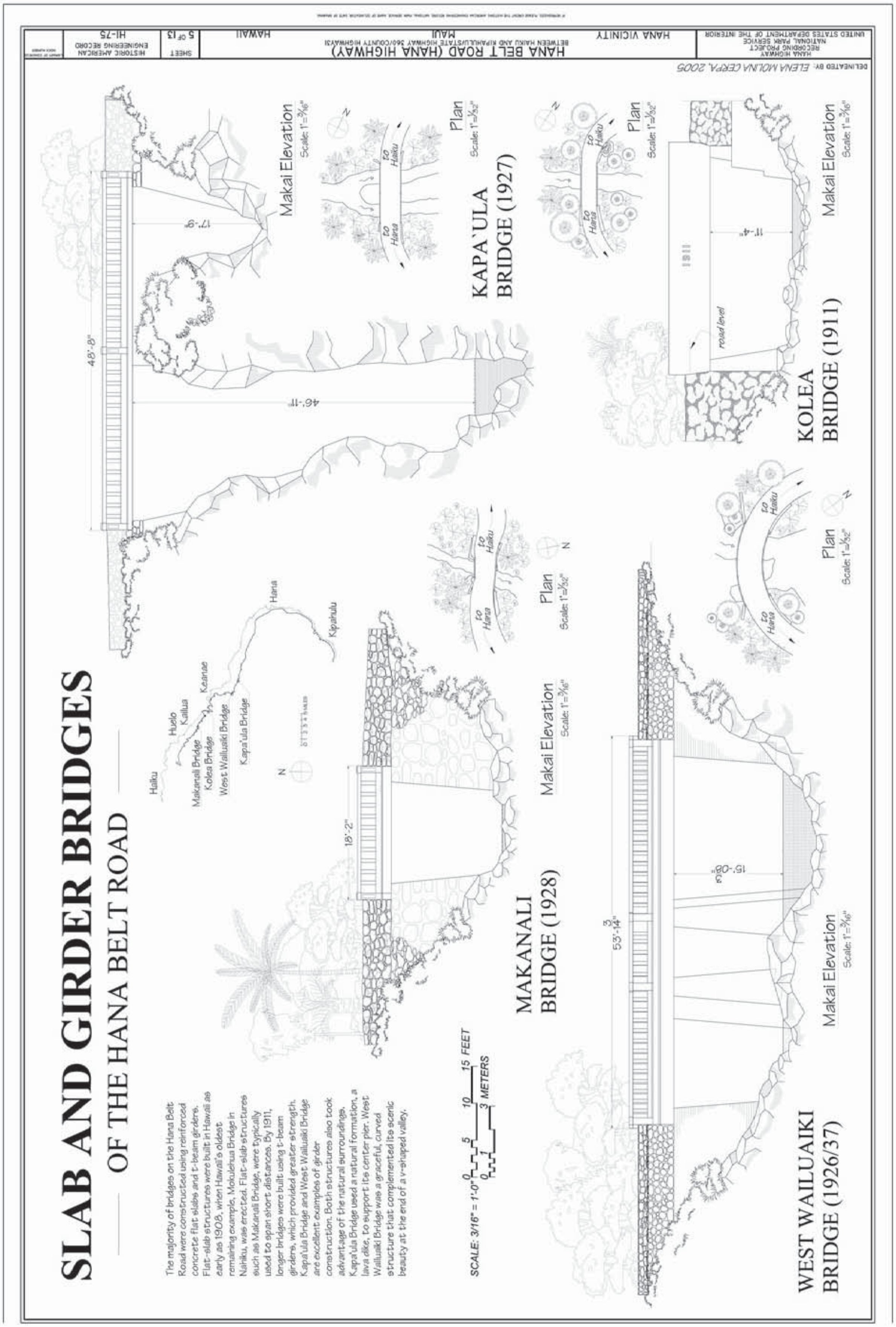
Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation



Courtesy of State of Hawaii Department of Transportation



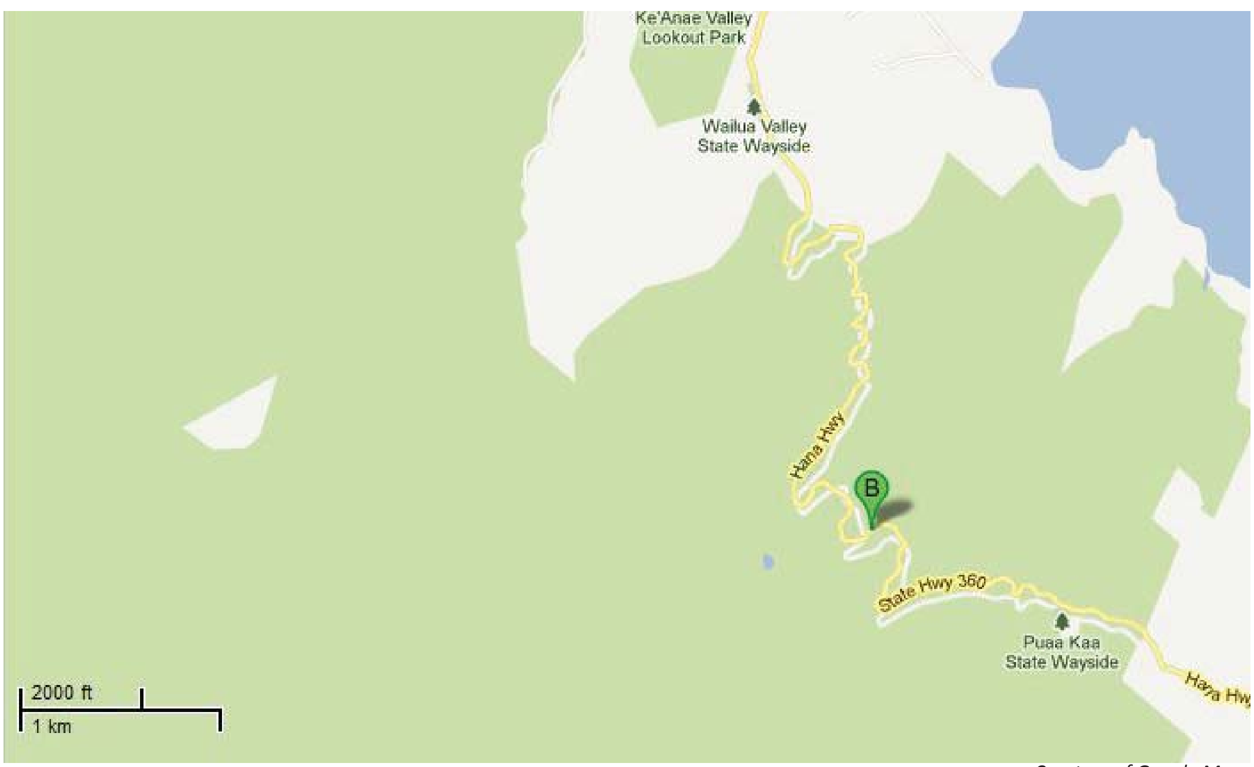
Courtesy of HAER HI-75

18 East Wailuaiki Stream Bridge

18 EAST WAILUAIKI STREAM BRIDGE

Bridge Number	009003600502131			**Island**	Maui		
Date of Construction	1926			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 49m 13s
Longitude	156d 08m 09s
Mile Point	21.23
Location	2.24 miles east of Wailua Valley Lookout
Feature Crossed	East Wailuaiki Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	34.12 feet
Number of Spans	1
Maximum Span	30.8 feet
Deck Width	• Curb-to-Curb = 18.40 feet • Out-to-Out = 20.34 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwall
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 34 inches • Downstream Railing Height = 36 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17 inches on-center • End posts = 12 inches x 12 inches • Railing cap = 6 inches x 8 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

East Wailuaiki Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 5 feet on-center. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of East Wailuaiki Stream Bridge
Courtesy of NOEI

Setting of East Wailuaiki Stream Bridge
Courtesy of FAI

Hana approach to East Wailuaiki Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to East Wailuaiki Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railings, upstream side
Courtesy of NOEI

Concrete open vertical railings, downstream side, posts have been replaced with solid parapet on Kahului side
Courtesy of FAI

Downstream Wingwall, Hana side
Courtesy of NOEI

Upstream Wingwall, Hana side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Wailua Iki and Kaliae
Designer / Builder	County Engineer's Office, A. P. Low, Designer
Historic Drawings	Yes (no year listed)
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Exemplary example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	Open deep curve over medium, slow stream
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutment • CRM Wingwalls • Open Concrete Vertical Railings • Alignment on curve
Detracting Features	Partially replaced railings with solid parapet on Kahului downstream side

Historic Significance & Context

Archaeological / Cultural Significance

The place name *Wailuaiki* is defined as, "little Wailua. Land section. Koolau, Maui."[1] The East Wailuaiki Stream Bridge spans the East Wailuaiki Stream, which forms the boundary between Wailua Iki Ahupuaa and Kaliae Ahupuaa.[2, 3]

Wailua Iki is known in Native Hawaiian legend as the place where Kapo (the elder sister of Hiiaka) saved Pele from Kamapuaa. According to Beckwith, the Maui legend of the hog-man Kamapuaa and the goddess Kapo at Wailua-iki is told this way:

Kamapuaa came to the island of Maui in his fish form and saw a rainbow resting over Kapo's house. Her husband was out fishing and she was beating tapa when the handsome stranger entered her house. Two men on the cliff signal to her husband and he comes running and hits Kamapuaa with his paddle. Kamapuaa sends the husband flying over the cliff, called today Kuou, and the spot where he fell is seen today in the shape of a huge stone by the roadside. The gap between Wailua and Wailua Iki through which today runs a steep trail, was torn out at the time of this struggle. Kapos house could also be seen. Similar stories of Kamapuaas attack upon Pele are among the popular stories told in this vicinity. In the pursuit Kamapuaa lost his hair at a point called Huluhulu-nui (many bristles), runs against the cliff at Puaahookui, and finally overcomes Pele at the hill called Kaiwi o Pele (The Bones of Pele).[4]

Fornander recorded the mythology surrounding the landmark Kaiwi o Pele (The Bones of Pele) in a story told by the informant John Moo at Lahainaluna School. In the *ahupuaa* of Aleamai, the story begins at a popular surfing spot known as Puhele, at Hana. It was here that Namakaeha, a stranger who came from Kahiki, met Mahinahina from the southern region of Hana. As they walked along a road, Namakaeha saw the goddess Pele digging potatoes. Confronted by Namakaeha as a traveler seeking opponents to fight, Pele battled Namakaeha. They fought until Pele weakened.

The body of Pele was taken and the bones were stripped of flesh and taken and buried in the ground. They were exhumed by dogs, placed in a pile, and that is why this hill is so named, because the bones of Pele were stripped off there.[5]

Famous places were listed on the hill Kaiwi o Pele. At the top, the place where the famous warrior Peapea's bones were burnt; on the eastern side of the same hill are the holes made by the club of Kane and Kanaloa; on the western side were the boys digging potatoes; near that is the fishing *noio* (small black tern).[6] It was from this hill that the goddess Hina left the earth to live on the moon.[7]

1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

4 Martha W. Beckwith, *Hawaiian Mythology* (Honolulu: University of Hawaii Press, 1970).

5 Abraham Fornander, "The Bones of Pele," *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians' Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, second series, trans. Thomas G. Thrum, vol. 5 of *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1919).

6 Ibid.

7 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

Refer to Section G, Appendix 1, Section 3.1.2.7 for the history of the Wailua Iki vicinity, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[8, 9]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the East Wailuaiki Stream Bridge.

8 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

9 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear, No yield • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left Object Markers (OM3-L)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Left and Right Object Markers (Vandalized, OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.87 • Operating Rating = 1.13
Condition	Functionally Obsolete

Civil & Traffic

East Wailuaiki Stream Bridge is located at mile point 21.23 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 20.34 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the Type 3 Object Markers (Left & Right) are vandalized. The “Narrow Bridge” sign is not up to current standards on the westbound approach to the bridge. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 17, 2013. The overall condition rating of the bridge at the time of inspection varied between fair and good.[10] This one-lane bridge is *functionally obsolete*, due to a rating of 2 for *deck geometry* and 3 for *approach alignment*, and scour critical with a rating of 3. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 34 inches and 36 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.87 and the operating rating is 1.13.

The current curb-to-curb dimension is 18.40 feet, which for a one-lane bridge is adequate for this project’s design criteria of 16 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of East Wailuaiki Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 17, 2013, record drawings,[11], [12], and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If East Wailuaiki Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. . The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The East Wailuaiki Stream Bridge currently meets the width standards of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete

11 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

12 County Engineer's Office, County of Maui, State of Hawaii, Kailua-Kopiliula Belt Road, Job No 7 (July, 19__). (Full date unavailable)

topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining downstream approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Existing CRM wingwall
Courtesy of FAI

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

The CRM abutments are recommended to be replaced with a reinforced concrete structure with a reconstructed CRM rock façade. To achieve this, the existing façades of the CRM abutments are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM abutments are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM abutments are to be placed in front of the new reinforced concrete abutments and wingwalls, functioning as their new façade. The appearance of the reconstructed façades shall closely match the shape, proportions, and style as that of the original historic craftsmanship along Hana Highway.

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

The existing CRM abutments are an exemplary example of this bridge component. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. This bridge is scour critical and a POA has been created. Currently, the POA does not recommend any immediate action.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-2), a "To Oncoming Traffic" sign, and a yield line are added to the west bridge approach. It is also recommended that a yield line is added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Right (OM3-R)
- Prune roadside brush and trees

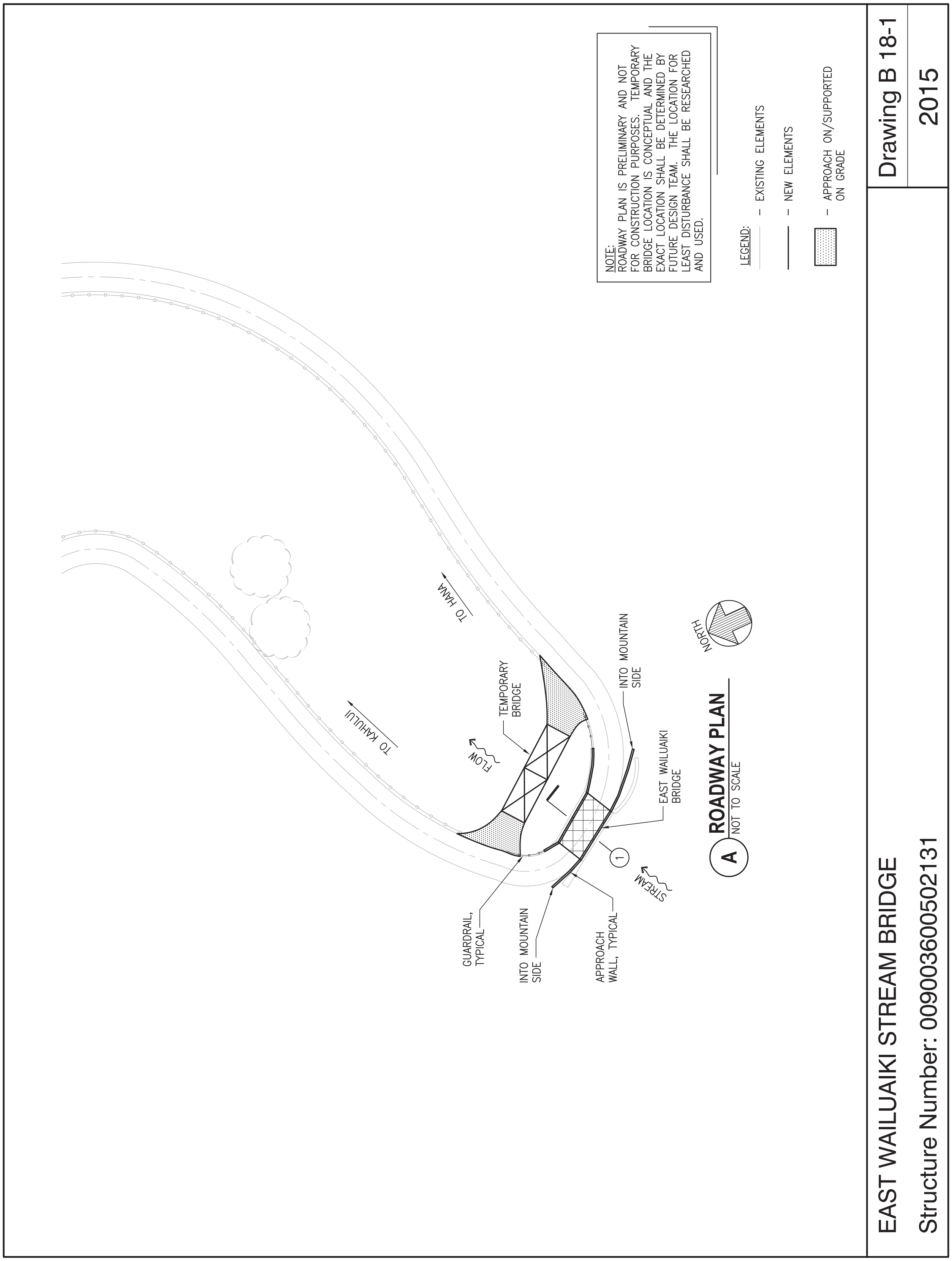
East Bridge Approach

- Add Yield Line
- Replace Object Marker Type 3 – Left and Right (OM3-L, OM3-R)
- Prune roadside brush and trees

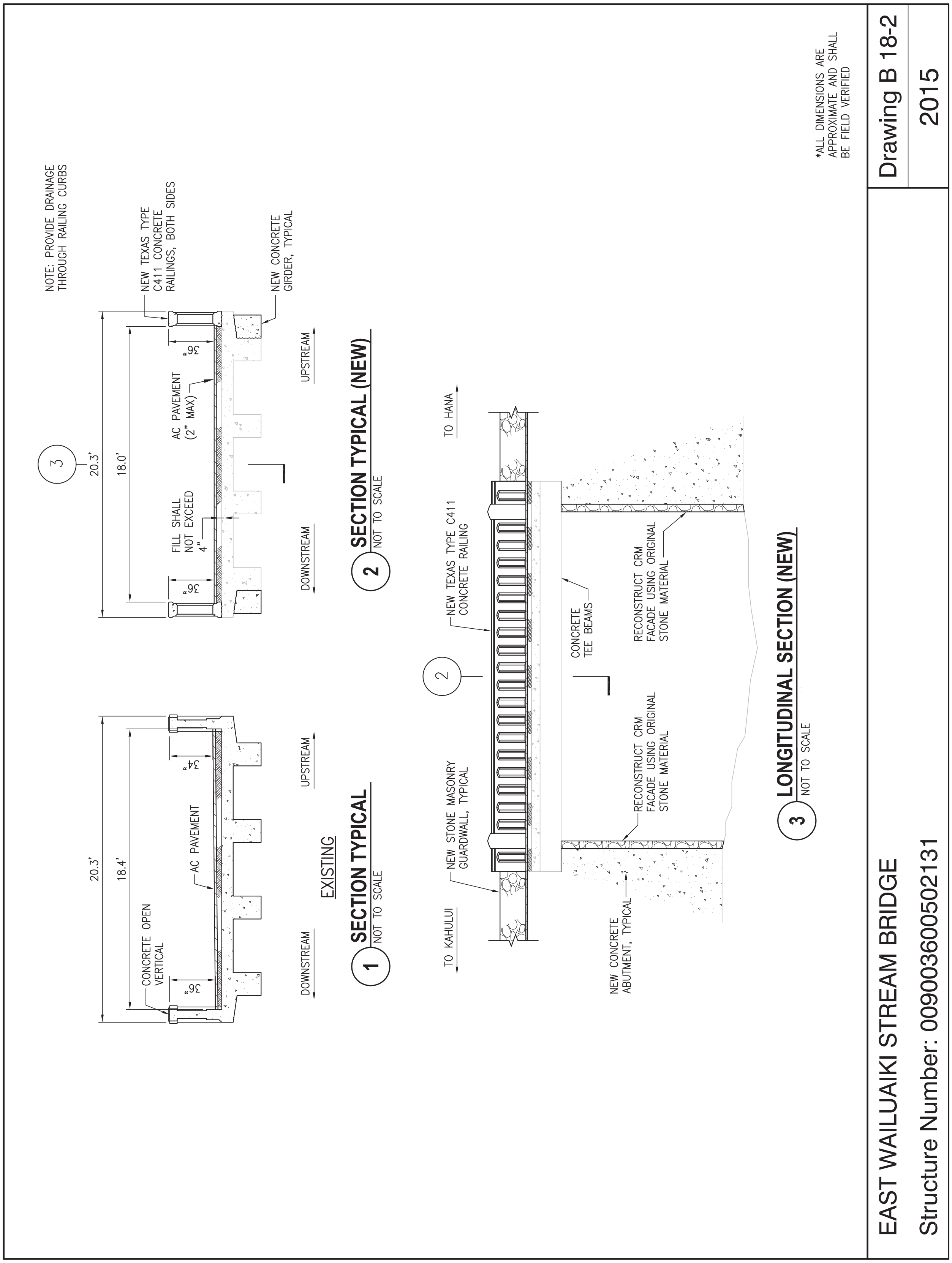
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for East Wailuaiki Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



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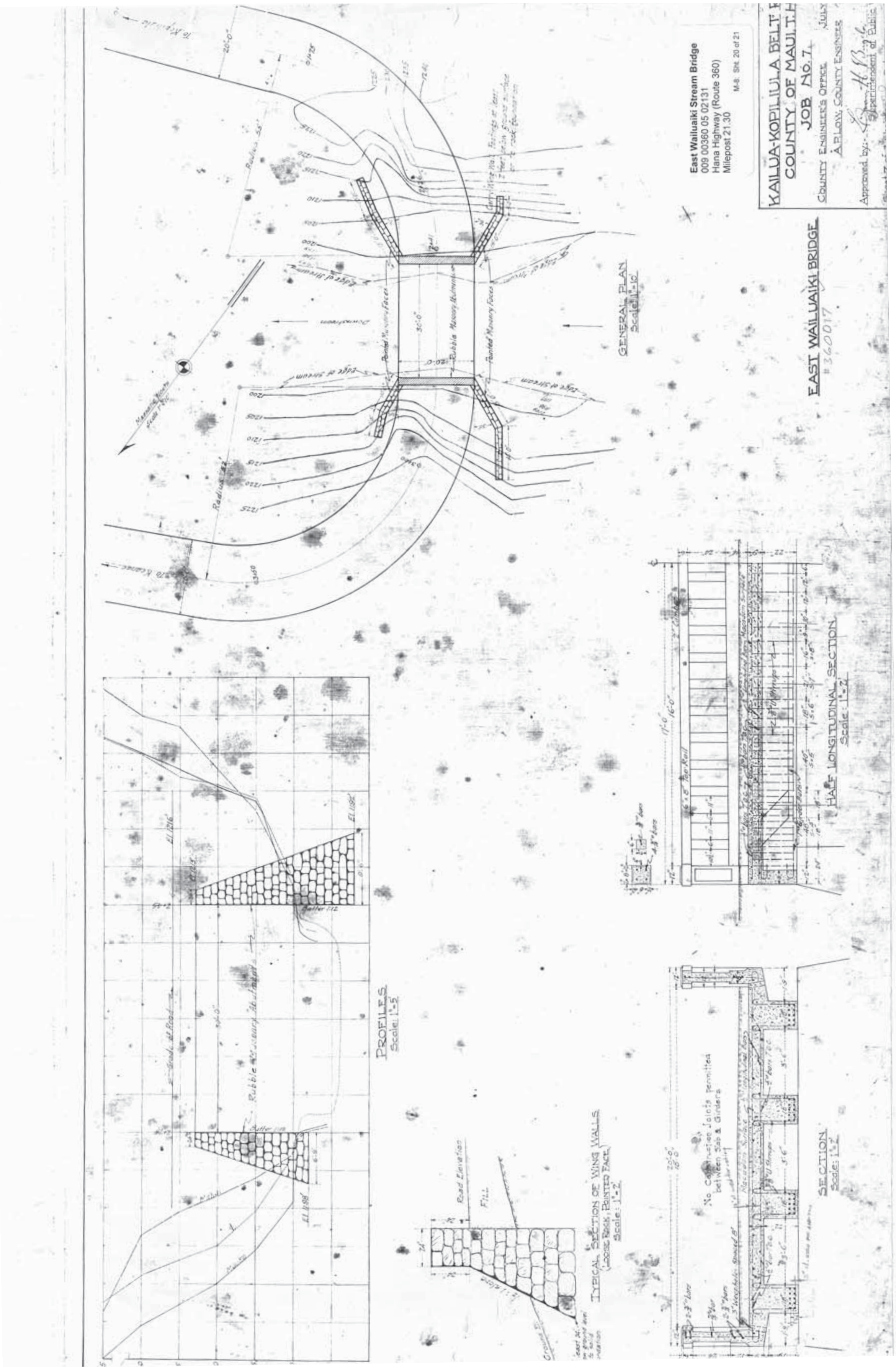


Courtesy of State of Hawaii Department of Transportation

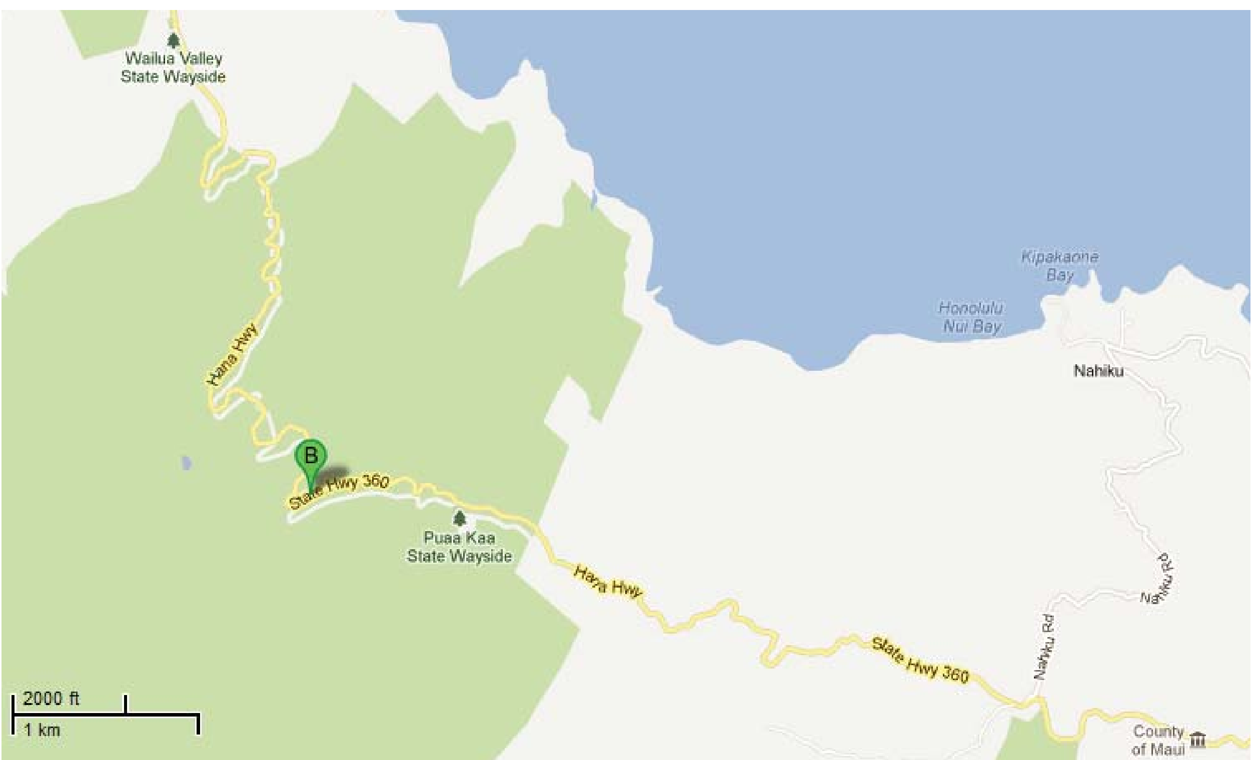
19

Kopiliula Stream Bridge

19 KOPILIULA STREAM BRIDGE

Bridge Number	009003600502189			**Island**	Maui		
Date of Construction	1926, possibly 1914			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement


Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 49m 02s
Longitude	156d 08m 03s
Mile Point	21.73
Location	2.80 miles east of Wailua Valley Lookout
Feature Crossed	Kopiliula Stream

Bridge Features

Bridge Type	Concrete Girder and Floorbeam System
Total Length	77.10 feet
Number of Spans	2
Maximum Span	33.1 feet
Deck Width	• Curb-to-Curb = 13.91 feet • Out-to-Out = 17.72 feet
Abutment Material	• Reinforced Concrete Abutments • Reinforced Concrete Pier Columns
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Solid
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 36 inches • Downstream Railing Height = 36 inches
Parapet / Railing Profile	• Large saddle coping cap • Parapet thickness = 22 inch top with 16 inch base • Parapets are concrete girders
Parapet Inscription	None

Bridge Features

Kopiliula Stream Bridge is a double-span reinforced concrete girder and floorbeam bridge built in 1926 (possibly built in 1914, refer to Section A, Chapter 7. *1912-1916 Road to Nowhere*) . The superstructure consists of a concrete deck slab with AC pavement overlay supported on a reinforced concrete girder and floorbeam system. The concrete through girders also function as the bridge's parapets. The substructure consists of reinforced concrete abutments and pier columns and CRM wingwalls. The abutments and pier bear directly on natural rock formations.

Setting of the Kopiliula Stream Bridge, upstream side
Courtesy of FAI

Setting of the Kopiliula Stream Bridge, downstream side
Courtesy of NOEI

Hana approach to Kopiliula Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kopiliula Stream Bridge toward Hana
Courtesy of NOEI

Concrete solid parapet, upstream side
Courtesy of NOEI

Concrete solid concrete parapet, downstream side
Courtesy of NOEI

Upstream approach wall, Hana side
Courtesy of NOEI

Concrete girders
Courtesy of NOEI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

Sluice gate beneath the bridge
Courtesy of NOEI

Significance & Context

Ahupuaa	Kaliae and Kekuapawela
Designer / Builder	Maui Loan Fund Commission - Wilson and McCandless Plans approved by William Fawcett Pogue, Vice Chairman
Historic Drawings	Yes (undated)
Alterations	None
Replacement	None
Preservation Priority	Exceptional Bridge: EMI Engineering System
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Associated with East Maui Irrigation • Only bridge with East Maui Irrigation equipment attached to bridge on Hana Highway, Route 360 • Good intact example of concrete abutments on Hana Highway • Good intact example of concrete pier columns on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Lush vegetation along the hillside • Adjacent to irrigation works - gears are attached to the upstream side of the bridge, with a significant concrete dam system in the upstream area and a low tunnel, slightly hidden amongst the verdant hillside on the Hana side
Character Defining Features	• Concrete Girder and Floor beam System • Reinforced Concrete Pier Columns • CRM Wingwalls • Concrete Solid Parapets with EMI gears attached • EMI irrigation system, dam and sluice gate below

Significance & Context

Bridge Site History

Construction Date Discrepancy: Refer to Section A, Chapter 7, *Design and Construction of Bridges on the Road to Hana*, “1913-1916 Road to Nowhere” for discussion of potential evidence that the bridge was constructed in 1914 by Wilson and McCandless.

East Maui Irrigation

Kopiliula Stream Bridge is one of five historic Hana bridges that is adjacent to the man-made EMI system. The EMI system is a National Historic Civil Engineering Landmark. It is the only bridge with EMI equipment attached (a pulley for the sluice gate). Also, the dam below is integrated into the foundation of the bridge support system.

The East Maui Irrigation System is Hawaii’s most dramatic water story. The Old Hamakua Ditch constructed between 1876 and 1878, along with the Reciprocity Treaty between the Kingdom of Hawaii and the United States in 1876, sparked the development of the Hawaiian Sugar industry.

> • *The East Maui Irrigation System demonstrated the feasibility of transporting water from steep tropical forested watersheds, with high rainfall, across difficult terrain to [the] fertile and dry plains [of central Maui]. Sugar production dramatically increased with irrigation and improved cultivation practices.*[1]

The Hamakua Ditch Company (precursor of the EMI Company), and the Haiku Sugar Company, managed by Samuel T. Alexander, commenced the construction of a ditch to acquire the water between the Honopou and Nailiilihaele streams. This project to construct the Hamakua Ditch took place in 1876.

> *The digging of the Hamakua Ditch was a work of no small magnitude. A large gang of men, sometimes numbering two hundred, was employed in the work, and the providing of food, shelter, tools, etc., was equal to the care of a regiment of soldiers on the march. All the heavy timbers for flumes, etc., were painfully dragged up hill and down, and in and out of deep gulches, severely taxing the energies and strength of man and beast.*[2]

The EMI System is the largest privately financed, constructed, and managed irrigation system in the United States.

> • *The construction of the Old Hamakua Ditch sparked major irrigation aqueduct construction on the Hawaiian Islands of Kauai, Oahu, Maui and Hawaii.*
> • *The East Maui Irrigation System was the forerunner of major aqueducts in the Western United States by the Bureau of Reclamation, irrigation districts and regional domestic supplies. Engineer M. M. O’Shaughnessy, in charge of*

1 ASCE Hawaii Section, “East Maui Irrigation System Honored as Historic Civil Engineering Landmark,” Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

2 Thomas G. Thrum, “Reinforced Concrete Siphon at Kailua,” *The Hawaiian Planter’s Record*, ed. C. F. Eckart (Hawaiian Sugar Planter’s Association, 1918).

constructing the Koolau Ditch in 1904 and 1905, subsequently built San Francisco Hetch Hetchy water system. Other engineers involved in Hawaii aqueducts subsequently worked in the western states.[3]

• Constructed over a period of 47 years, in several phases, the private irrigation system eventually included 50 miles of tunnels; 24 miles of open ditches, inverted siphons and flumes; and incorporates approximately 400 intakes and 8 reservoirs.[4]

Archaeological / Cultural Significance

The place name *Kopiliula* is defined as, "a red birth gift. Stream, Hana, Maui."[5] The bridge spans Kopiliula Stream, which forms the boundary between Kaliae Ahupuaa and Kekuapawela Ahupuaa.[6, 7]

In 1923, the survey by the county engineer of the Hana belt road from Keanae to Kopiliula was authorized, and bids for construction called for. Paul Low, the County Engineer, and a committee from the Maui Chamber of Commerce asked that more of Maui's prisoners be secured to work on the belt road project. A. H. Wong, assistant engineer to Paul Low and his eventual successor, also oversaw the completion of the belt road. The amounts allocated to the completion of the belt road were: $50,000 for upgrades to the Hana water system, and $117,500 for the road construction from Kailua to Kopiliula. Earlier, $25,000 had been required to construct the portion of the belt road between Kuiaha and Kakipi Gulch. The Territory made no effort to sell bonds to push the project ahead until 1920. Financing for the belt road construction had become more difficult to justify, and in 1922, the management of the sugar plantation at Kaeleku offered to buy bonds to finish the road.[8]

East Maui Irrigation, Upstream Kahului side
Courtesy of NOEI

East Maui Irrigation upstream side
Courtesy of NOEI

3 ASCE Hawaii Section, "East Maui Irrigation System Honored as Historic Civil Engineering Landmark," Hawaii Historic Civil Engineering Landmarks, ASCE Hawaii, http://www.ascehawaii.org/ (accessed 2013-2015).

4 Ibid.

5 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

6 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

7 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

8 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990).

Refer to Section G, Appendix 1, Section 3.1.4 for the history of the construction of the Hana belt road in the vicinity of the Kopiliula Stream Bridge, and to Appendix 1, Figure 10 for nearby archaeological study areas.[9]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kopiliula Stream Bridge.

9 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound, West Bound: Obstructed by roadside bushes • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Right Object Markers (OM3-R)
Apron	Dirt pathway by east approach of bridge
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.19 • Operating Rating = 0.24
Condition	Structurally Deficient

Civil & Traffic

Kopiliula Stream Bridge is located at mile point 21.73 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 17.72 feet that has no bicycle or pedestrian access routes. The signs in this area are in relatively good condition except the Chevron Alignment signs are in poor condition on the eastbound and westbound approaches. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 2, 2013. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[10] This one-lane bridge is *structurally deficient* due to a rating of 4 for the *deck and superstructure*. This bridge is also *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment and structural evaluation*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 36 inches. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.19 and the operating rating is 0.24.

The current curb-to-curb dimension is 13.91 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kopiliula Stream Bridge be preserved and maintained in situ. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 2, 2013, record drawings,[11, 12, 13] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information. EMI notes that the dam and the sluice gate equipment is an integral part of the EMI aqueduct system and must remain in place.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. P*reservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kopiliula Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

No further archaeological work is recommended for the Kopiliula Stream Bridge at this time, due to the current structural and historical recommendation to preserve and maintain *in situ*. Should the structural and historical recommendation change and/or rehabilitation work be required for this bridge in the future, an archaeological inventory survey is recommended prior to any construction

Existing deck
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

11 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

12 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

13 Maui Loan Fund Commission, Territory of Hawaii, *Kopiliula (West) Bridge*, Station 324+03.

in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4, for Hana Belt Road National Register Nomination Form).

The Kopiliula Bridge has been known to have a history of ponding and flooding. Since the parapet railing design does not have any openings or scuppers along its length, runoff is forced to accumulate at the center of the bridge (local low point) which leads to ponding and flooding.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck & Superstructure

The Kopiliula Stream Bridge currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane bridge. Widening of this bridge is not recommended due to the close proximity of historic and cultural areas. This also affects the ability to upgrade the parapets to meet TL-2 crash requirements and to increase the roadway curb-to-curb width. Therefore, it is recommended that this bridge be exempt from the HDOT 16 feet width design criteria due to the various historical and unique features of the bridge.

There are no recommendations for adding a pedestrian or bicycle access route.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

The bridge deck and superstructure are structurally deficient. Repairs to the deck and superstructure shall include, but not be limited to, epoxy injection crack repairs, chipping out and replacing exposed severely corroded reinforcing, and chipping out and patching delaminated and spalled areas with an epoxy non-shrink grout. Finish of the repaired area shall match the original condition of the bridge. Sprayed shotcrete finish shall not be permitted.

CRM Approach Walls

This bridge has a CRM approach wall of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance. Approach walls of similar quality are shown in the following bridges and may be used for reference: current existing approach walls to this bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge. The rock wall portions of the EMI system at

#06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a reconstructed rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To achieve the reconstructed rock façade appearance, the existing CRM façades are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM approach walls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM approach walls are to be placed in front of the new reinforced concrete approach walls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. The surface of the rock façade shall not exceed 0.5 inches in variation.

The upstream Kahului and Hana approach corners have adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision occurring. The remaining downstream approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Railings / Parapets

The concrete bridge parapets do not meet the TL-2 crash design criteria. For Kopiliula Stream Bridge, it is recommended to have the parapets meet a TL-1 rating criteria instead of a TL-2 rating. Also, as an added precaution for having a lower crash-tested railing, it is recommended to post a 5 mph speed limit signs at each of the approaches. A 10 mph sign is currently posted at the Kahului approach, which will be replaced per this recommendation.

Foundations, Piers, Wingwalls, & Abutments

It is recommended to investigate the current material composition of the CRM wingwalls, concrete abutments, pier columns, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments and concrete pier columns are good intact examples of these components along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments and concrete pier columns, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Good intact example of CRM wingwall
Courtesy of NOEI

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the CRM wingwalls, the upstream wingwall (Hana side) is recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship of other existing wingwalls at this bridge. If the appearance of the wingwalls that are necessary to be rehabilitated are similar to the good intact examples at this bridge, they are recommended to be replaced with reinforced concrete structures with reconstructed CRM rock façades. To achieve this, the existing façades of the CRM wingwalls are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM wingwalls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM wingwalls are to be placed in front of the new reinforced concrete abutments and wingwalls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments, CRM wingwalls, and concrete pier columns, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. Also, the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a yield line is added to the west bridge approach. It is also recommended that a "Yield" sign (R1-2), a "To Oncoming Traffic" sign (R1-2a), and a yield line at the east bridge approach. An object marker (OM-3L) should be added to the left side bridge end treatment at the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Divide for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and “To On Coming Traffic” plaque (R1-2a)
- Add Yield Line

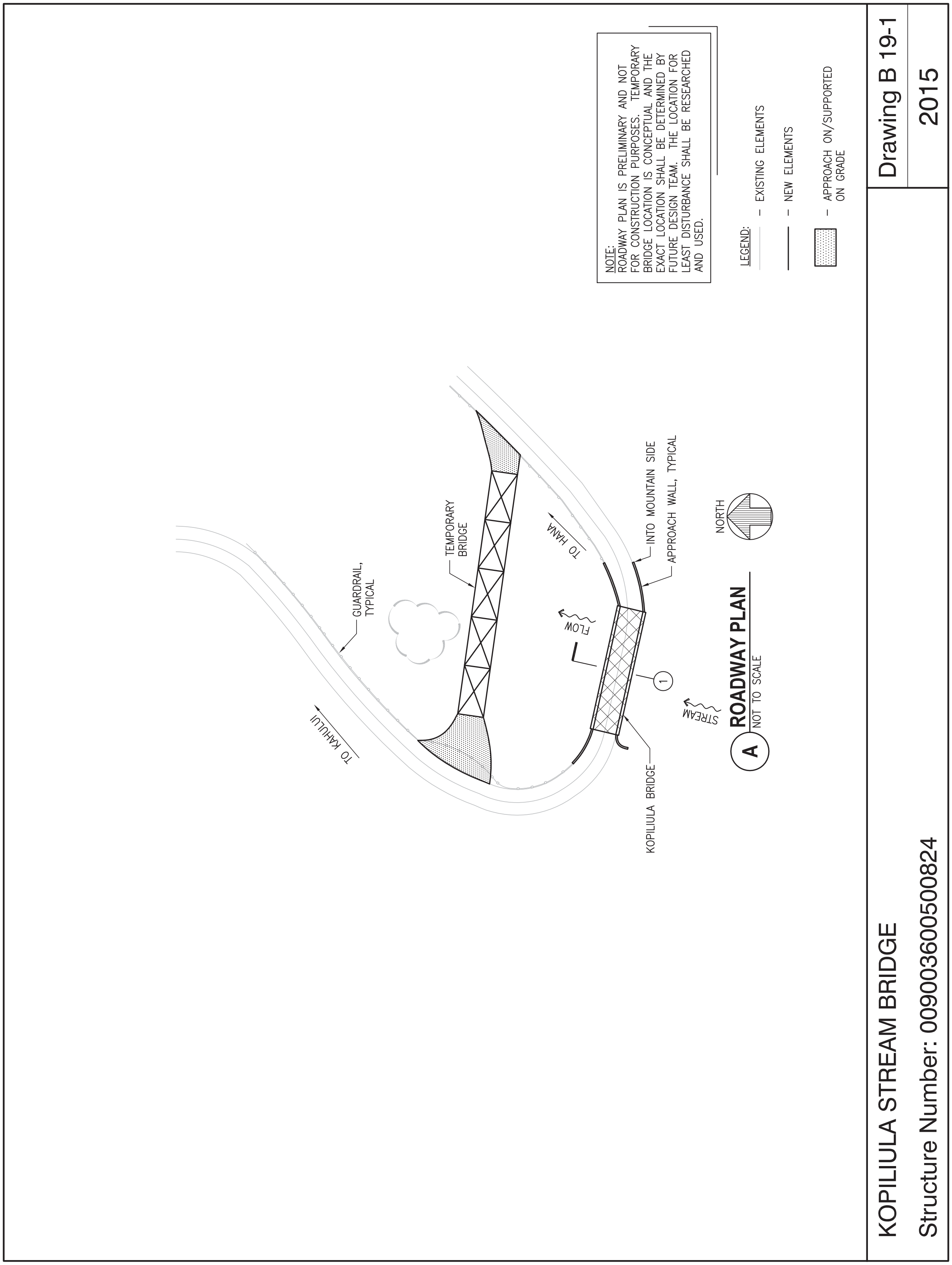
East Bridge Approach

- Add Yield sign (R1-2) and “To On Coming Traffic” plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left (OM3-L)

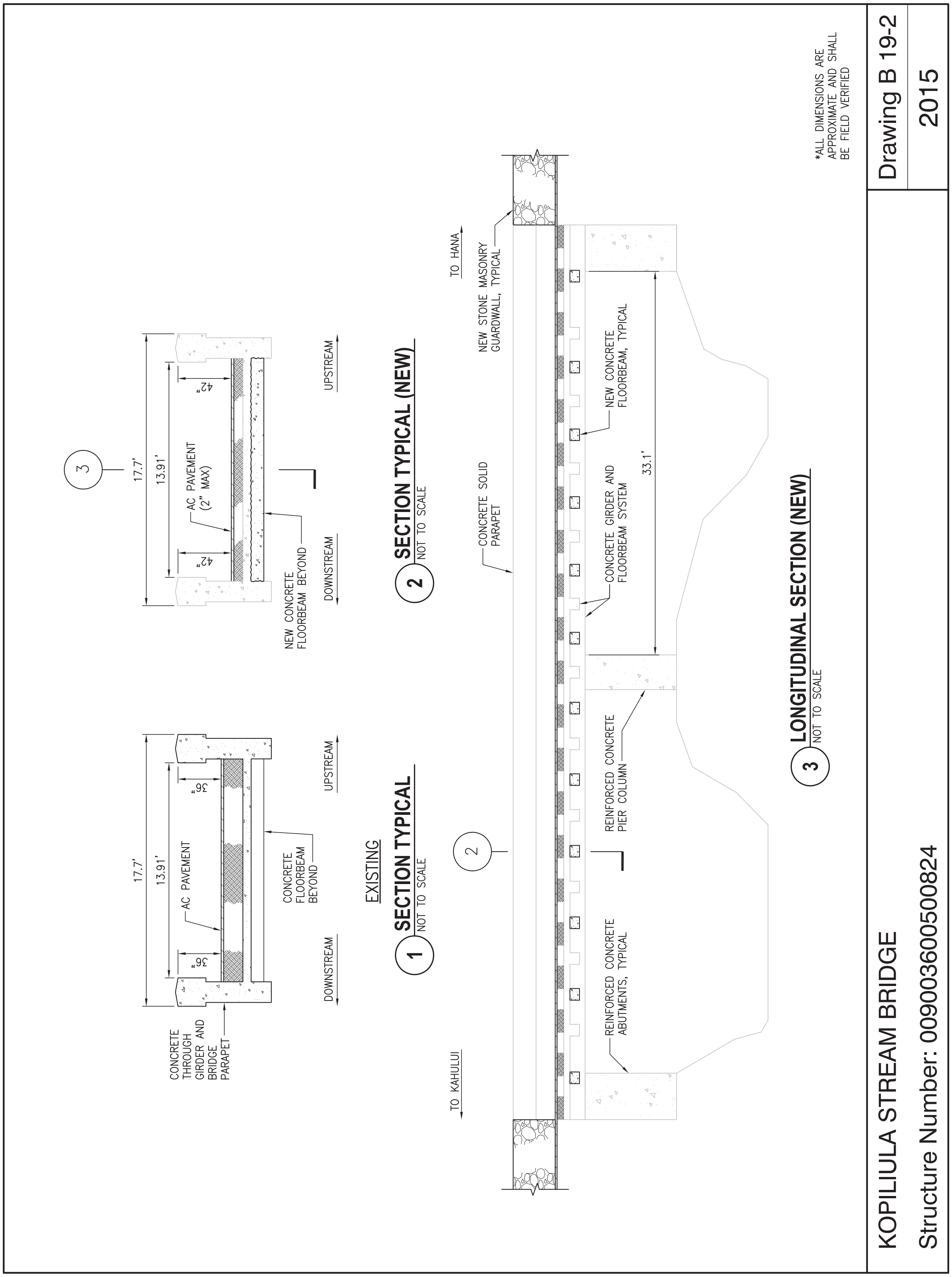
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Kopiliula Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.

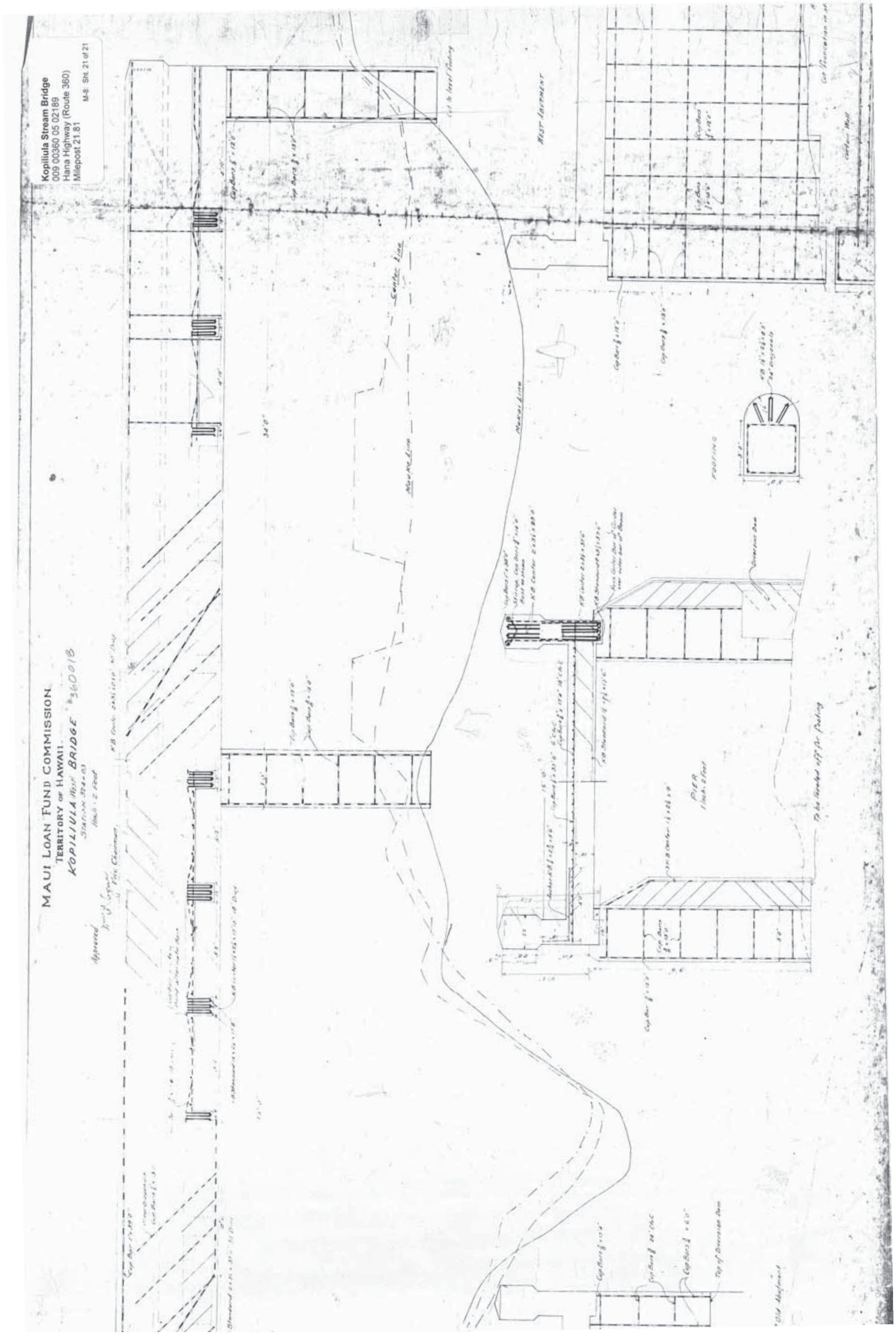


Courtesy of NOEI



Courtesy of NOEI

HISTORIC DRAWING



Courtesy of State of Hawaii Department of Transportation

20

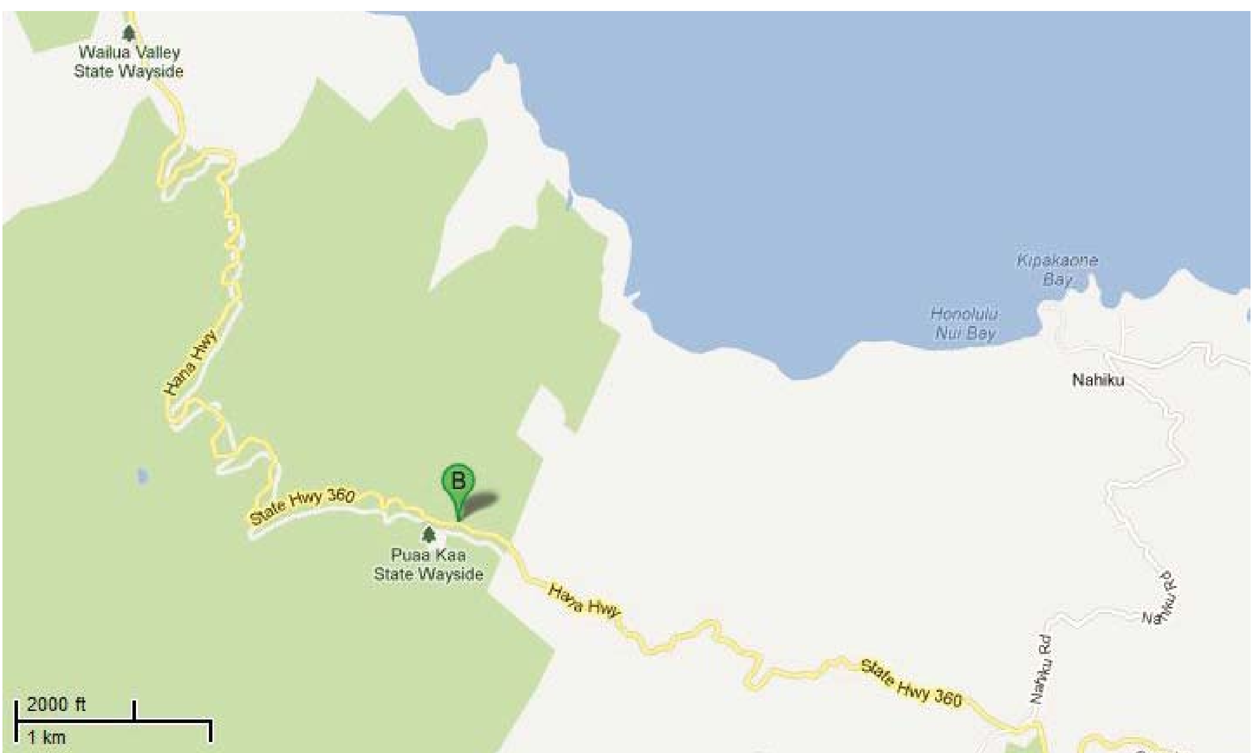
Puaakaa Stream Bridge

20

PUAAKAA STREAM BRIDGE

Bridge Number	009003600502231			**Island**	Maui			
Date of Construction	1926			**Route**	Hana Highway			
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of FAI



Courtesy of Google Maps

Location

Latitude	20d 49m 04s
Longitude	156d 07m 39s
Mile Point	22.23
Location	2.74 miles west of Lower Nahiku Road
Feature Crossed	Puaakaa Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	20.01 feet
Number of Spans	1
Maximum Span	19.0 feet
Deck Width	• Curb-to-Curb = 22.31 feet • Out-to-Out = 24.28 feet
Abutment Material	Concrete Abutment
Wingwall Material	CRM Wingwall
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 34 inches • Downstream Railing Height = 38 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Puaakaa Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on seven concrete tee beam. The substructure consists of concrete abutments and CRM wingwalls. The abutments bear directly on natural rock formations.

Setting of Puaakaa Stream Bridge
Courtesy of NOEI

Puaakaa Stream
Courtesy of NOEI

Hana approach to Puaakaa Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Puaakaa Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railings, upstream side
Courtesy of NOEI

Concrete open vertical railings, downstream side
Courtesy of NOEI

Downstream CRM approach wall, Hana side
Courtesy of NOEI

Upstream bridge end post profile, Hana side
Courtesy of NOEI

Upstream CRM wingwall , Hana side
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Kekuapawela and Waiohue
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of concrete abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Just west of Puaakaa State Wayside • Lush vegetation • Open bend in road • Narrow low-slope stream below
Character Defining Features	• Concrete Tee Beam Bridge • CRM Wingwalls • Concrete Open Vertical Railings • Alignment on curve
Detracting Features	• Non-historic cementitious materials on face of CRM abutments and CRM wingwalls

Significance & Context

Archaeological / Cultural Significance

The place name *Puaakaa* is defined as, "Park, Hana, Maui. *Lit.,* rolling pig."[1] The bridge spans Puaakaa Stream, which forms the boundary between Kekuapawela Ahupuaa and Waiohue Ahupuaa.[2, 3]

According to Fornander, various regions of the Hana coast were noted as places where the goddess Pele was ravished by Kamapuaa, a hog god, who much of the time, took the form of a handsome human. The episode between Pele and Kamapuaa is common in much of East Maui, and this region of the "rolling pig" perhaps is meant to recall this legendary union between Pele and Kamapuaa.[4] Many stories of the attack of Kamapuaa on Pele are among the popular stories told in this vicinity of Maui, according to Beckwith.[5]

Refer to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[6]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Puaakaa Stream Bridge.

1 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

2 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

4 Abraham Fornander, "Legend of Kamapuaa," *Fornander Collection of Hawaiian Antiquities and Folk-lore: The Hawaiians' Account of the Formation of Their Islands and origin of Their Race, With the Traditions of Their Migrations, Etc., as Gathered from Original Sources*, trans. Thomas G. Thrum, in *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* (Honolulu: Bishop Museum Press, 1918).

5 Martha W. Beckwith, *Hawaiian Mythology* (Honolulu: University of Hawaii Press, 1970).

6 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammat, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	Two Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.43
Condition	Functionally Obsolete

Civil & Traffic

Puaakaa Stream Bridge is located at mile point 22.23 along Hana Highway and its existing conditions are as follows. This bridge is a two-lane bridge with an out-to-out width of 24.28 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the "Narrow Bridge" sign on the westbound approach to the bridge is not up to standard. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no nearby existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 2, 2013. The overall condition rating of the bridge at the time of inspection was fair.[7] This two-lane bridge is *functionally obsolete* due to a rating of 3 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 34 inches and 38 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.43.

The current curb-to-curb dimension is 22.31 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

7 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Puakaa* Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 2, 2013, record drawings,[8, 9, 10] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Puaakaa Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards and consider the historical and cultural areas in its surroundings during design and construction. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4, for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

*The current spelling of the bridge name and stream name "Puakaa" is incorrect on the HDOT database. It is recommended to revise the database to reflect the correct spelling "Puaakaa," which correlates with additional geographical and historical sources.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

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8 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

9 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

10 Maui Load Fund Commission, Territory of Hawaii, *Waiakamoi Bridge*, Koolau, Maui (June 1911).

Recommendations have been identified per bridge component, as follows:

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Deck

The Puaakaa Stream Bridge currently does not meet the minimum standard width of 24 feet for a two lane bridge. Due to the decreased curb-to-curb width resulting from the installation of interior crash-tested rails (refer to "Railings/ Parapets" section for more information), two cars can no longer safely pass by each other on the bridge. Therefore, it is recommended to change the number of striped lanes on the bridge from 2 to 1, in which case, widening the bridge to meet the 24 feet requirement for a two-lane bridge would no longer be necessary.

Due to the curb-to-curb width and the curvature of the approach to this bridge, it is also recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a 1-lane 2-way traffic bridge, and to not widen the bridge.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

There are no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Existing CRM wingwall
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Existing concrete girders
Courtesy of FAI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

It is recommended to investigate the current material composition of the concrete abutments, CRM wingwalls, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, it is recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions.

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the CRM wingwalls, it is recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete abutments and CRM wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a Yield sign (R1-2), a "To Oncoming Traffic" sign, and a yield line are added to both bridge approaches. It is also recommended that "Object Marker" signs are added to the bridge end treatments at both approaches. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

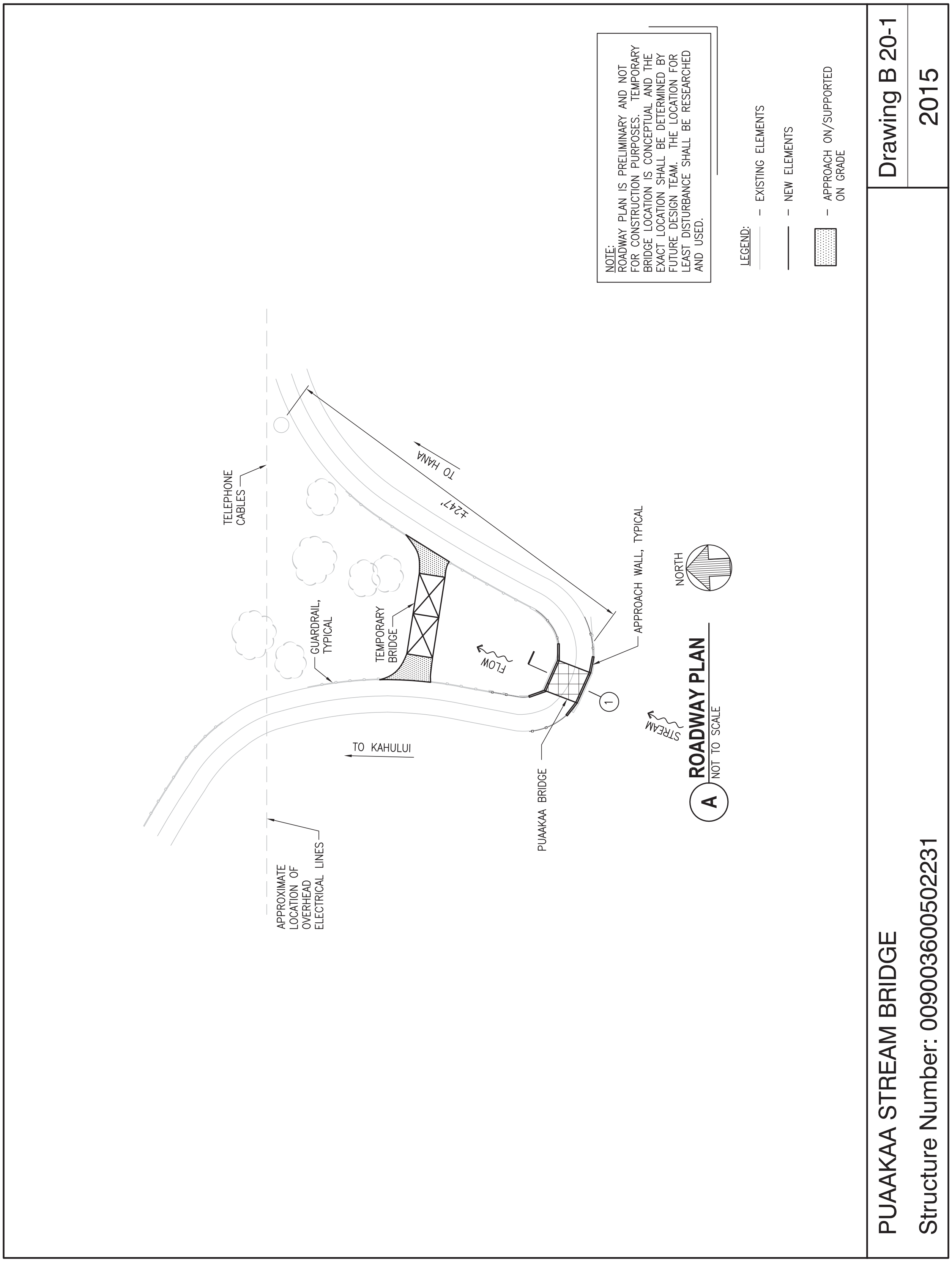
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Replace Narrow Bridge (W5-2a) sign with Advisory Speed Plaque (W13 1P(10))

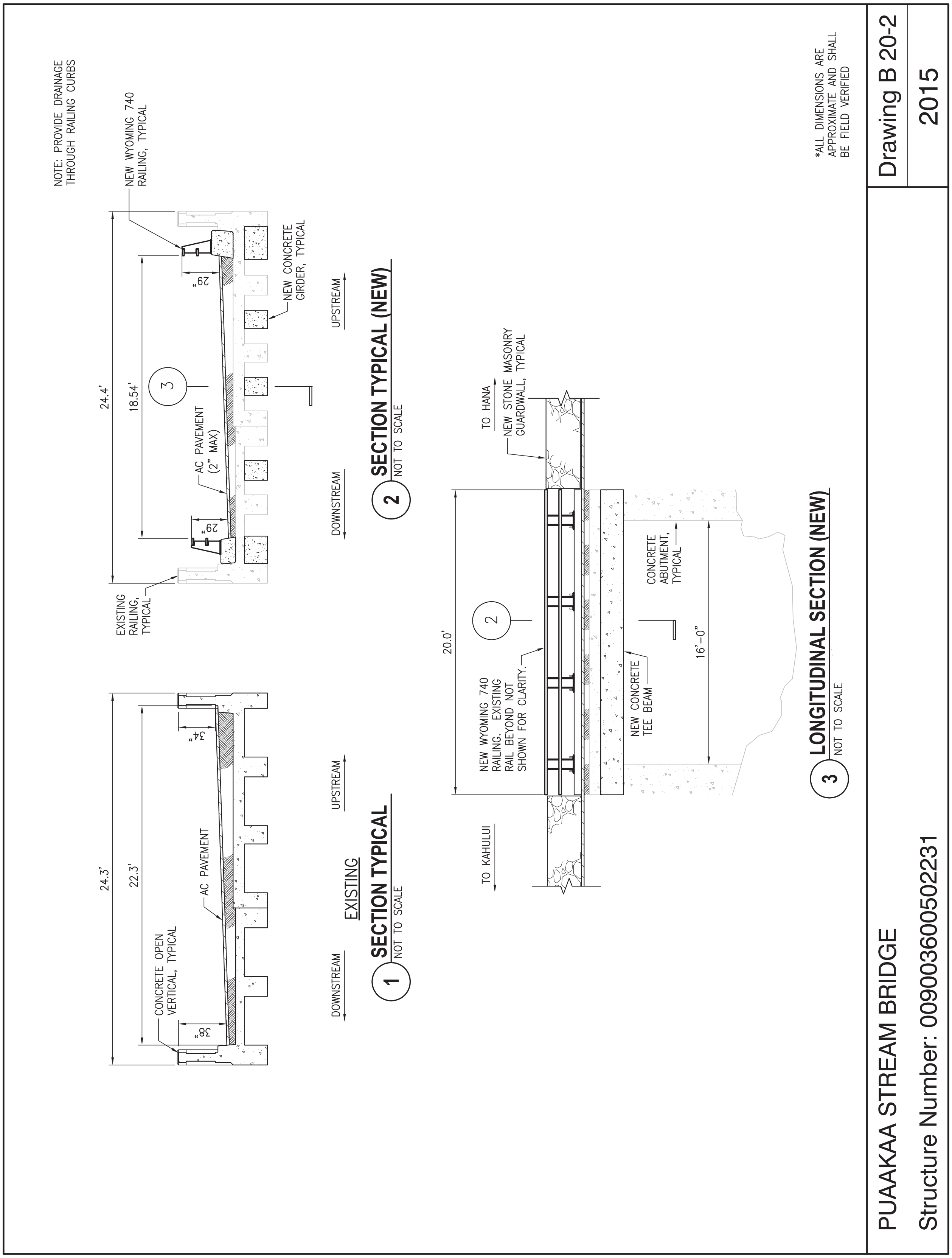
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Puaakaa Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

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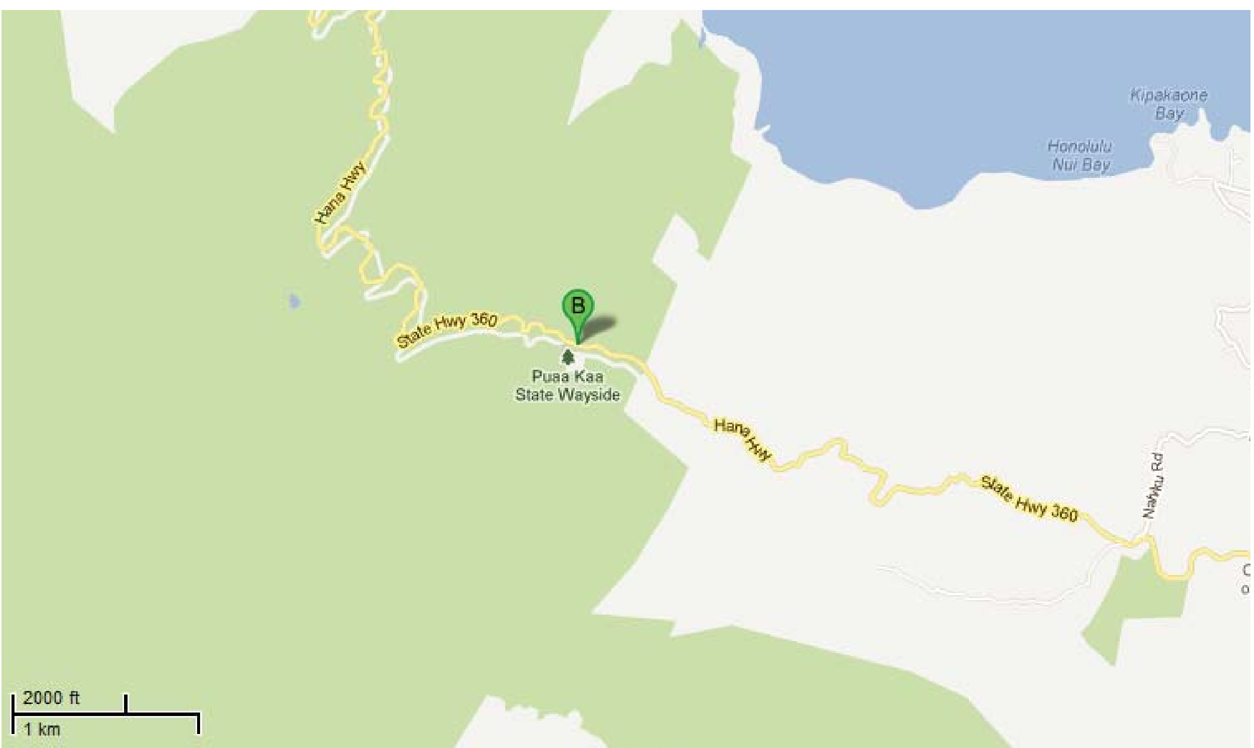
21 Waiohue Stream Bridge

21 WAIOHUE STREAM BRIDGE

Bridge Number	009003600502250			**Island**	Maui		
Date of Construction	1926			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 49m 03s
Longitude	156d 07m 32s
Mile Point	22.41
Location	2.54 miles west of Lower Nahiku Road
Feature Crossed	Waiohue Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	40.03 feet
Number of Spans	2
Maximum Span	16.1 feet
Deck Width	• Curb-to-Curb = 13.00 feet • Out-to-Out = 14.76 feet
Abutment Material	• CRM Abutments • CRM Pier Wall with cutwater profile
Wingwall Material	CRM Wingwall
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	• Concrete Solid (Downstream side) • Concrete Solid Panel with Cap (Upstream side)
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 33 inches • Downstream Railing Height = 33 inches
Parapet / Railing Profile	• Saddle coping cap • Parapet thickness = ±7 inches
Parapet Inscription	None

Bridge Features

Waiohue Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span. The substructure consists of CRM abutments and wingwalls and a rubble concrete pier wall. The abutments and pier bear directly on natural rock formations.

Setting of Waiohue Stream Bridge
Courtesy of FAI

Waiohue Stream
Courtesy of NOEI

Hana approach to Waiohue Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Waiohue Stream Bridge toward Hana
Courtesy of NOEI

Concrete solid with cap parapet, upstream parapet
Courtesy of NOEI

Concrete solid parapet, downstream side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

CRM pier wall with cutwater profile
Courtesy of NOEI

Downstream CRM wingwall, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Waiohue and Nakapehu
Designer / Builder	Maui Loan Fund Commission - Unknown Designer Plans approved by Wm. F. Pogue [William Fawcett Pogue], Vice Chairman
Historic Drawings	Yes (undated)
Alterations	Downstream parapet replaced (date unknown)
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Piers
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Exemplary example of CRM pier on Hana Highway (unique, as it is the only example of a CRM pier) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• At Puaakaa State Wayside with parking area, comfort station, and picnic tables/shelters • Lush vegetation, waterfall and pool
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Pier Wall with Cutwater Profile • CRM Wingwalls • Concrete Solid Parapet with Panel and Cap (Upstream side)
Detracting Features	• Non-historic cementitious materials on face of CRM abutment, CRM wingwalls, and CRM pier wall

Significance & Context

Bridge Site History

Waiohue Stream Bridge is one of four consecutive solid parapet bridges designed ca. 1911-1912, according to historic drawings. However, this bridge was not constructed until 1926. The following bridges #22 Unnamed Stream Bridge No. 1 (Waiohuolua), #23 Unnamed Stream Bridge No. 2, and #24 Unnamed Stream Bridge No. 3 appear to have been designed together as a set and were constructed in 1920.

Archaeological / Cultural Significance

The place name *Waiohue* is defined as, "Water of Hue. Land section. Koolau. Maui."[1] The bridge spans Waiohue Stream, which forms the boundary between Waiohue Ahupuaa and Nakapehu Ahupuaa.[2, 3] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[4, 5]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Waiohue Stream Bridge.

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Joseph Iao, “Portion of Hamakualoa & Koolau Maui,” registered map no. 2482, Hawaii Territory Survey (1909).

3 W. D. Alexander, “Map of the Koolau Coast Maui: From Wailuanui to Keaa,” registered map no. 1066 (1878).

4 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

5 Erick M. Fredericksen, “An Archaeological Monitoring Report for Individual Wastewater System Improvements at Puaʻa Kaʻa State Wayside Park, Nakapehu Ahupuaʻa, Hana District, Maui Island (TMK: (2) 1-2-01: 03),” Xamanek Researches, LLC (Pukalani: 2007).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound, West Bound: Clear • West Bound: No yield
Signage (as of September 2014)	West Bridge Approach • Yield Sign (R1-2) • Left Object Marker (OM3-L)
	East Bridge Approach • Left Object Marker (OM3-L)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Telephone and other unidentified communication cables located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.71 • Operating Rating = 0.93
Condition	Functionally Obsolete

Civil & Traffic

The Waiohue Stream Bridge is located at mile point 22.41 along Hana Highway and its existing conditions are as follows. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Visibility of the oncoming traffic is clear of any obstructions while traveling in both directions. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass nearby on the downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 2, 2013. The overall condition rating of the bridge at the time of inspection varied between fair and good.[6] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at the Hana upstream and downstream, and Kahului downstream approaches to the bridge. There is no approach wall or guardrail at the Kahului upstream approach to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 33 inches. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.71 and the operating rating is 0.93.

The current curb-to-curb dimension is 13.00 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

6 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Waiohue Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 2, 2013, record drawings,[7] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Waiohue Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4, for Hana Belt Road National Register Nomination Form).

In order to improve the existing drainage conditions, a more detailed drainage study (with the aid of a topographic survey) should be conducted by the design engineer to analyze the magnitude of potential flooding. Drainage solutions may consist of multiple spillways or a drain inlet system that empties back into the stream under the appropriate and current water quality standards.

The Waiohue Bridge has been known to have a history of ponding and flooding. Since the parapet railing design does not have any openings or scuppers along its length, runoff is forced to accumulate at the center of the bridge (local low point) which leads to ponding and flooding. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

Regarding the name of this bridge, discrepancies have been identified by comparing available modern and historic resources and in response to community comments during the preparation of this report. Historic drawings originally label this bridge as "Waiohue Bridge," consistent with the name of the intersecting stream and the surrounding Waiohue Gulch area. Although this bridge is located directly west of Puaakaa State Park and a handwritten inscription denotes the name, "Paakea Bridge (Waiohue Stream)," it is recommended that the name "Waiohue Stream Bridge" be retained for consistent identification of this particular bridge.

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7 Maui Loan Fund Commission, Territory of Hawaii, *Waiohue Bridge*, Station 362+35.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Existing deck
Courtesy of NOEI

Recommendations have been identified per bridge component, as follows:

Deck

The Waiohue Stream Bridge currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the downstream side of the bridge.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

There are no recommendations for adding a pedestrian or bicycle access route.

If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two Kahului approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Existing concrete girders
Courtesy of FAI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to preserve the upstream parapet by constructing a crash-tested railing in front it. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The downstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical wall type SBC01c concrete parapet (refer to Section G, Appendix 5. Proposed Crash-Tested Railing Options). The existing deck does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapet will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash tested railing design height can be changed to match existing conditions, have an exterior panel detail and a sloped top cap appearance.

Foundations, Piers, Wingwalls, & Abutments

The CRM pier wall is recommended to be replaced with a reinforced concrete structure with a reconstructed CRM rock façade. To achieve this, the existing façades of the CRM pier wall is to have its rock configuration documented and recorded. Once documentation has been completed, the CRM pier wall is to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM pier wall are to be placed in front of the new reinforced concrete pier functioning as its new façade. The appearance of the reconstructed façades shall closely match the shape, dimensions, profile, proportions, and style as that of the original historic craftsmanship.

Although the CRM abutments are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments.

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship on Hana Highway.

Reinforced concrete abutments, pier, and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (Refer to Section A, Chapter 5 *Application of Design Standards & Guidelines* for more information).

The existing CRM pier wall is an exemplary example of this bridge component. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM pier wall and CRM abutments, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. Also, the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver’s visibility should be trimmed or removed per an approved landscape plan. It is recommended that a yield line is added to the west bridge approach. It is also recommended that a “Yield” sign (R1-2), a “To Oncoming Traffic” sign (R1-2a), and a yield line are added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield Line
- Add “To On Coming Traffic” plaque (R1-2a)
- Add Object Marker Type 3 - Right (OM3-R)

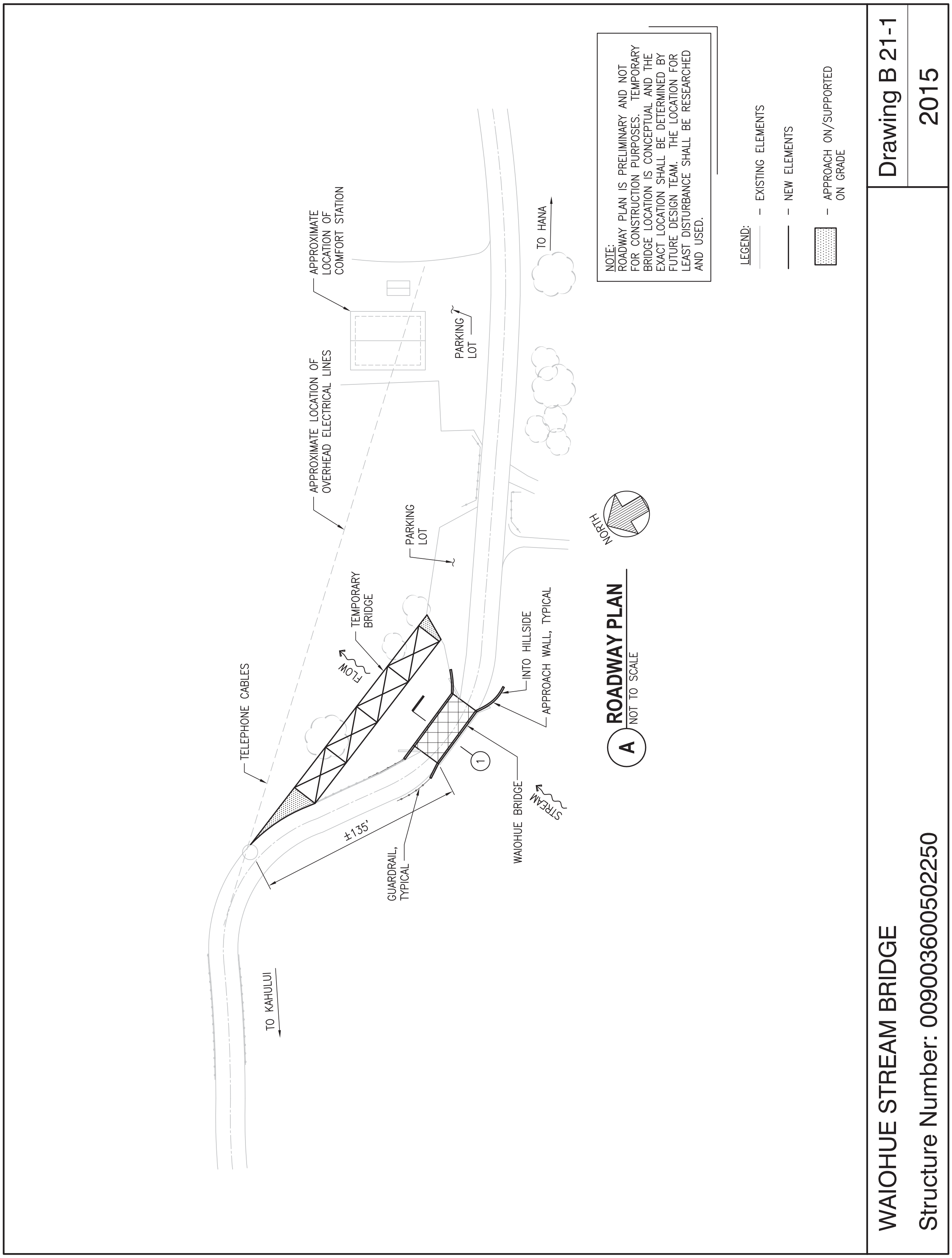
East Bridge Approach

- Add Yield sign (R1-2) and “To On Coming Traffic” plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Right (OM3-R)

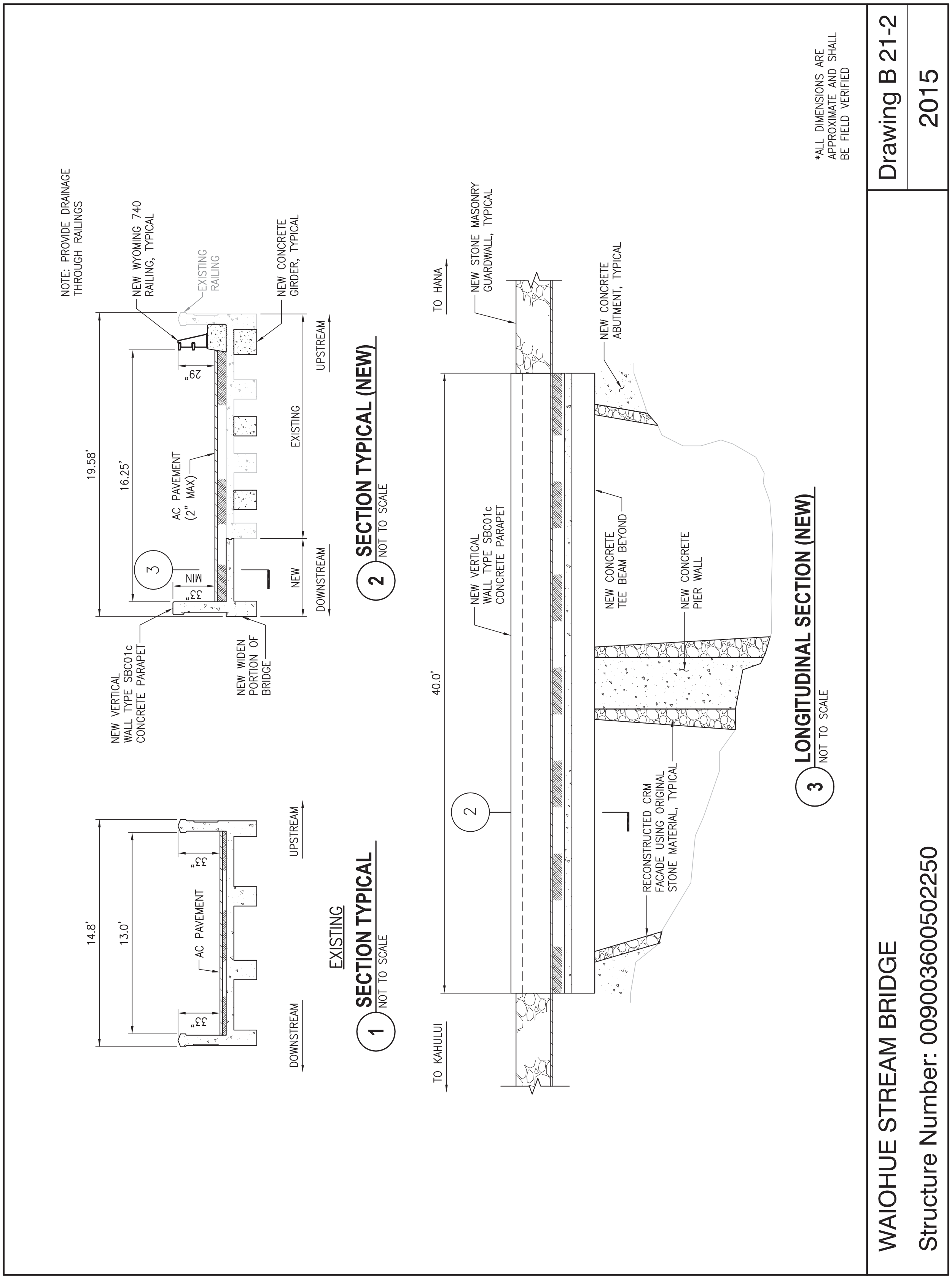
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

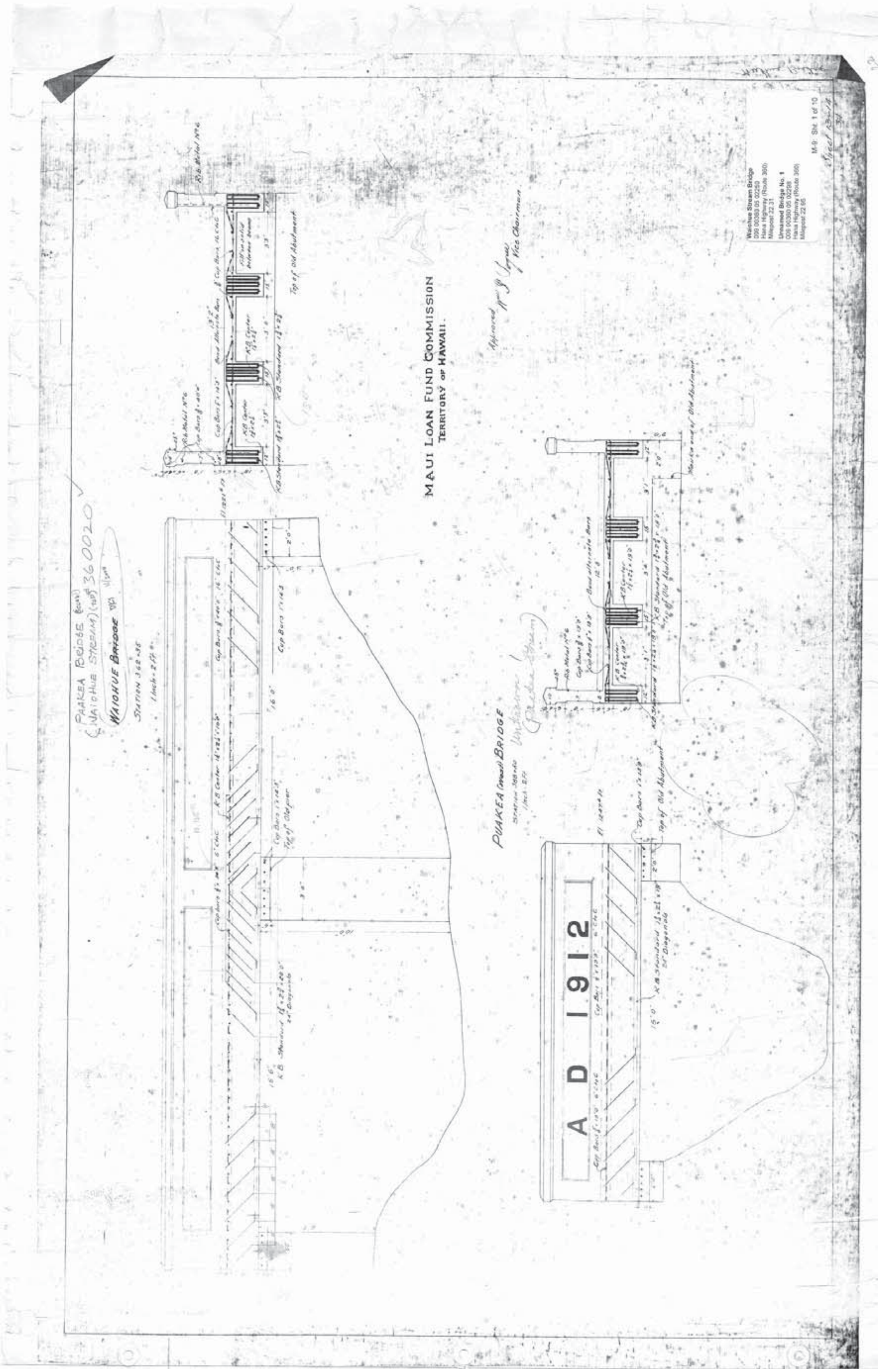
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Waiohue Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

22

Unnamed Bridge No. 1 (Waiohuolua)

22 UNNAMED BRIDGE NO.1 (WAIOHUOLUA)

Bridge Number	009003600502298			**Island**	Maui		
Date of Construction	1920			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI

Courtesy of Google Maps

Location

Latitude	20d 48m 52s
Longitude	156d 07m 11s
Mile Point	22.86
Location	2.08 miles west of Lower Nahiku Road
Feature Crossed	Unnamed Stream (refer to Section G, Appendix 10, *Hawaiian Place Name Research*)

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	19.03 feet
Number of Spans	1
Maximum Span	18.0 feet
Deck Width	• Curb-to-Curb = 12.50 feet • Out-to-Out = 13.78 feet
Abutment Material	CRM Abutments
Wingwall Material	None
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Solid with Cap
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 26 inches (2013), 36.5 inches (2014) • Downstream Railing Height = 26 inches (2013), 36.5 inches (2014)
Parapet / Railing Profile	• Parapet thickness = ±7 inches • Rectangular cap ± 4 inches x 9 inches
Parapet Inscription	None Note: Date drawn on record drawings is 1912; however, the date was not inscribed on the parapet at the time of construction in 1920

**Note: The name of this bridge varies according to several sources. For the purposes of this report, this bridge will be known as* Unnamed Stream Bridge No. 1 (Waiohuolua)*. The varying names for this bridge are: Unnamed Bridge No. 1, Unknown Bridge No. 1, Waiohuolua Bridge, and Puakea (West) Bridge (refer to page B22-11).*

Bridge Features

Unnamed Stream Bridge No. 1 (Waiohuolua)* is a single-span reinforced concrete tee beam bridge built in 1920 and reconstructed in 1974. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments. The abutments bear directly on solid rock formations.

Setting of Unnamed Stream Bridge No. 1
Courtesy of NOEI

Unnamed Stream
Courtesy of NOEI

Hana approach to Unnamed Stream Bridge No. 1 toward Kahului
Courtesy of NOEI

Kahului approach to Unnamed Stream Bridge No. 1 toward Hana
Courtesy of NOEI

Concrete solid parapet with cap, upstream side
Courtesy of NOEI

Concrete solid parapet with cap, downstream side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Puakea
Designer / Builder	Maui Loan Fund Commission - Unknown Designer Plans approved by William Fawcett Pogue, Vice Chairman
Historic Drawings	Yes (undated), Puakea (West) Bridge
Alterations	None
Replacement	1974 - Reconstructed
Preservation Priority	Contributing Bridge: Solid Parapet
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Spans a narrow gorge; bridge is immediately west of #23 Unnamed Stream Bridge No. 2 and #24 Unnamed Stream Bridge No. 3 • Semi-open rural clearing, with mature trees and undergrowth on upstream side
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • Concrete Solid Parapets with Cap
Detracting Features	• Non-historic cementitious materials on face of CRM abutments • Thrie-beams bolted to upstream parapet

Significance & Context

Bridge Site History

Unnamed Stream Bridge No. 1 (Waiohuolua) is one of four consecutive solid parapet bridges designed ca. 1911-1912, according to historic drawings. #23 Unnamed Stream Bridge No. 2 and #24 Unnamed Stream Bridge No. 3 appear to have been designed with this bridge as a set. However, all three bridges were not constructed until 1920. Waiohue Stream Bridge nearby was constructed in 1926.

Archaeological / Cultural Significance

This bridge is listed as the Waiohuolua Bridge in the Hana Belt Road National Register of Historic Places Nomination Form and HAER Report.[1] No definition could be located for the Hawaiian word *waiohuolua*. The Waiohuolua Stream Bridge spans an unnamed stream in Puakea Ahupuaa.[2] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[3]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of Unnamed Stream Bridge No. 1 (Waiohuolua).

1 Hana Belt Road, National Register of Historic Places #20010615 (May 2001).

2 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (Vandalized, OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Telephone and other unidentified communication cables located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.58 • Operating Rating = 0.76
Condition	Functionally Obsolete

Civil & Traffic

Unnamed Stream Bridge No. 1 (Waiohuolua) is located at mile point 22.86 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 13.78 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the Type 3 Object Marker (Right) is vandalized on the east bridge approach. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass nearby on the downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 2, 2013. The overall condition rating of the bridge at the time of inspection was fair.[4] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. Both ends of the upstream parapet have approach metal guardrails with transitions. The approach guardrails at the downstream parapet do not transition to the parapet.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 26 inches. Following AC removal by HDOT in October 2014, the upstream and downstream parapets had a height of 36.5 inches. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.58 and the operating rating is 0.76.

The current curb-to-curb dimension is 12.50 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

4 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Unnamed Stream Bridge No. 1 (Waiohuolua) be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 2, 2013, record drawings,[5, 6, 7] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Unnamed Stream Bridge No.1 (Waiohuolua) is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4, for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

Regarding the name of this bridge, discrepancies have been identified by comparing available modern and historic resources and in response to community comments during the preparation of this report. The name "Waiohuolua" was identified in the National Register nomination and HAER report for this bridge, although team research was unable to find further information connecting the Hawaiian place name and bridge name. The historic drawing dated 1912, labels this bridge as "Puakea (West) Bridge" An additional handwritten inscription on the historic drawing denotes the name, "Unknown 1 (Paakea Stream)," which appears to incorrectly identify the stream name. Consistent with the surrounding geographical features of the Puakea Gulch and the Puakea Ahupuaa within which this bridge lies, it is recommended to revise the bridge name to "Puakea West Bridge" as shown on the historic drawing.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

5 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

6 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

7 Maui Loan Fund Commission, Territory of Hawaii, *Puakea (West) Bridge*, Station 388+50.

Recommendations have been identified per bridge component, as follows:

Existing deck
Courtesy of NOEI

Deck

The Unnamed Stream Bridge No. 1 (Waiohuolua) currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the downstream side of the bridge.

There are no recommendations for adding a pedestrian or bicycle access route.

Initial site investigation in 2013 found there was an excessive amount of AC overly on the deck. In October of 2014, excessive AC was removed. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Approach Walls

Currently, there are no approach walls at this bridge; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other bridges along Hana Highway. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*).

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

All of the approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts.

Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.


Existing concrete girders
Courtesy of NOEI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to replace the parapets on the upstream and downstream sides with a similarly designed reinforced concrete parapet (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This parapet is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapet will be required, for instance in the form of a new girder under the bridge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions, with an exterior panel detail and a sloped top cap appearance.

Foundations & Abutments

The CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5 *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. Also, the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a yield line is added to the east and west bridge approach. It is also recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a) are added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Aprons should be added to both approaches in accordance to current standards. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

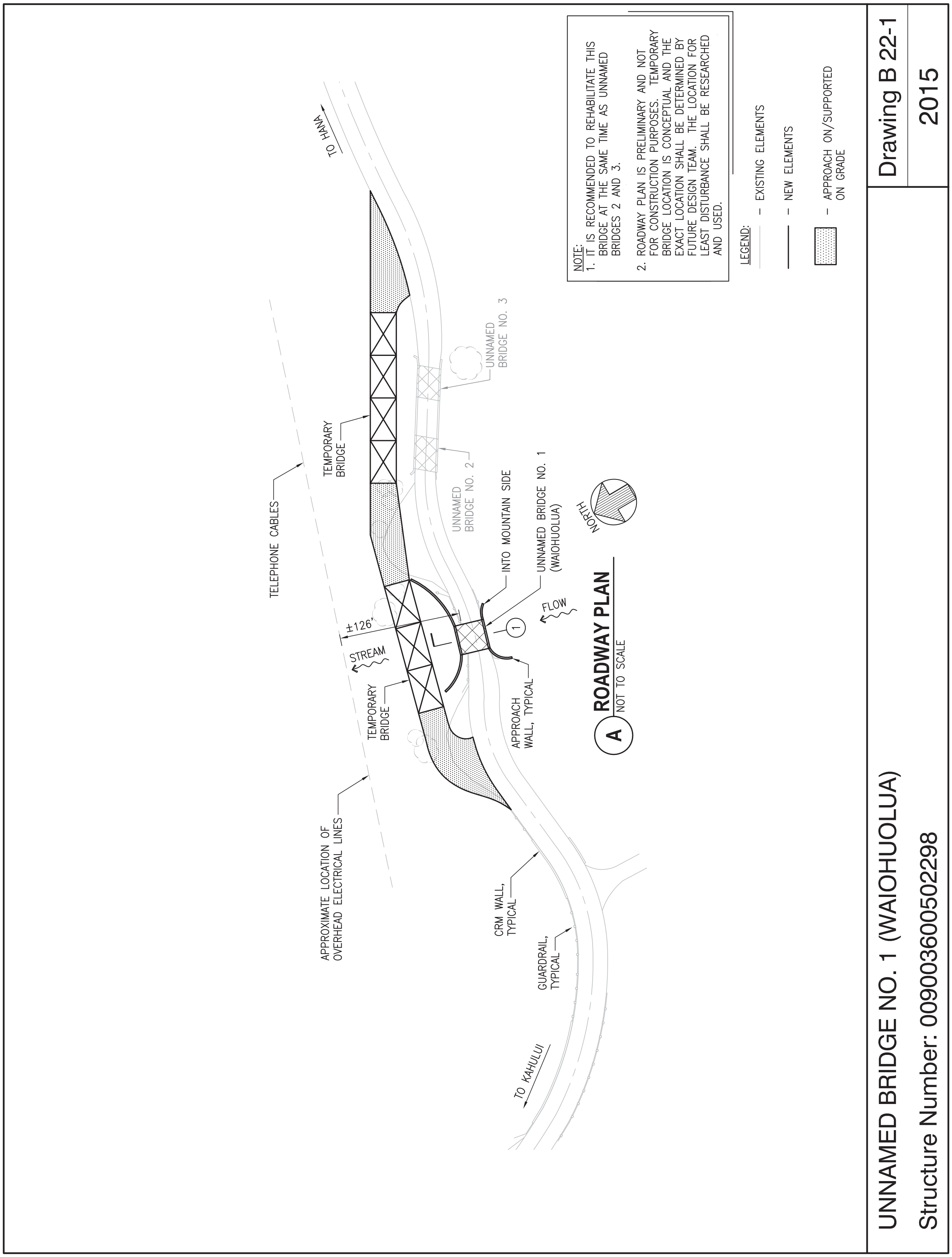
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Replace Object Marker Type 3 - Right (OM3-R)

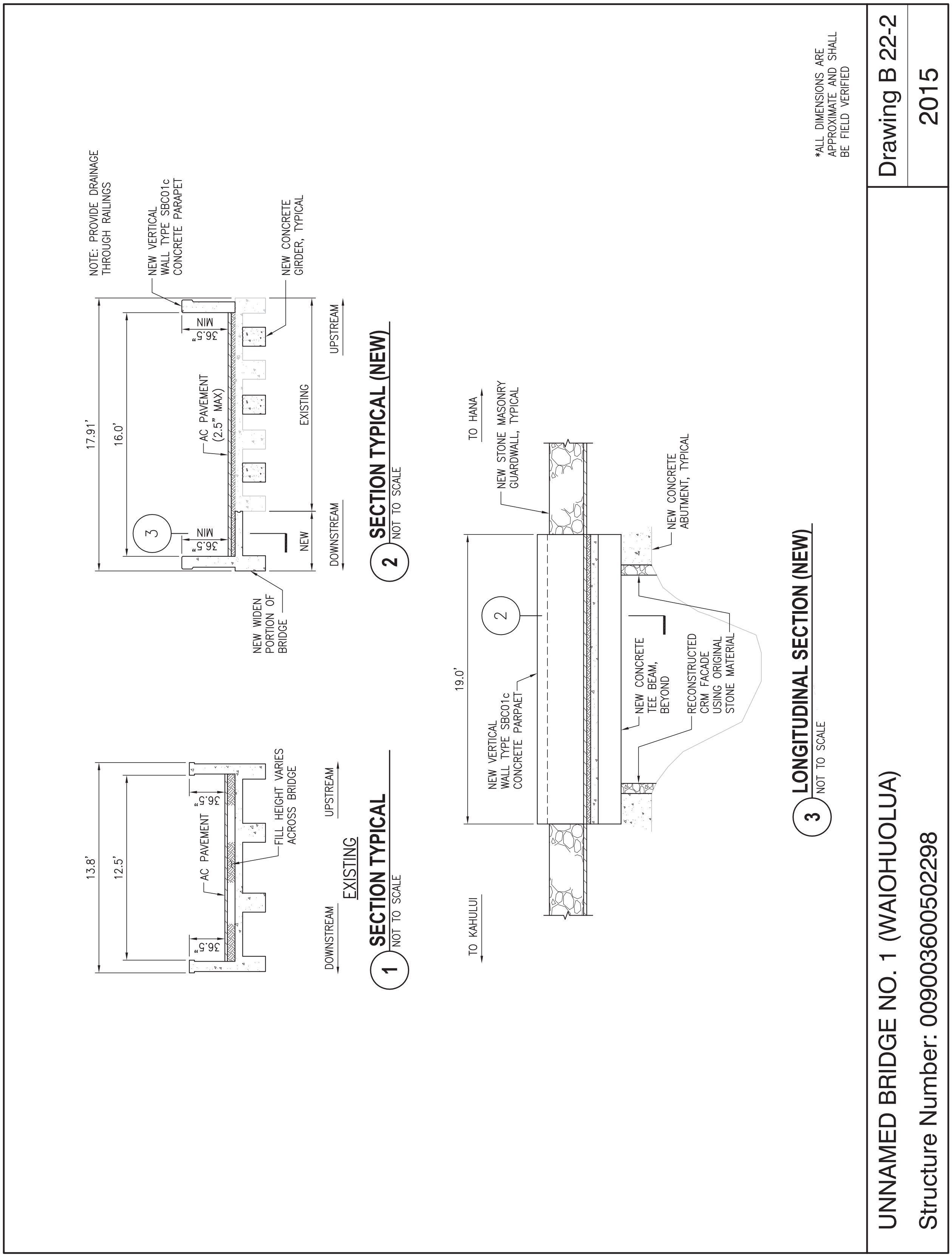
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

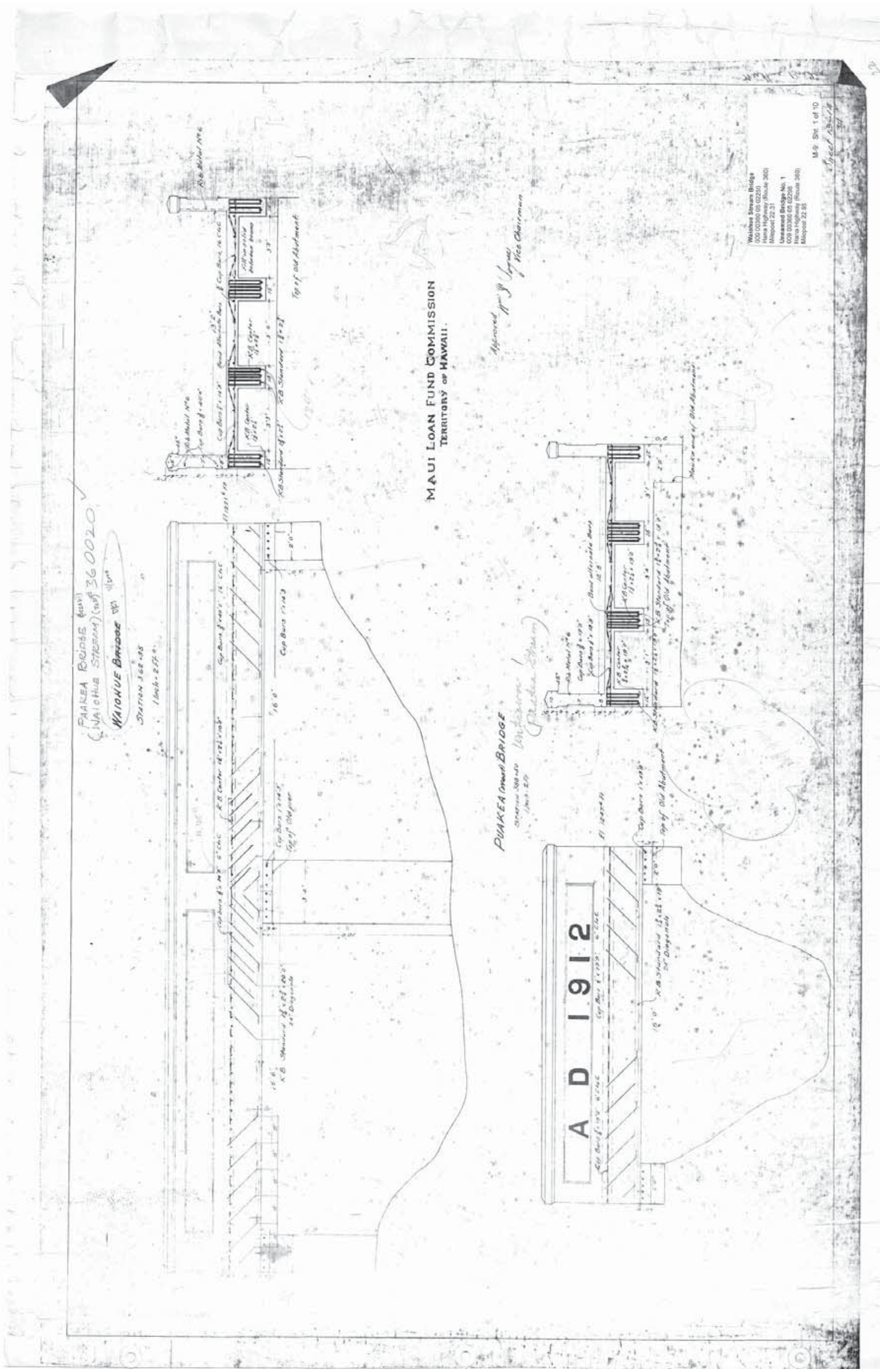
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Unnamed Stream Bridge No. 1 (Waiohuolua) at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

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23 Unnamed Bridge No. 2

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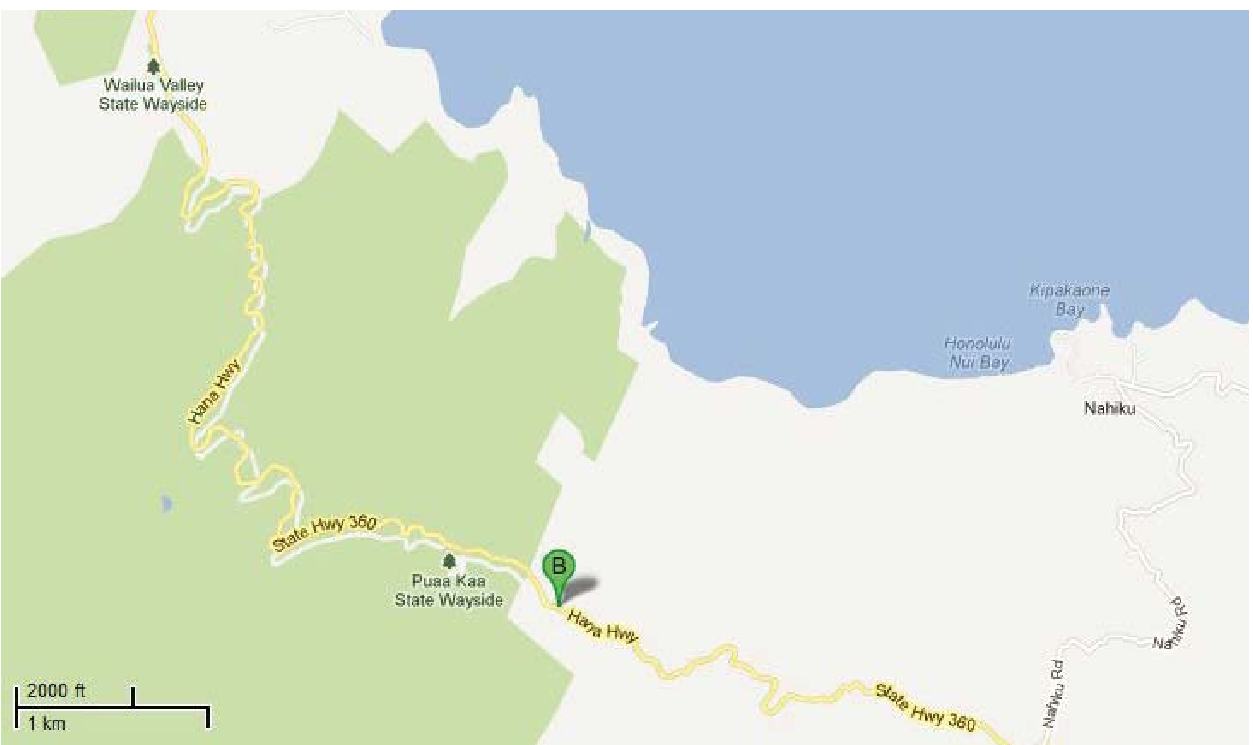
UNNAMED BRIDGE NO.2

Bridge Number	009003600502300			**Island**	Maui		
Date of Construction	1920			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 51s
Longitude	156d 07m 10s
Mile Point	22.89
Location	2.05 miles west of Lower Nahiku Road
Feature Crossed	Unnamed Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	20.01 feet
Number of Spans	1
Maximum Span	16.1 feet
Deck Width	• Curb-to-Curb = 12.50 feet • Out-to-Out = 14.44 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM WIngwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Solid with Cap
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 26 inches (2013), 31.5 inches (2014) • Downstream Railing Height = 26 inches (2013), 31 inches (2014)
Parapet / Railing Profile	• Saddle coping cap • Parapet thickness = ±7 inches
Parapet Inscription	None Note: Date drawn on record drawings is 1912; however, the date was not inscribed on the parapet at the time of construction in 1920

**Note: The name of this bridge is not confirmed and varies according to several sources. For the purposes of this report, this bridge will be known as* Unnamed Stream Bridge No. 2. *The varying names for this bridge are: Unnamed Bridge No. 2, Unknown Bridge No. 2, and Puakea Bridge (refer to page B23-11).*

Bridge Features

Unnamed Stream Bridge No. 2* is a single-span reinforced concrete tee beam bridge built in 1920. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of Unnamed Stream Bridge No. 2
Courtesy of NOEI

Unnamed Stream
Courtesy of NOEI

Hana approach to Unnamed Stream Bridge No. 2 toward Kahului
Courtesy of NOEI

Kahului approach to Unnamed Stream Bridge No. 2 toward Hana
Courtesy of NOEI

Concrete solid with cap parapet, upstream side
Courtesy of NOEI

Concrete solid with cap parapet, downstream side
Courtesy of NOEI

Downstream CRM approach wall, Kahului side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Concrete tee beams
Courtesy of NOEI

Significance & Context

Ahupuaa	Puakea
Designer / Builder	Maui Loan Fund Commission - Unknown Designer Plans approved by William Fawcett Pogue, Vice Chairman
Historic Drawings	Yes (undated), titled "Puakea Bridge"
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Solid Parapet
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Bridge is immediately east of #22 Unnamed Stream Bridge No. 1 (Waiohuolua) and immediately west of #24 Unnamed Stream Bridge No. 3 • Open with heavy vegetation • CRM wall separates the bridges • Bridge spans same stream as #24 Unnamed Stream Bridge No. 3, which is very close; Bridges #23 & #24 separated by CRM walls that were rebuilt in April 1985 (HAER Notes pp. 74-75) • Alignment on curve
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Solid Panel Parapets with Cap
Detracting Features	• Non-historic cementitious materials on face of CRM abutments and CRM wingwalls

Significance & Context

Bridge Site History

Unnamed Stream Bridge No. 2 is one of four consecutive solid parapet bridges designed ca. 1911-1912, according to historic drawings. #22 Unnamed Stream Bridge No. 1 (Waiohuolua) and #24 Unnamed Stream Bridge No. 3 appear to have been designed with this bridge as a set. However, all three bridges were not constructed until 1920. Waiohue Stream Bridge nearby was constructed in 1926.

Archaeological / Cultural Significance

This unnamed bridge spans an unnamed stream in Puakea Ahupuaa, which appears to be a branch of Paakea Gulch.[1] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[2]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Unnamed Stream Bridge No. 2.

1 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

2 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • None
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Telephone and other unidentified communication cables located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.85 • Operating Rating = 1.10
Condition	Functionally Obsolete

Civil & Traffic

Unnamed Stream Bridge No. 2 is located at mile point 22.89 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 14.44 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass nearby on the downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 2, 2013. The overall condition rating of the bridge at the time of inspection was fair.[3] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 26 inches. Following AC removal by HDOT in October 2014, the upstream and downstream parapets had a height of 31.5 inches and 31 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.85 and the operating rating is 1.10.

The current curb-to-curb dimension is 12.50 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

3 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Unnamed Stream Bridge No. 2 be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 2, 2013, record drawings,[4, 5, 6] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Unnamed Stream Bridge No.2 is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

Regarding the name of this bridge, discrepancies have been identified by comparing available modern and historic resources and in response to community comments during the preparation of this report. The historic drawing, dated 1912, labels this bridge as "Puakea Bridge" An additional handwritten inscription on the historic drawing denotes the name, "Unknown 2 (Paakea Stream)," which appears to incorrectly identify the stream name. Consistent with the surrounding geographical features of the Puakea Gulch and the Puakea Ahupuaa within which this bridge lies, it is recommended to revise the bridge name to "Puakea Gulch Bridge" as shown on the historic drawing.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

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4 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

5 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

6 Maui Loan Fund Commission, Territory of Hawaii, *Puakea Bridge*, Station 389+78.

Recommendations have been identified per bridge component, as follows:

Existing deck
Courtesy of NOEI

Deck

The Unnamed Stream Bridge No. 2 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the downstream side of the bridge.

There are no recommendations for adding a pedestrian or bicycle access route.

Initial site investigation in 2013 found there was an excessive amount of AC overly on the deck. In October of 2014, excessive AC was removed. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The downstream Kahului approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The upstream Kahului approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall. Bridge #24 Unnamed Stream Bridge No. 3, is in close proximity to this bridge; therefore, it is recommended to have the stone masonry guardwall be continuous between the upstream and downstream Hana parapets.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to replace the parapets on the upstream and downstream sides with a similarly designed reinforced concrete parapet. For this purpose, it is recommended to use a vertical wall type SBC01c concrete parapet which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This parapet is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapet will be required, for instance in the form of a new girder under the bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash tested railing design height can be changed to match existing conditions, with an exterior panel detail and a sloped top cap appearance.

Foundations, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are good intact examples of these component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5 *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), and a yield line are added to the west bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Device for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

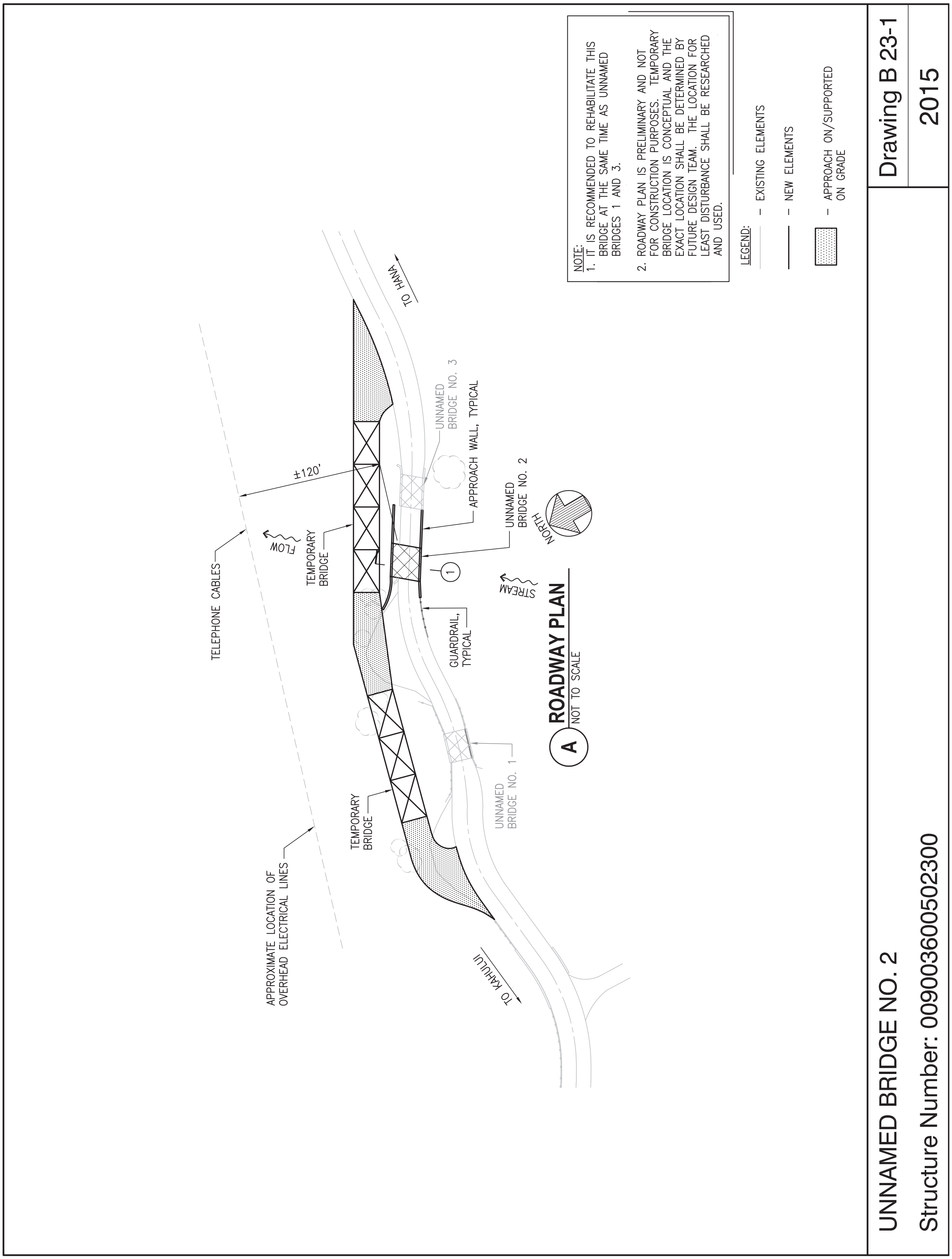
East Bridge Approach

- Add Object Marker Type 3 – Left and Right (OM3-R)

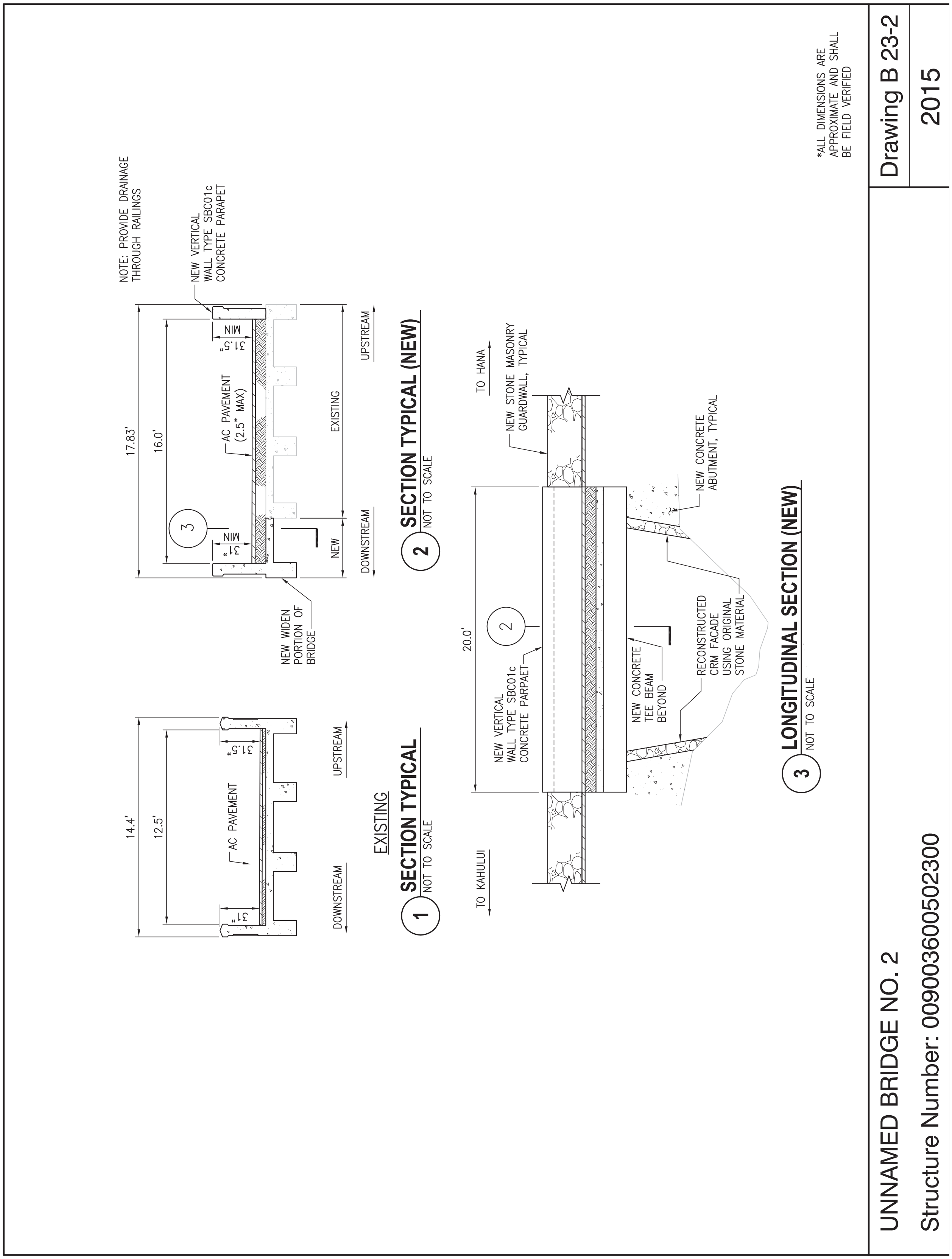
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

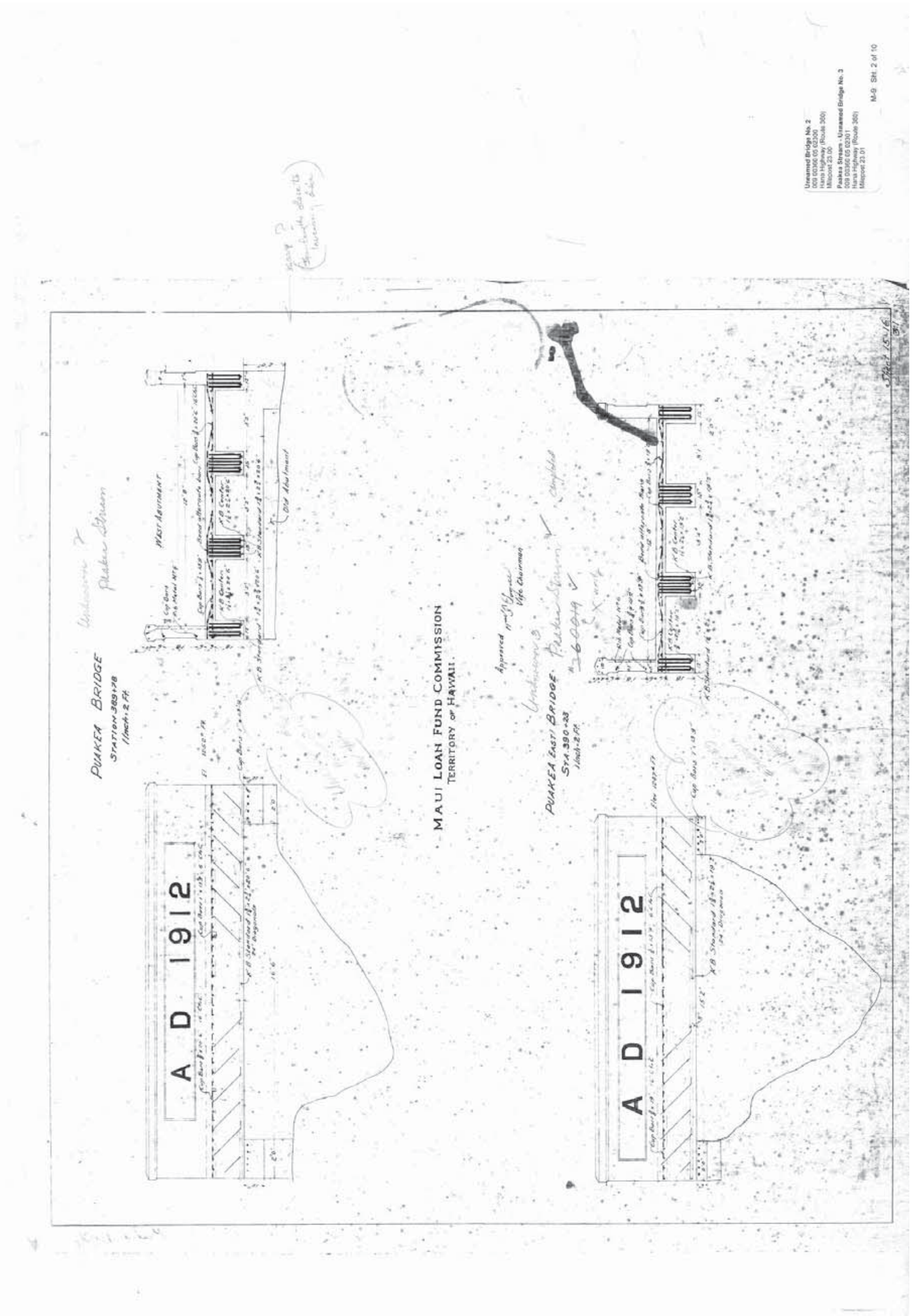
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Unnamed Stream Bridge No. 2 at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

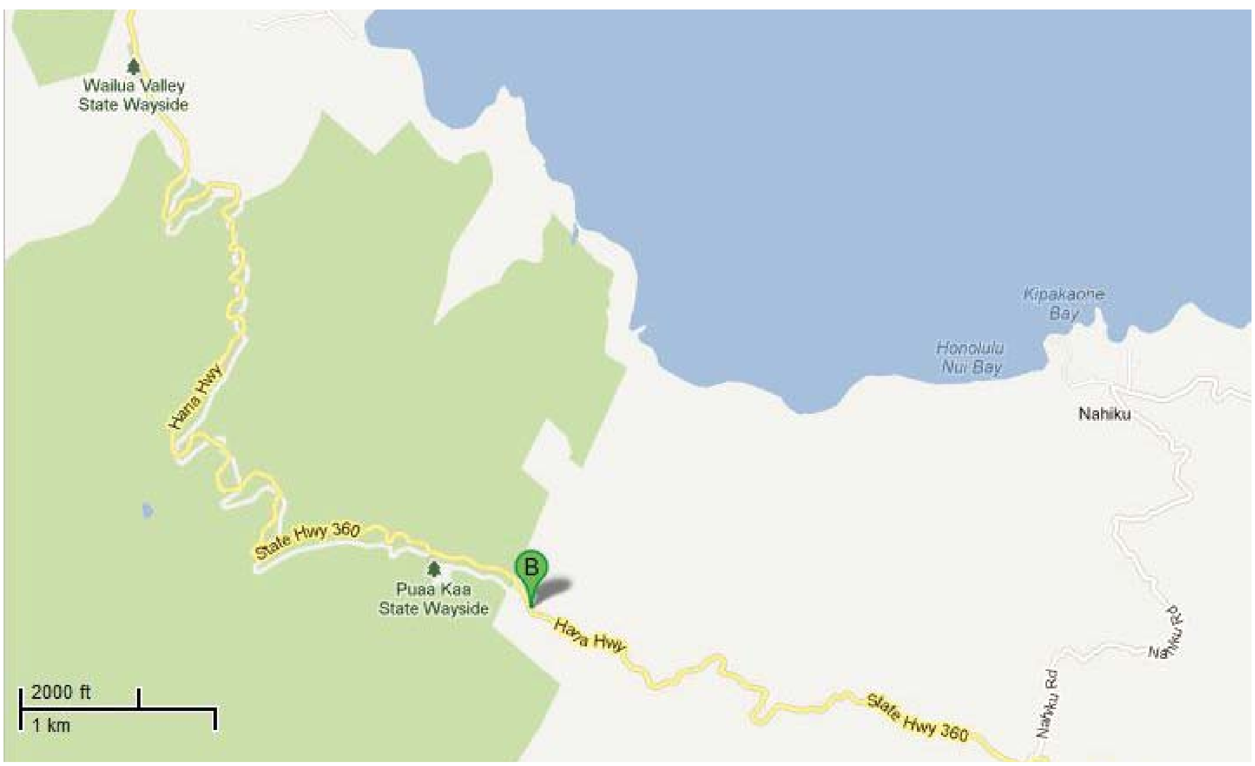


Courtesy of State of Hawaii Department of Transportation

24
Unnamed Bridge No. 3

24 UNNAMED BRIDGE NO.3

Bridge Number	009003600502301			**Island**	Maui		
Date of Construction	1920			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Location

Latitude	20d 48m 51s
Longitude	156d 07m 10s
Mile Point	22.91
Location	2.00 miles west of Lower Nahiku Road
Feature Crossed	Paakea Gulch

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	19.03 feet
Number of Spans	1
Maximum Span	15.1 feet
Deck Width	• Curb-to-Curb = 12.66 feet • Out-to-Out = 14.11 feet
Abutment Material	CRM Abutments
Wingwall Material	None
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Solid
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 29 inches (2013), 36 inches (2014) • Downstream Railing Height = 29 inches (2013), 32 inches (2014)
Parapet / Railing Profile	• Saddle coping cap (upstream) • No cap (downstream) • Parapet thickness = ±7 inches
Parapet Inscription	None Note: Date drawn on record drawings is 1912; however, the date was not inscribed on the parapet at the time of construction in 1920

**Note: The name of this bridge is not confirmed and varies according to several sources. For the purposes of this report, this bridge will be known as* Unnamed Stream Bridge No. 3*. The varying names for this bridge are: Unnamed Bridge No. 3, Unknown Bridge No. 3, Puakea (East) Bridge, and Paakea Stream-Unnamed Bridge No. 3. The historic drawing shows the name of the bridge is "Puakea East". Although the bridge crosses Paakea Stream, the USGS Map shows this bridge spans Paakea Gulch, which divides Puakea Ahupuaa and Paakea Ahupuaa (refer to page B24-11).*

Bridge Features

Unnamed Stream Bridge No. 3* is a single-span reinforced concrete tee beam bridge built in 1920. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments. The abutments bear directly on natural rock formations.

Setting of Unnamed Stream Bridge No. 3
Courtesy of FAI

Paakea Stream
Courtesy of NOEI

Hana approach to Unnamed Stream Bridge No. 3 toward Kahului
Courtesy of NOEI

Kahului approach to Unnamed Stream Bridge No. 3 toward Hana
Courtesy of NOEI

Concrete solid parapet with cap, upstream side
Courtesy of NOEI

Concrete solid parapet, downstream side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Concrete tee beams
Courtesy of NOEI

Unconnected parapet remnant beneath the bridge, upstream side
Courtesy of NOEI

Significance & Context

Ahupuaa	Puakea and Paakea
Designer / Builder	Maui Loan Fund Commission - Unknown Designer Plans approved by William Fawcett Pogue, Vice Chairman
Historic Drawings	Yes (undated), titled "Puakea (East) Bridge"
Alterations	None
Replacement	1974 - Reconstruct
Preservation Priority	Contributing Bridge: Solid Parapet
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Bridge is immediately east of #23 Unnamed Stream Bridge No. 2 and #22 Unnamed Stream Bridge No. 1 (Waiohuolua) • Open rural clearing • Bridge spans same stream as #23 Unnamed Stream Bridge No. 2, which is very close; Bridges #23 & #24 separated by CRM walls that were rebuilt in April 1985 (HAER Notes pp. 74-75)
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • Original downstream Concrete Solid Parapet
Detracting Features	Non-historic cementitious materials on face of CRM abutments

Significance & Context

Bridge Site History

Unnamed Stream Bridge No. 3 is one of four consecutive solid parapet bridges designed ca. 1911-1912, according to historic drawings. #22 Unnamed Stream Bridge No. 1 (Waiohuolua) and #23 Unnamed Stream Bridge No. 2 appear to have been designed with this bridge as a set. However, all three bridges were not constructed until 1920. Waiohue Stream Bridge nearby was constructed in 1926.

Archaeological / Cultural Significance

This unnamed bridge spans Paakea Gulch, which forms the border between Puakea Ahupuaa and Paakea Ahupuaa.[1,2] The Hawaiian word *paakea* is defined as, "Limestone, coral beds, as found on the leeward sides of the islands. *Lit*., white hardness."[3] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Appendix 1, Figure 10 for nearby archaeological study areas.[4]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Unnamed Stream Bridge No. 3.

1 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

2 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

3 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

4 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Approach: Clear • West Approach: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Telephone and other unidentified communication cables located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 1.06 • Operating Rating = 1.11
Condition	Structurally Deficient

Civil & Traffic

Unnamed Stream Bridge #3 is located at mile point 22.91 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 14.11 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass nearby on the downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on December 2, 2013. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[5] This one-lane bridge is *structurally deficient* due to a rating of 4 for the *superstructure*. This bridge is also *functionally obsolete* due to a rating of 2 for *Deck Geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 29 inches. Following AC removal by HDOT in October 2014, the upstream and downstream parapets had a height of 36 inches and 32 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.56 and the operating rating is 0.73.

The current curb-to-curb dimension is 12.66 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

5 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Unnamed Stream Bridge No. 3 be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated December 2, 2013, record drawings,[6, 7, 8] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. Application of Design Standards & Guidelines for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. Preservation Solutions Following Secretary of the Interior's Standards, and Chapter 5. iii. f. Activities to Prolong the Life of the Bridge, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Unnamed Stream Bridge No. 3 is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

Regarding the name of this bridge, discrepancies have been identified by comparing available modern and historic resources and in response to community comments during the preparation of this report. The historic drawing, dated 1912, labels this bridge as "Puakea (East) Bridge." An additional handwritten inscription on the historic drawing denotes the name, "Unknown 3 Paakea Stream," which appears to be the correct stream name. Although the bridge is labeled "Puakea (East) Bridge" on historic drawings, the bridge spans Paakea Gulch, which divides Puakea Ahupuaa and Paakea Ahupuaa. It is recommended that the bridge name "Paakea Gulch Bridge" be retained because it is consistent with the HDOT bridge naming convention that identifies the feature intersected, and in this case, is also consistent in identifying the surrounding geographical feature of the Paakea Gulch within which the bridge lies.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

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6 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

7 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

8 Maui Loan Fund Commission, Territory of Hawaii, *Puakea (East) Bridge*, Station 390+23.

Recommendations have been identified per bridge component, as follows:

Existing deck
Courtesy of NOEI

Deck

The Unnamed Stream Bridge No. 3 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the downstream side of the bridge.

There are no recommendations for adding a pedestrian or bicycle access route.

Initial site investigation in 2013 found there was an excessive amount of AC overly on the deck. In October of 2014, excessive AC was removed. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Existing tee beams
Courtesy of NOEI

Superstructure

The bridge superstructure is structurally deficient. Repairs to the superstructure shall include, but not be limited to, epoxy injection crack repairs, chipping out and replacing exposed severely corroded reinforcing, and chipping out and patching delaminated and spalled areas with an epoxy non-shrink grout. Finish of the repaired area shall match the original condition of the bridge. Sprayed shotcrete finish shall not be permitted.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. Bridge #23 Unnamed Stream Bridge No. 2, is in close proximity to this bridge; therefore, it is recommended to have the stone masonry guardwall be continuous between the upstream and downstream Kahului parapets.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. A*pproach Walls and Safety Features at* *the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to replace the parapets on the upstream and downstream sides with a similarly designed reinforced concrete parapet. For this purpose, it is recommended to use a vertical wall type SBC01c concrete parapet (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This parapet is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the parapets. Additional support for the parapet will be required, for instance in the form of a new girder under the bridge. Refer to current bridge drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash tested railing design height can be changed to match existing conditions, with an exterior panel detail and a sloped top cap appearance.

Document and remove old parapet that is abandoned on upstream Kahului side of stream channel.

Foundations & Abutments

Although the CRM abutments are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship on Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments.

Reinforced concrete abutments are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5 *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

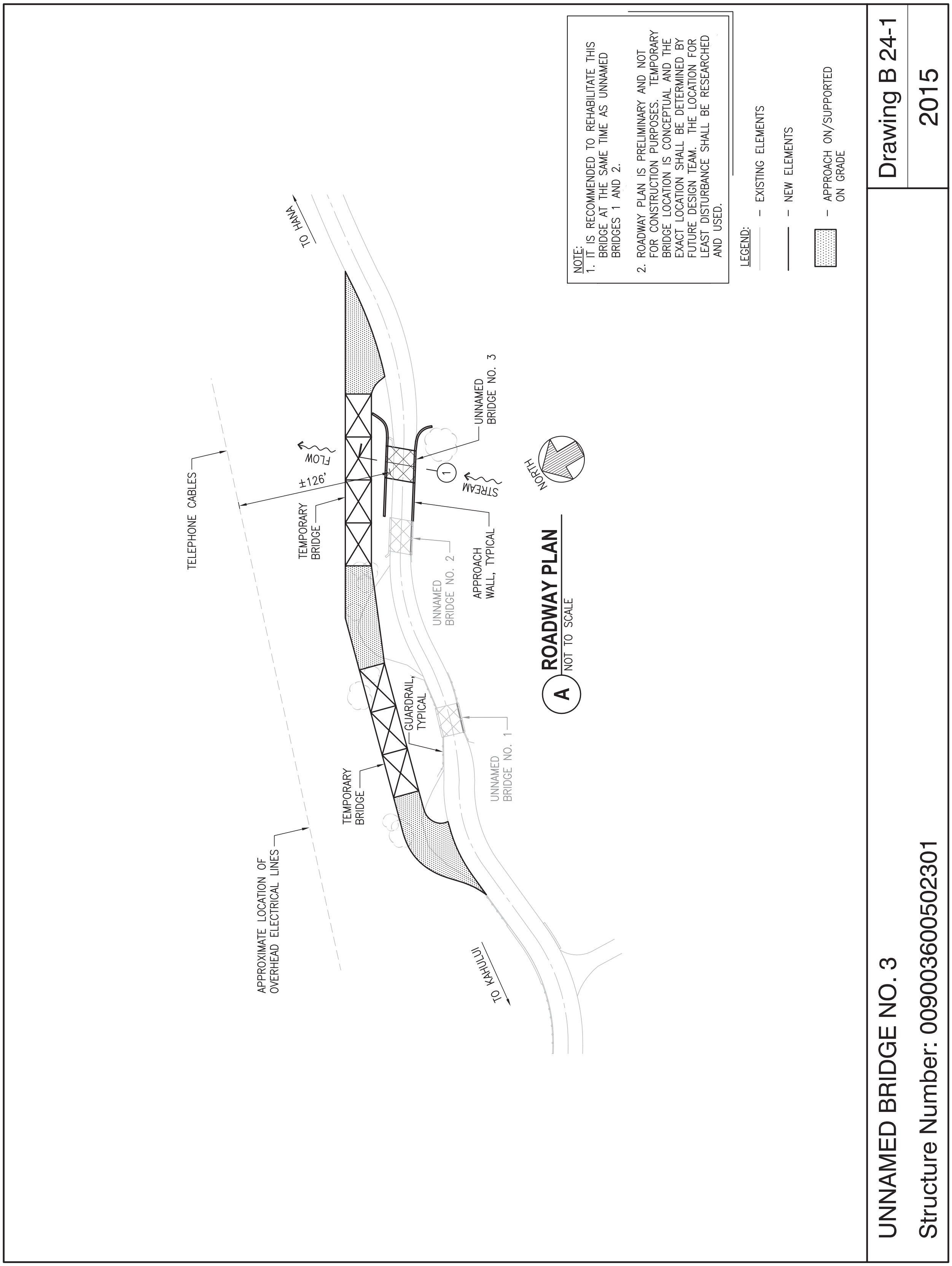
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Unnamed Stream Bridge No. 3 at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



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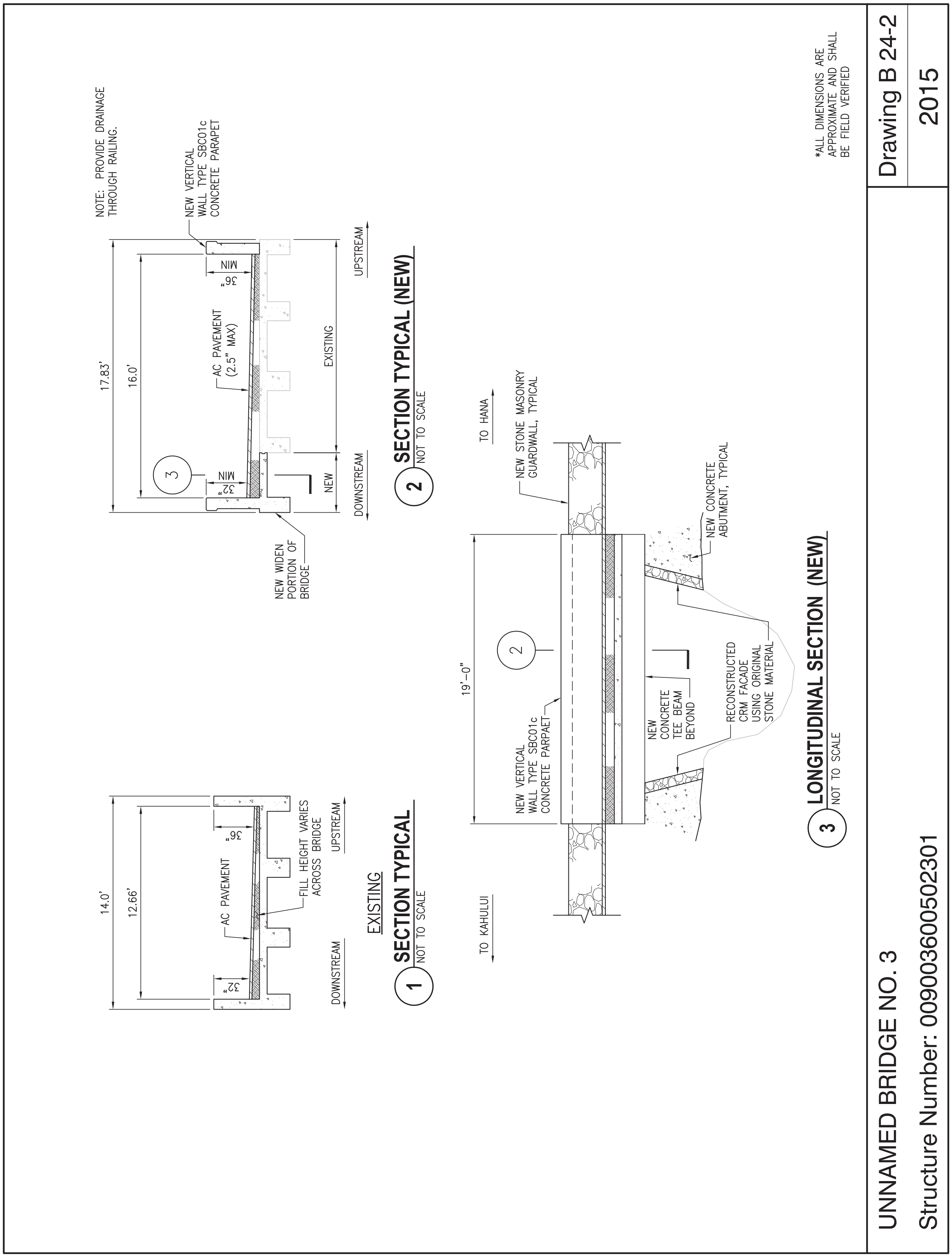

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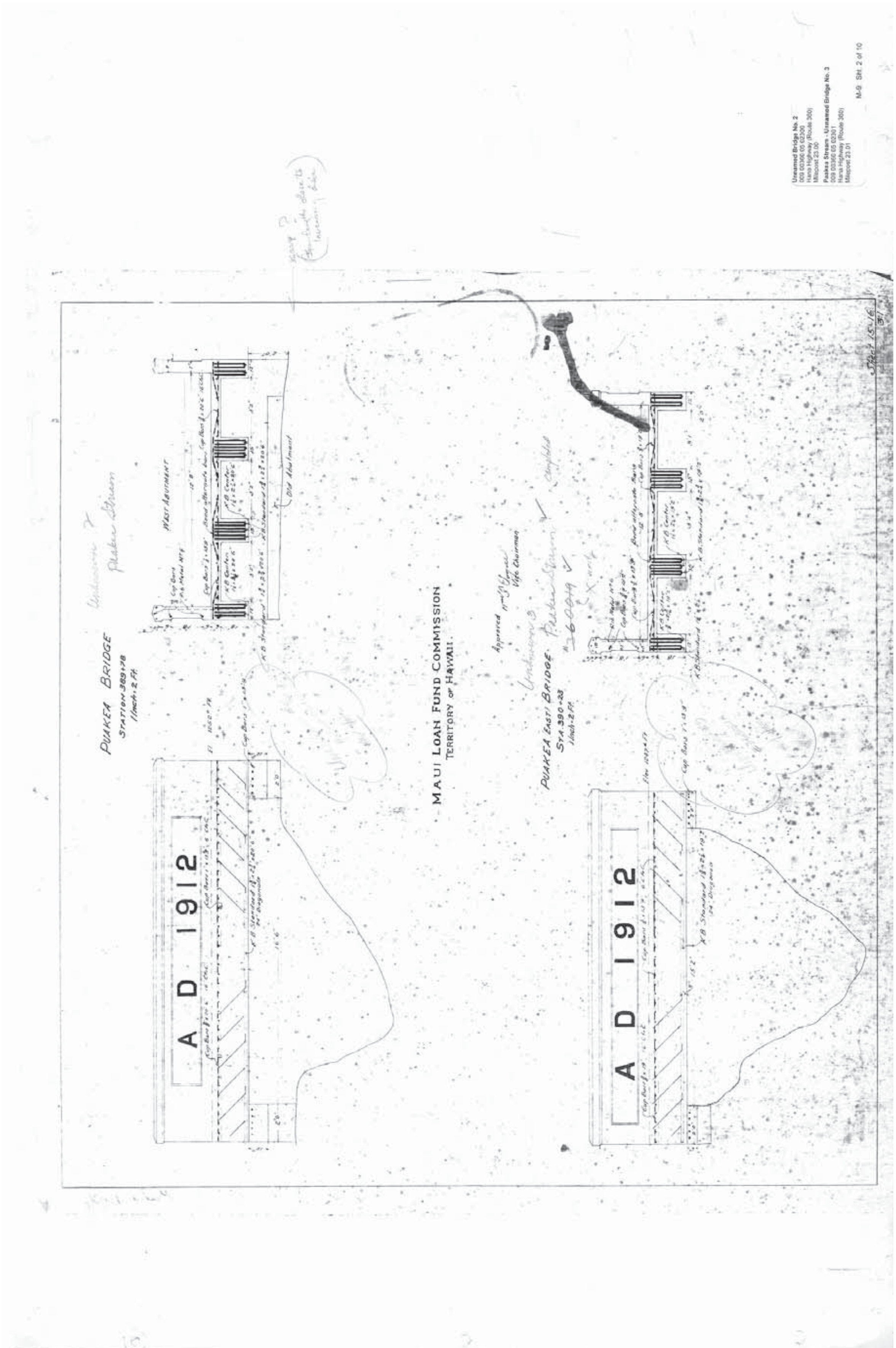

Courtesy of State of Hawaii Department of Transportation

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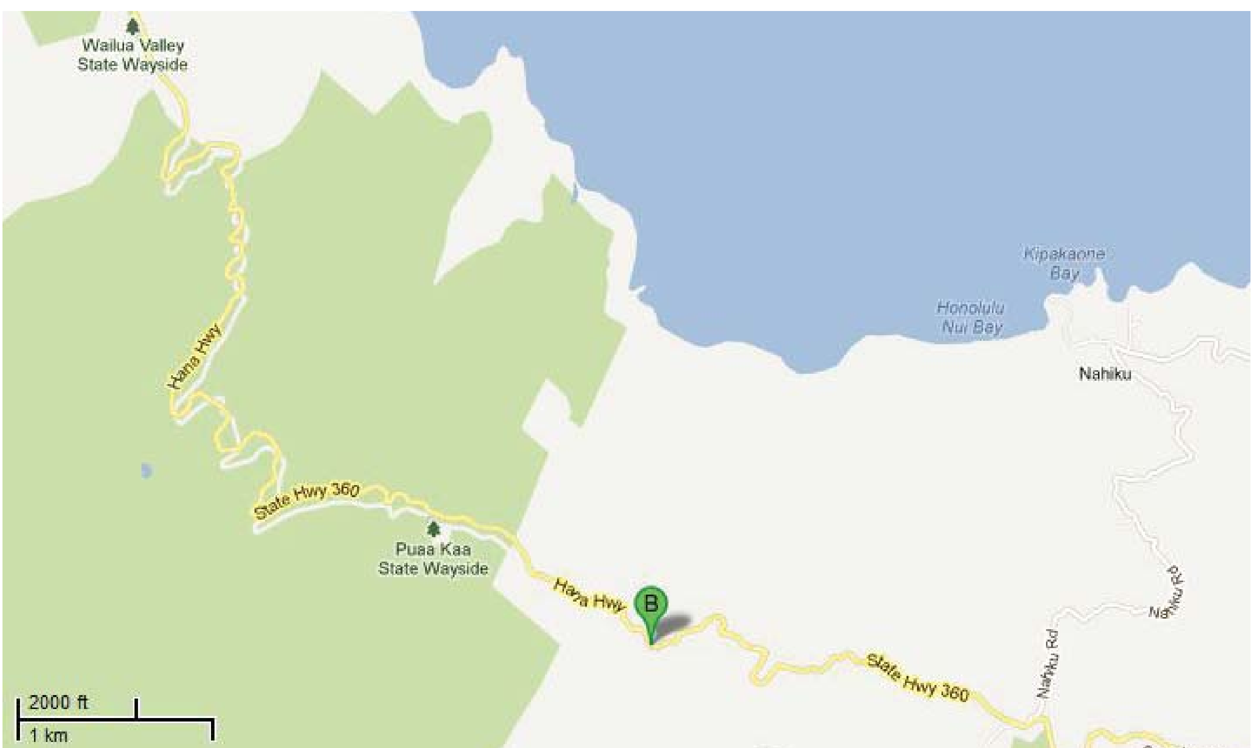
25 Kapaula Stream Bridge

25

KAPAULA STREAM BRIDGE

Bridge Number	009003600502339				**Island**	Maui	
Date of Construction	1926				**Route**	Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 41s
Longitude	156d 06m 53s
Mile Point	23.31
Location	1.64 miles west of Lower Nahiku Road
Feature Crossed	Kapaula Gulch

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	48.88 feet
Number of Spans	2
Maximum Span	21.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	• Concrete Abutments • Concrete Pier Wall resting on natural rock formation
Wingwall Material	CRM Wingwall
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	2
Parapet / Railing Height	• Upstream Railing Height = 30 inches • Downstream Railing Height = 29 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • Intermediate posts = 12 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kapaula Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span. The substructure consists of concrete abutments and pier wall and CRM wingwalls. The abutments and pier bear directly on natural rock formations.

Setting of Kapaula Stream Bridge
Courtesy of FAI

Kapaula Gulch
Courtesy of NOEI

Hana approach to Kapaula Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kapaula Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railings, upstream side
Courtesy of NOEI

Concrete open vertical railings, downstream side
Courtesy of NOEI

Bridge name painted on cap
Courtesy of FAI

Concrete abutment, Kahului side
Courtesy of NOEI

Concrete pier wall
Courtesy of NOEI

Upstream CRM wingwall, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Kapaula and Puuhaehae
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Piers
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of concrete abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Exemplary example of concrete pier on natural rock formation on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Vegetation is heavily overgrown • Bridge spans deep gorge; intermediate support built on lava rock formation in streambed • Open clearing setting
Character Defining Features	• Concrete Tee Beam Bridge • Concrete Pier Wall on natural rock formation • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Existing non-historic cementitious materials on face of CRM wingwalls

Significance & Context

Archaeological / Cultural Significance

The place name *Kapaula* is defined as, "red enclosure. Land section, Koolau, Maui."[1] The Kapaula Stream Bridge spans the Kapaula Gulch, which forms the boundary between Kapaula Ahupuaa and Puhaehae Ahupuaa.[2, 3, 4] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[5]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kapaula Stream Bridge.

1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

3 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

4 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	East Bound: Clear West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left Object Marker (OM3-L) • Yield Sign (R1-2) • Yield Line
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.35 • Operating Rating = 0.45
Condition	Functionally Obsolete

Civil & Traffic

Kapaula Stream Bridge is located at mile point 23.31 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables cross Hana Highway west of Kapaula Bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 22, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[6] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*, and a 3 for *structural evaluation*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings have a height of 30 inches and 29 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.35 and the operating rating is 0.45.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

6 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kapaula Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 22, 2014 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kapaula Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future Contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Kapaula Stream Bridge currently meets the width standards of a one lane bridge; therefore, no widening is needed.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Existing deck
Courtesy of NOEI

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on the current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

Existing concrete girders
Courtesy of NOEI

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship on Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

It is recommended to investigate the current material composition of the concrete abutments, concrete pier wall, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete abutments are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete abutments, it is recommended to be replaced in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions. Although the concrete pier wall resting on natural rock formation is an exemplary example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier wall, it is recommended to be replaced in-kind with a reinforced concrete structure.

The existing concrete pier wall resting on a natural rock formation is an exemplary example of this bridge component. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete pier wall resting on a natural rock formation, CRM abutments, and CRM wingwalls, which show evidence of excellent historic craftsmanship, is recommended through preservation and routine maintenance.

The natural rock foundations of this bridge are unique in the bridge's construction and contribute to the overall setting of the bridge. Therefore, all efforts should be made to preserve the appearance of the natural rock during bridge rehabilitation work. Documentation of the existing foundations is strongly recommended if it is not feasible to retain the natural rock foundations in future projects.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility of the oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-2) and a "To Oncoming Traffic" sign (R1-2a) are added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

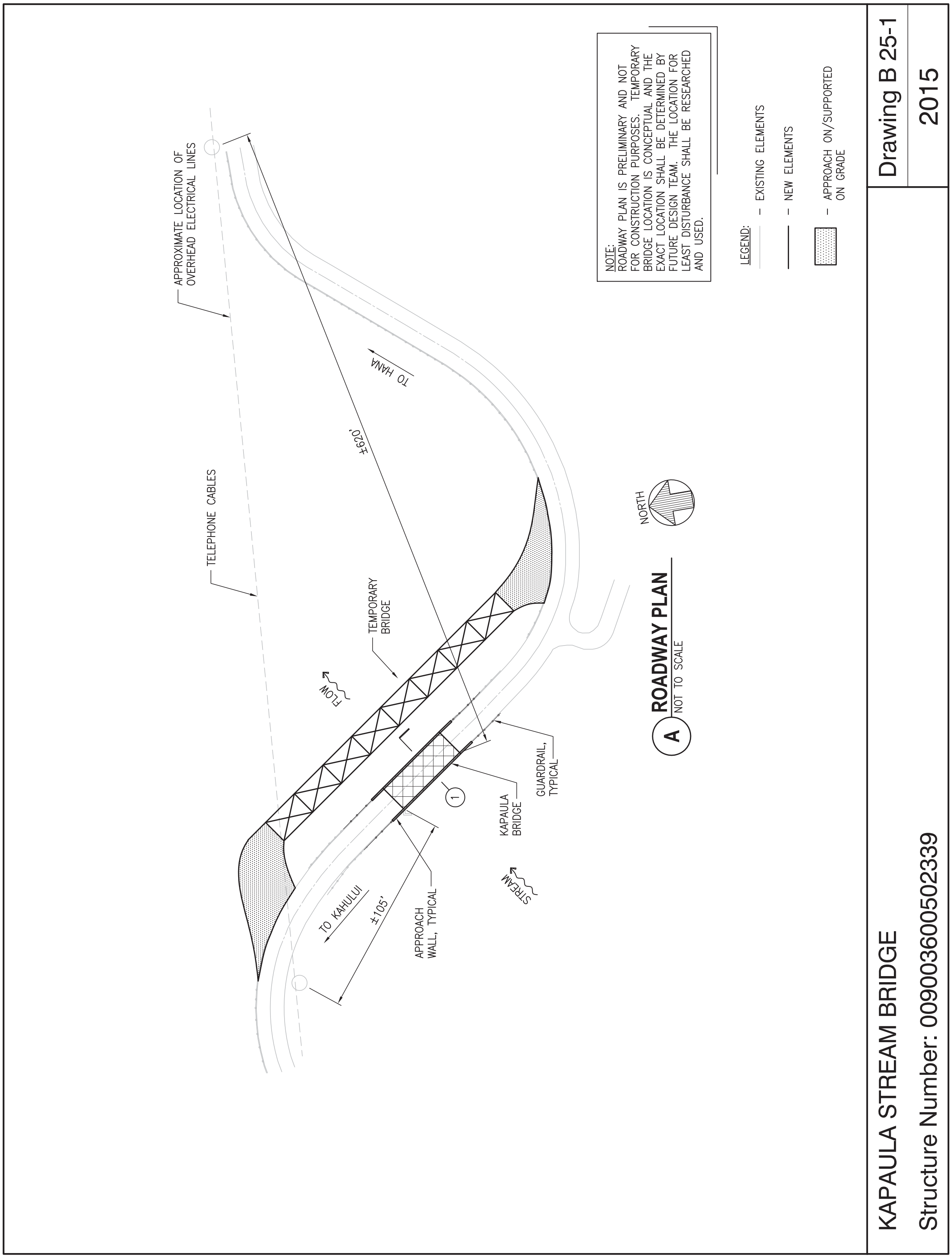
East Bridge Approach

- Add "To On Coming Traffic" plaque (R1-2a)
- Add Object Marker Type 3 - Right (OM3-R)

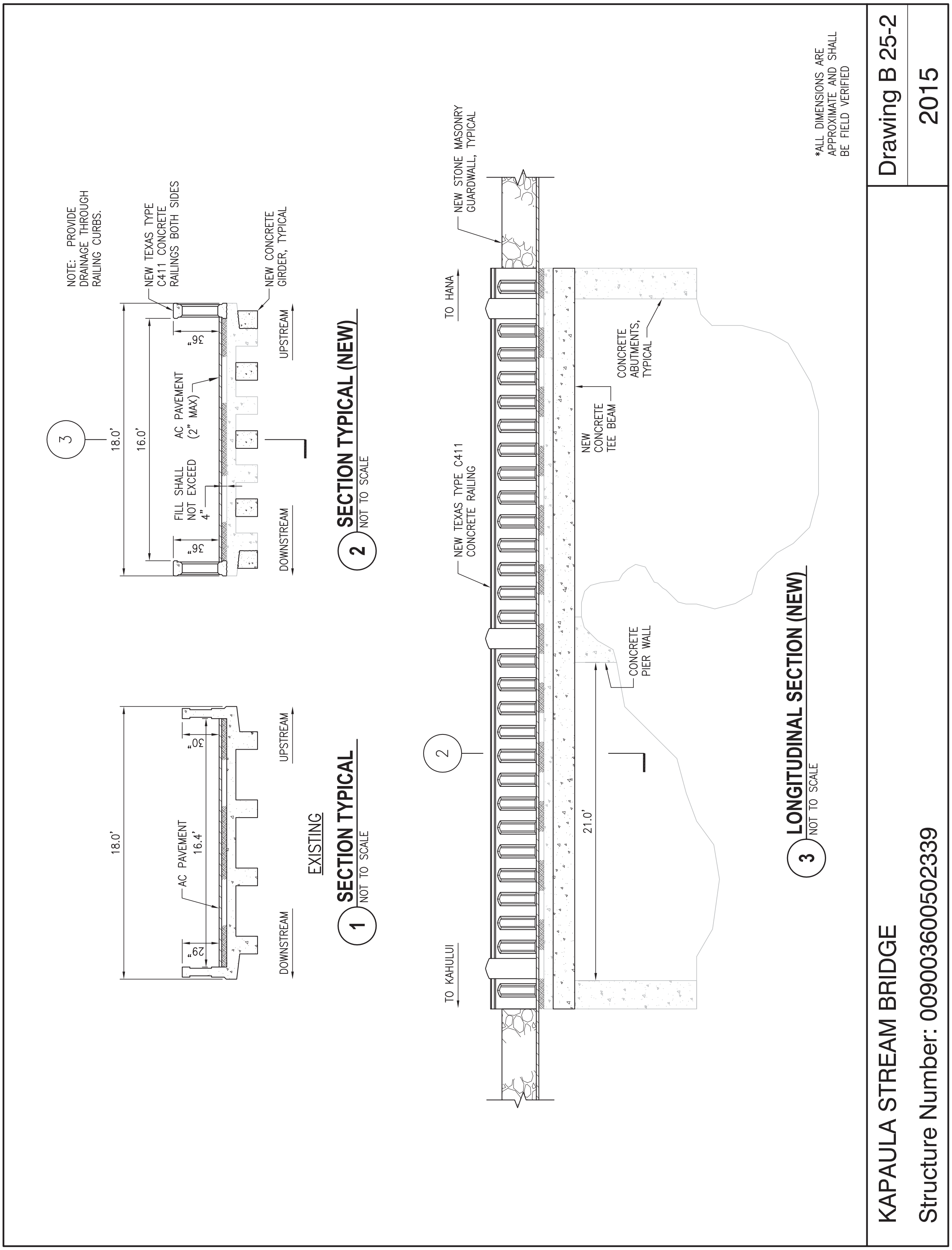
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

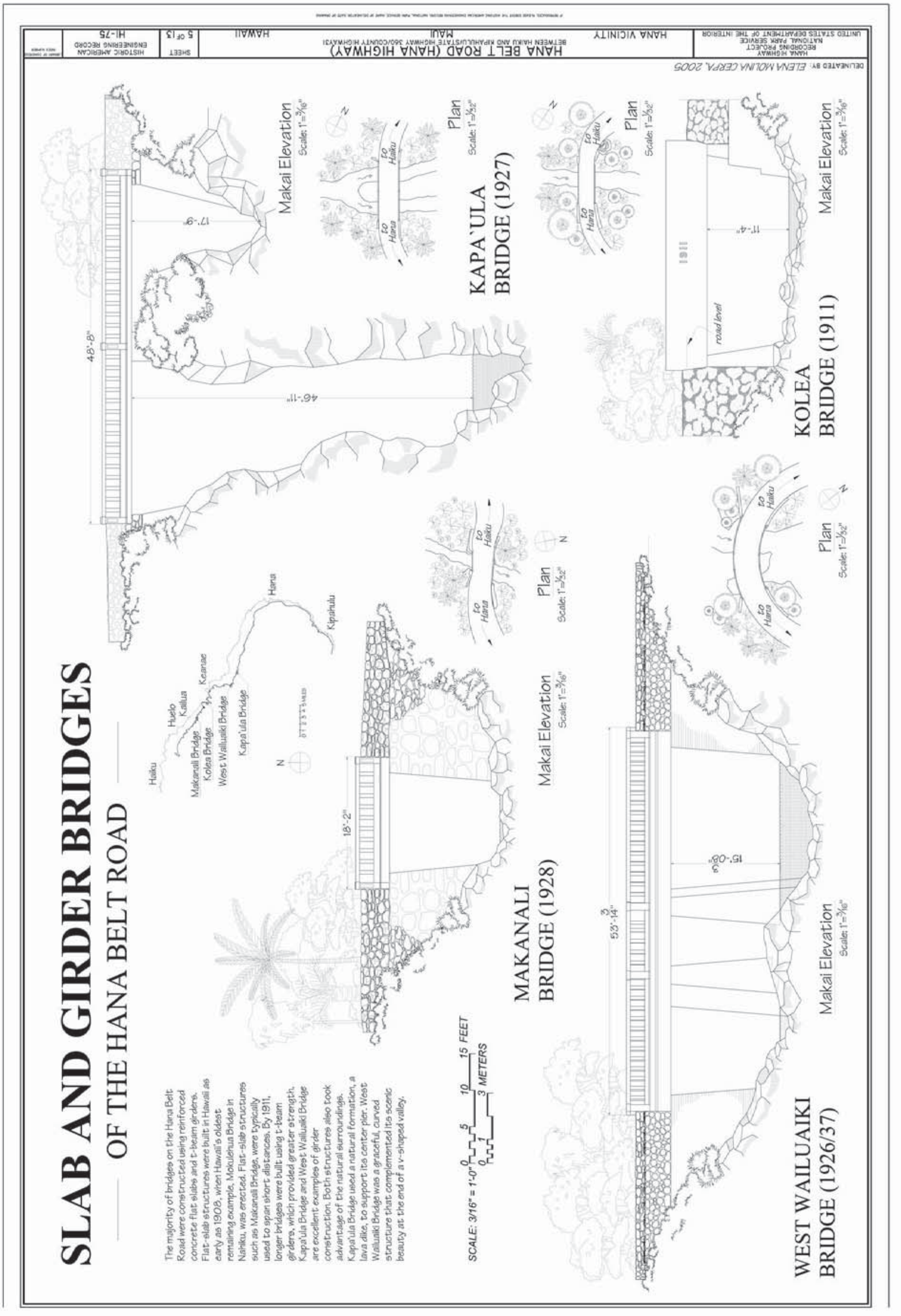
The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of HAER HI-75

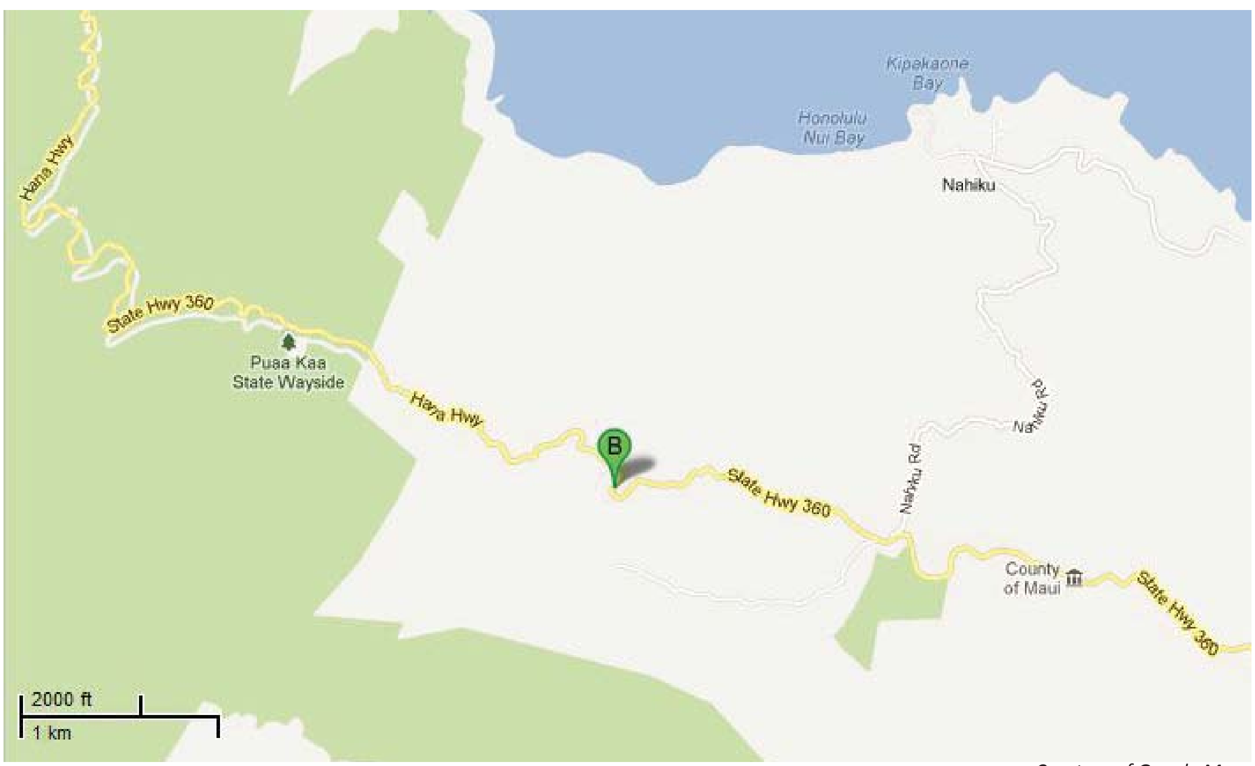
26
Hanawi Stream Bridge

26

HANAWI STREAM BRIDGE

Bridge Number	009003600502402			**Island**	Maui		
Date of Construction	1926; SPW reports indicate 1929			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 48m 35s
Longitude	156d 06m 34s
Mile Point	23.93
Location	1.03 miles west of Lower Nahiku Road
Feature Crossed	Hanawi Stream

Bridge Features

Bridge Type	Closed Spandrel Arch
Total Length	60.04 feet
Number of Spans	1
Maximum Span	36.1 feet
Deck Width	• Curb-to-Curb = 20.30 feet • Out-to-Out = 23.62 feet
Abutment Material	Concrete Arch Ring
Wingwall Material	None
Floor / Decking Material	AC Pavement
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	5
Parapet / Railing Height	• Upstream Railing Height = 24 inches • Downstream Railing Height = 30 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • Intermediate posts = 12 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Hanawi Stream Bridge is a single-span reinforced concrete closed spandrel arch bridge built in 1926 (but according to SPW reports, Hanawi was built in 1929). The structure is covered with AC pavement overlay and there is fill between the AC pavement and the reinforced concrete arch ring. The foundation at the base of the arch ring was not visible during the inspection and was concealed beneath riprap.

Setting of Hanawi Stream Bridge
Courtesy of NOEI

Hanawi Stream
Courtesy of NOEI

Hana approach to Hanawi Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Hanawi Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railings, downstream side
Courtesy of FAI

Concrete open vertical railings, upstream side
Courtesy of NOEI

Concrete arch ring
Courtesy of NOEI

Small shack by the bridge
Courtesy of FAI

Natural rock foundation, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Hopenui
Designer / Builder	County Engineer's Office
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Exceptional Arched Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Arch bridges are an uncommon bridge type • Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of closed spandrel arch bridge on Hana Highway, Route 360 • Good intact example of concrete arch ring on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Multiple waterfalls in the immediate area, with a picturesque waterfall that flows into a pond framed by small flowering shrubs on the upstream side • Gradually sloping hillside topography with rocky landscape • A small, green dilapidated shack covered in graffiti stands at the inner curve on the Kahului side of the bridge • Unconnected concrete remnant of earlier bridge pier wall on downstream side
Character Defining Features	• Closed Spandrel Arch Bridge • Board Formed Concrete Arch Ring • Concrete Open Vertical Railings • Alignment on curve
Detracting Features	• Excessive asphalt • Cementitious material on face of rock foundation • Existing waterline at upstream elevation

Significance & Context

Bridge Site History DOT

> *DOT records state that the [#26] Hanawi Bridge, which is a twin bridge of [#29] Kuhiwa, was also built in 1926. The SPW Report, however, noted that Hanawi Bridge and its approach were built for $7,600 in 1929. The SPW Report recorded the bridges that were built by the county, and as per the law, checked and approved by the SPW.*[1]

Archaeological / Cultural Significance

The place name *Hanawi* is defined as, "seeking freshwater shellfish. Stream, Koolau. Maui."[2] The Hanawi Stream Bridge spans the Hanawi Stream, located in the Hopenui Ahupuaa.

The Koolau Ditch, an irrigation canal over 40 miles long, runs along the windward side of Haleakala from above Nahiku to the sugar fields of Paia and Puunene. In the Nahiku region, the Koolau Ditch was described in 1915 as crossing through areas rich in field watercress, white ginger, water lemons, and mountain apples. The lands surrounding the village of Nahiku, located directly east of the mouth of the Hanawi Stream, was planted in rubber trees in the early decades of the 1900s.[3]

The Hanawi Stream in Nahiku contained a large fresh water source called Big Spring, which was the subject of a 12 year study conducted by W.O. Clark, the geologist for the Hawaiian Sugar Planters Association, between 1930 and 1942. Geologic studies were carried out at Hanawi Canyon by G. A. MacDonald between 1939 and 1940, during which he succeeded in mapping a number of perched springs and high water tables. The structure of the artesian spring which supplied the large water source was not discovered at that time, but subsequent work by the East Maui Irrigation Company located an artesian source at Hanawi for fresh water 395 feet above sea level.[4]

Refer to Section G, Appendix 1, Section 3.1.2.8 for the regional history of Nahiku, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[5]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Hanawi Stream Bridge.

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1 "Hana Belt Road," Historic American Engineering Record, HEAR HI-75 (2005), 48.

2 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

3 Alexander Hume Ford, "Around About Nahiku," *The Mid-Pacific Magazine*, 1915.

4 Territory of Hawaii, *Geology and Ground-Water Resources of the Island of Maui, Hawaii (Including Haleakala Section, Hawaii National Park),* Harold T. Stearns and Gordon A. MacDonald, Bulletin 7 of Division of Hydrography, prepared in cooperation with the Geological Survey, United States Department of the Interior (Honolulu: Advertiser Pub. Co. 1942).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by roadside brush, electrical, and structural • West Bound: Obstructed by roadside brush, electrical, and structural
Signage (as of September 2014)	West Bridge Approach • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Right Object Markers (Vandalized, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: Existing waterline at upstream elevation
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.65 • Operating Rating = 0.96
Condition	Functionally Obsolete

Civil & Traffic

Hanawi Stream Bridge is located at mile point 23.93 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 23.62 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approaches to the bridge are currently obstructed by roadside brush and an electrical structure causing poor visibility of oncoming traffic. The signs in this area are in relatively good condition except on the westbound approach the Type 3 Object Marker (Right) is vandalized. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Overhead primary circuits dead-end on the west side of Hanawi Stream Bridge. The secondary and telephone overhead lines feed shed on the west side of bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 22, 2014. The overall condition rating of the bridge at the time of inspection was good.[6] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 24 inches and 30 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.65 and the operating rating is 0.96.

The current curb-to-curb dimension is 20.30 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

6 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Hanawi Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 22, 2014 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4., iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f., a. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Hanawi Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the Area of Potential Effect (APE) for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Hanawi Stream Bridge currently meets the width standards width of a one lane bridge; therefore, no widening is needed. There are no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Existing deck
Courtesy of NOEI

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information).

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The downstream Kahului and Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining upstream approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Existing arch ring and foundation
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing which will be supported by a new continuous concrete footing constructed adjacent to the interior face of the arch ring headwall. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations & Arch Ring

It is recommended to investigate the current material composition of the concrete arch ring and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the concrete arch ring, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted. After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility of oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and “To On Coming Traffic” plaque (R1-2a)

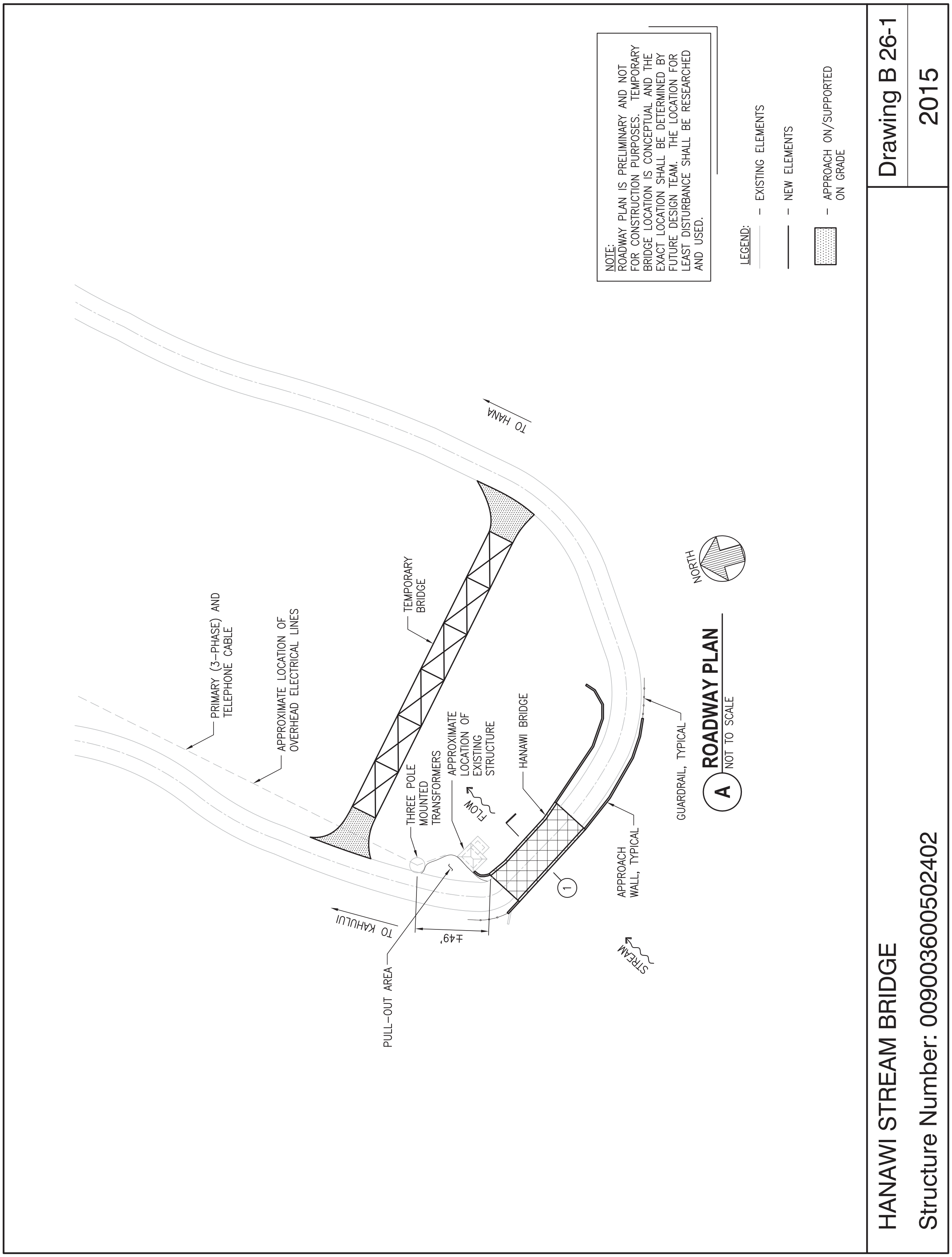
East Bridge Approach

- Add Object Marker Type 3 - Left (OM3-L)
- Replace Object Marker Type 3 - Right (OM3-R)

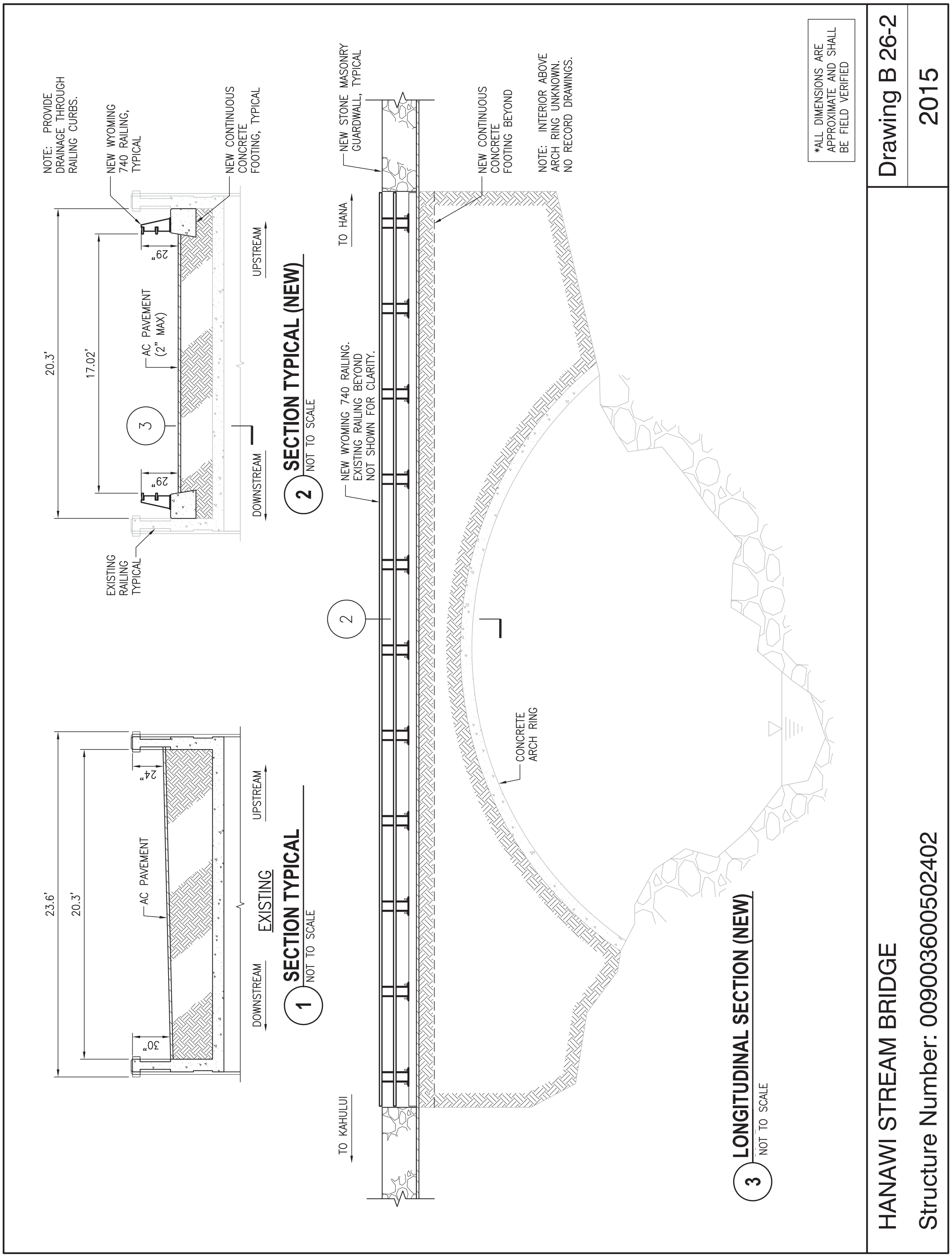
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



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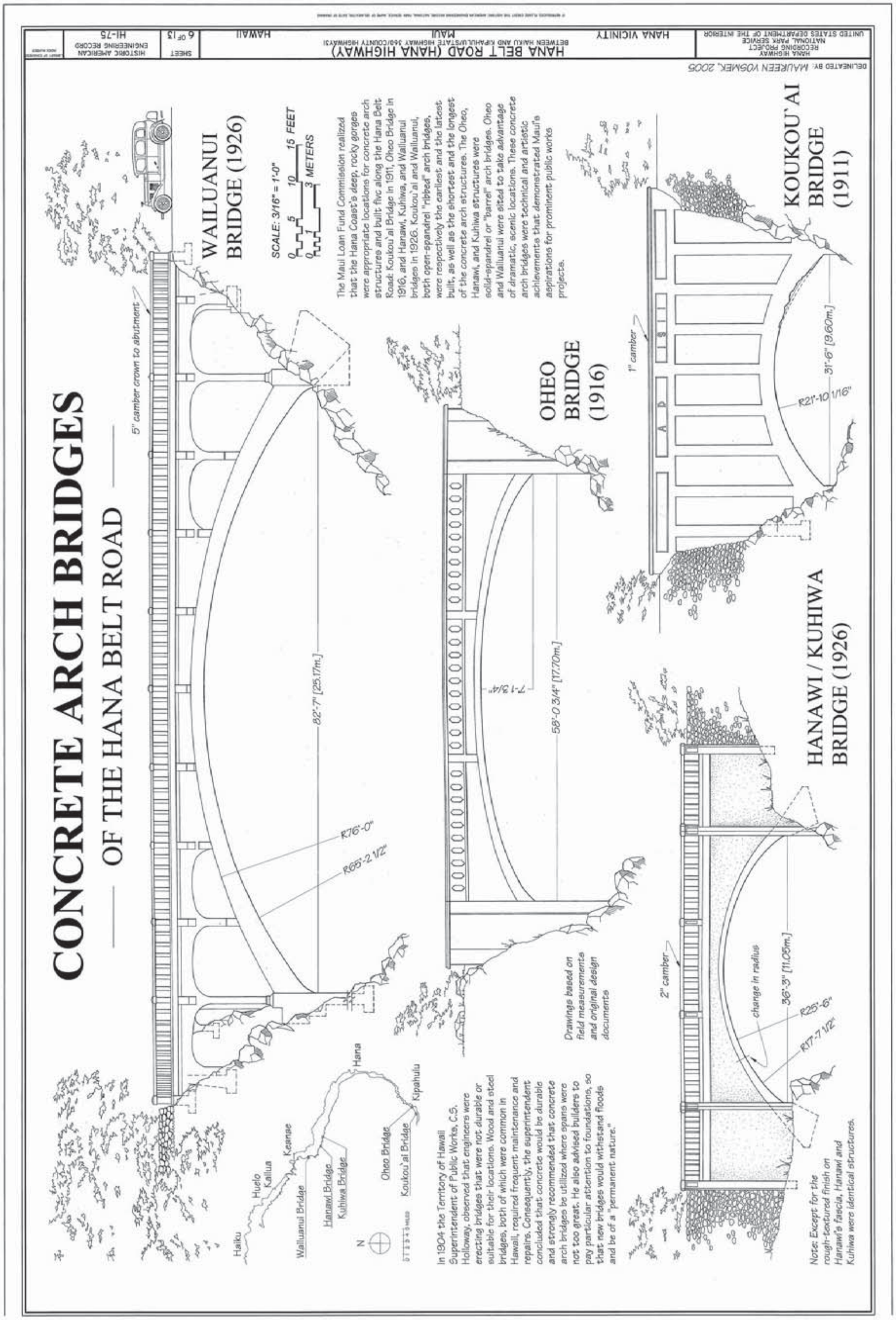

Courtesy of HAER HI-75

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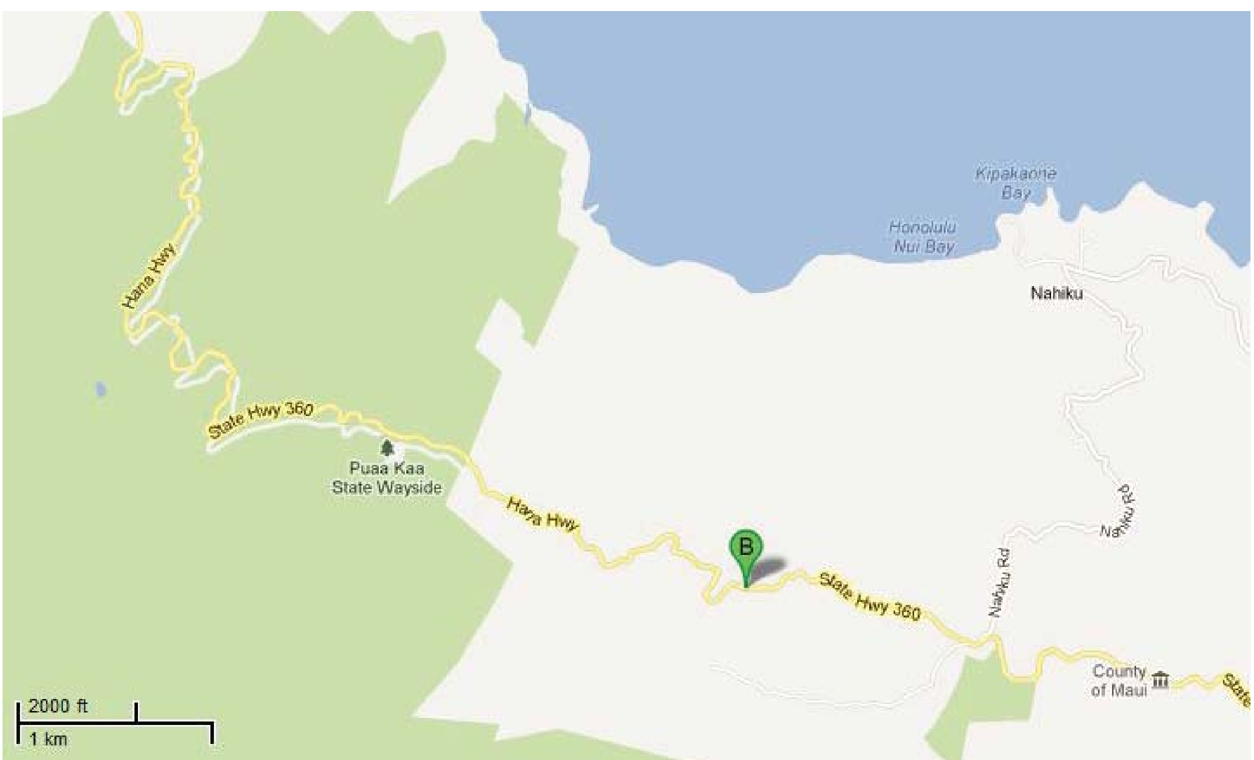
27 East Hanawi Stream Bridge

27 EAST HANAWI STREAM BRIDGE

Bridge Number	009003600502419			**Island**	Maui		
Date of Construction	1926			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 48m 36s
Longitude	156d 06m 26s
Mile Point	24.10
Location	0.86 miles west of Lower Nahiku Road
Feature Crossed	Hanawi Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	22.97 feet
Number of Spans	1
Maximum Span	18.0 feet
Deck Width	• Curb-to-Curb = 16.10 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutment
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 32 inches • Downstream Railing Height = 32 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

BRIDGE INFORMATION

Bridge Features

East Hanawi Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of East Hanawi Stream Bridge
Courtesy of NOEI

Hanawi Stream
Courtesy of NOEI

Hana approach to East Hanawi Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to East Hanawi Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railings, upstream side
Courtesy of NOEI

Concrete open vertical railings, downstream side
Courtesy of NOEI

Bridge name painted on the cap
Courtesy of FAI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Downstream CRM wingwall, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Hopenui
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Bridge spans a small stream • Open, partly shaded area with a view to the ocean • Flowering trees • Mossy growth on bridge components
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Existing non-historic cementitious materials on face of CRM abutments and CRM wingwalls

Significance & Context

Archaeological / Cultural Significance

The place name *Hanawi* is defined as, "seeking freshwater shellfish. Stream, Koolau. Maui."[1] The East Hanawi Bridge spans the East Branch of the Hanawi Stream, located in Hopenui Ahupuaa.[2]

The Koolau Ditch, an irrigation canal over 40 miles long, runs along the windward side of Haleakala from above Nahiku to the sugar fields of Paia and Puunene. In the Nahiku region, the Koolau Ditch was described in 1915 as crossing through areas rich in field watercress, white ginger, water lemons, and mountain apples. The lands surrounding the village of Nahiku, located directly east of the mouth of the Hanawi Stream, were planted in rubber trees in the early decades of the 1900s.[3]

The Hanawi Stream in Nahiku contained a large fresh water source called Big Spring, which was the subject of a 12-year study conducted by W.O. Clark, the geologist for the Hawaiian Sugar Planters Association, between 1930 and 1942. Geologic studies were carried out at Hanawi Canyon by G.A. MacDonald between 1939 and 1940, during which he succeeded in mapping a number of perched springs and high water tables. The structure of the artesian spring which supplied the large water source was not discovered at that time, but subsequent work by the East Maui Irrigation Company located an artesian source at Hanawi for fresh water 395 feet above sea level.[4]

Refer to Section G, Appendix 1, Section 3.1.2.8 for the regional history of Nahiku, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[5]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the East Hanawi Stream Bridge.

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 U.S. Geological Survey, ed., *Keanae Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 Alexander Hume Ford, "Around About Nahiku," *The Mid-Pacific Magazine*, 1915.

4 Territory of Hawaii, *Geology and Ground-Water Resources of the Island of Maui, Hawaii (Including Haleakala Section, Hawaii National Park),* Harold T. Stearns and Gordon A. MacDonald, Bulletin 7 of Division of Hydrography, prepared in cooperation with the Geological Survey, United States Department of the Interior (Honolulu: Advertiser Pub. Co. 1942).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.43
Condition	Functionally Obsolete

Civil & Traffic

East Hanawi Stream Bridge is located at mile point 24.10 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition on both approaches to the bridge. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 22, 2014. The overall condition rating of the bridge at the time of inspection was fair.[6] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 31.5 inches and 35 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.43.

The current curb-to-curb dimension is 16.10 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

6 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of East Hanawi Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 22, 2014 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If East Hanawi Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The East Hanawi Stream Bridge currently meets the width standards of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the

Existing deck
Courtesy of NOEI

deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information).

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the upstream and downstream Kahului approach corners to the bridge after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. A*pproach Walls and Safety Features at the Approaches*). Culvert 42C, East Hanawi Culvert, is in close proximity to this bridge; therefore, it is recommended to have the stone masonry guardwall be continuous between the upstream and downstream Hana parapets. The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

Existing concrete girders
Courtesy of NOEI

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Although the CRM abutments are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5 *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

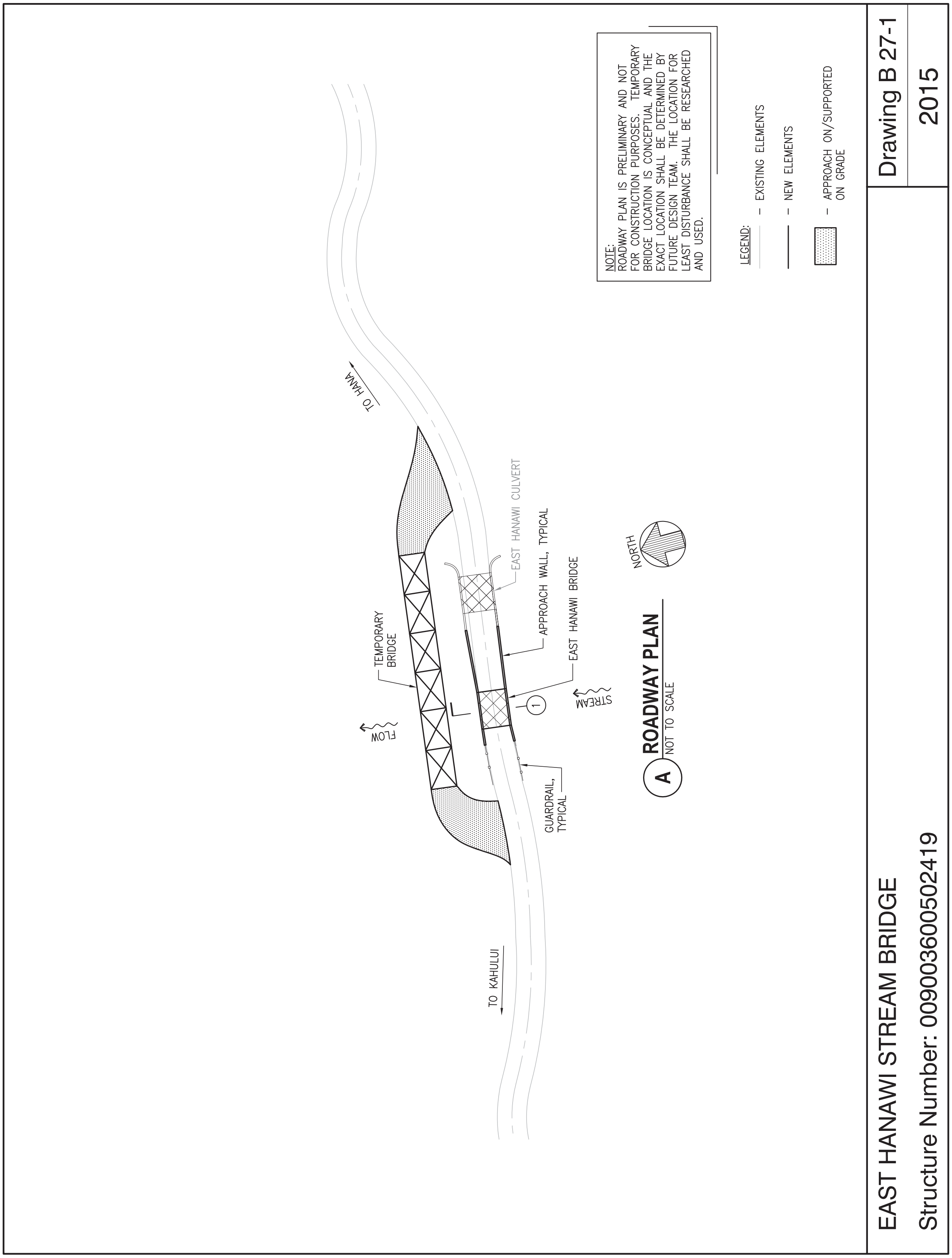
Civil, Traffic, & Signage

In regard to visibility on oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-2), a "To Oncoming Traffic" sign, and a yield line are added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Currently, there are no signage, traffic, and visibility recommendations.

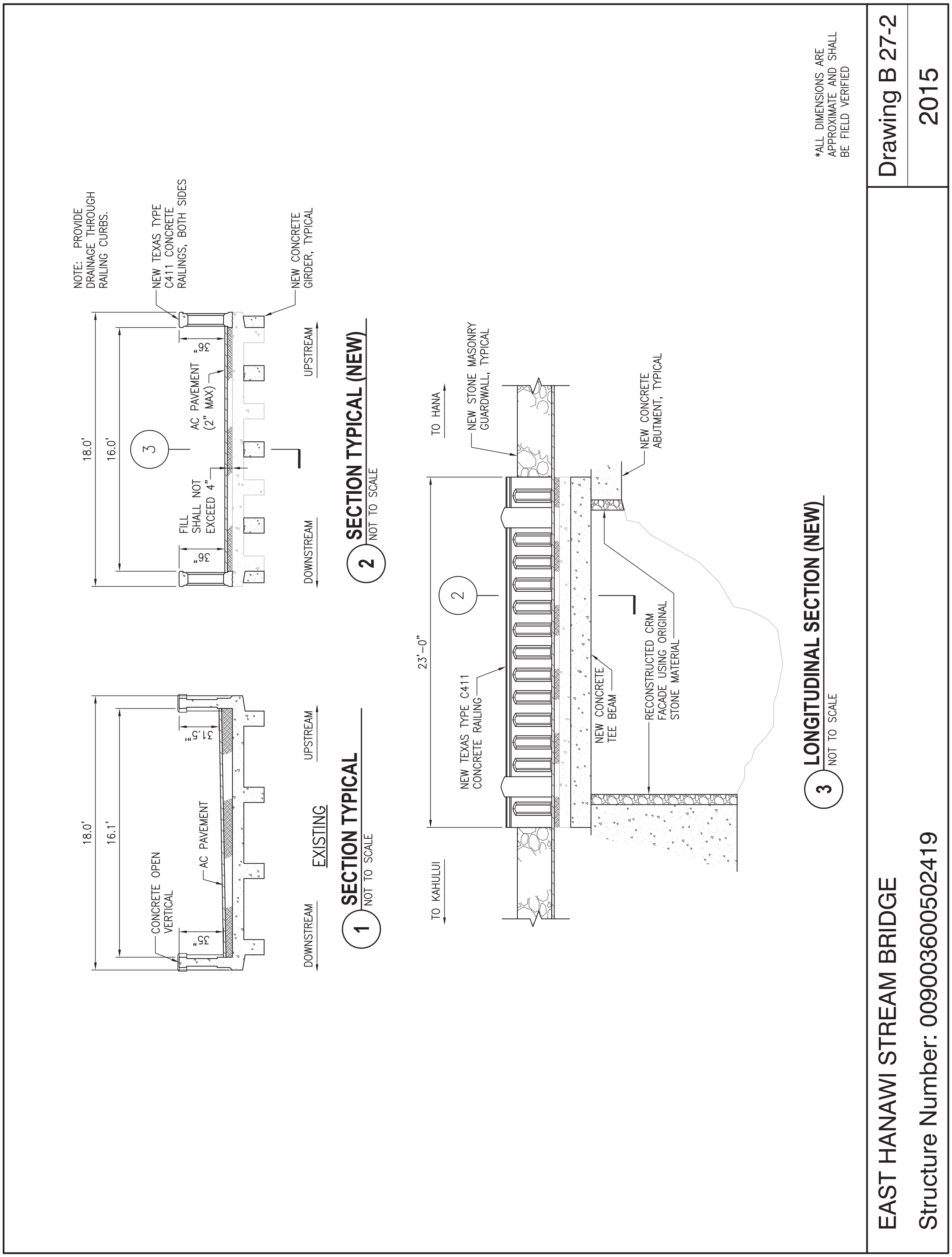
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for East Hanawi Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

28

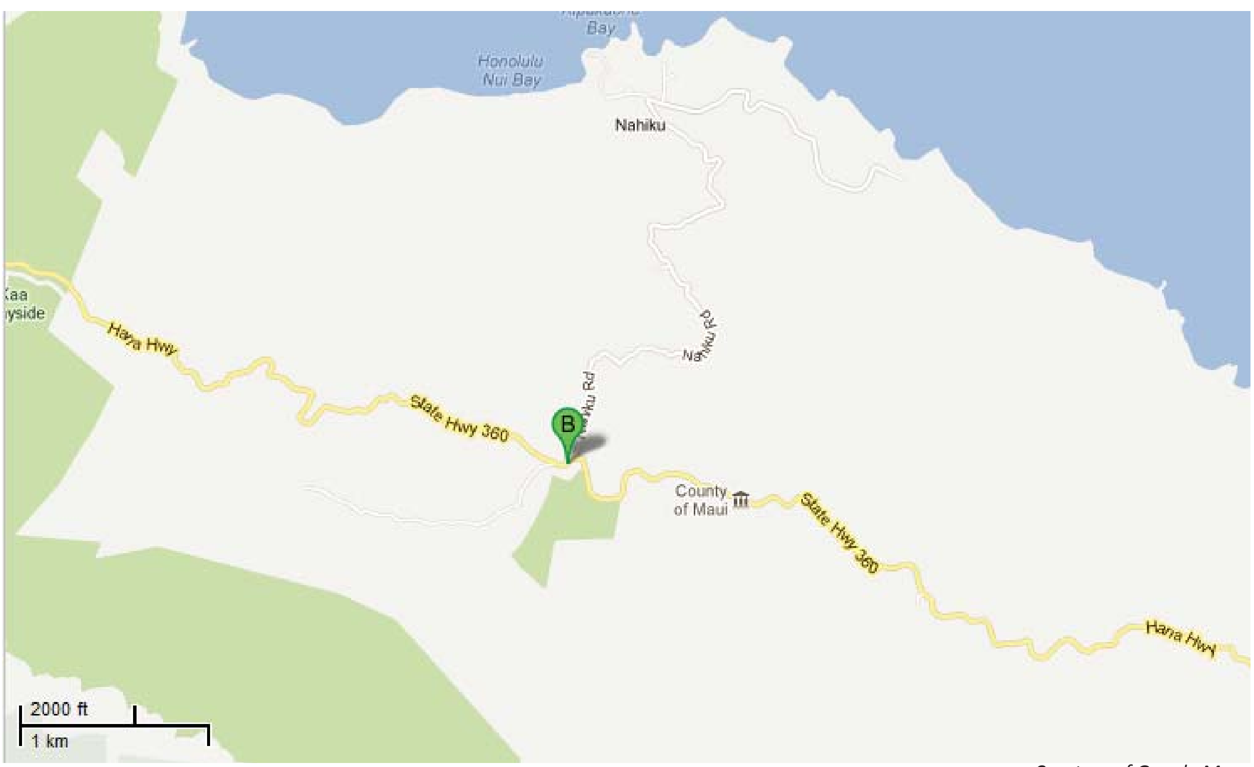
Makapipi Stream Bridge

28

MAKAPIPI STREAM BRIDGE

Bridge Number	009003600502502			Island		Maui	
Date of Construction	1926			Route		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 27s
Longitude	156d 05m 46s
Mile Point	24.92
Location	0.03 miles west of Lower Nahiku Road
Feature Crossed	Makapipi Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	40.03 feet
Number of Spans	2
Maximum Span	22.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	• CRM Abutments • Reinforced Concrete Pier Cap and Columns on a Concrete Pier Wall
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	2
Parapet / Railing Height	• Upstream Railing Height = 29 inches • Downstream Railing Height = 31 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • Intermediate posts = 12 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Makapipi Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span. The substructure consists of CRM abutments, reinforced concrete pier cap and columns supported on a concrete pier wall, and CRM wingwalls. The abutments and pier bear directly on natural rock formations.

Setting of Makapipi Stream Bridge
Courtesy of NOEI

Makapipi Stream
Courtesy of NOEI

Hana approach to Makapipi Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Makapipi Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Concrete pier
Courtesy of NOEI

Significance & Context

Ahupuaa	Honolulu Iki and Makapipi
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good example of CRM abutments on Hana Highway • Good example of concrete pier cap and columns on concrete pier wall on Hana Highway • Good example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• At Lower Nahiku Road intersection • Heavy vegetation, lush groundcover in this open, yet shaded area • An enclave of tall trees frames a curving stream and opens to the sky on the upstream side • Dramatic drop on the rocky downstream side to a gorge below • The substructure of the bridge is visible from the Hana approach, providing a picturesque view of both the bridge and waterfall
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • Reinforced Concrete Pier Cap and Columns on a Concrete Pier Wall • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Non-historic cementitious materials on face of CRM abutments, CRM wingwalls, and concrete pier wall with pier cap and columns • Utility pipes on upstream side

Significance & Context

Archaeological / Cultural Significance

The place name *Makapipi* is defined as, "sprinkled eyes. Stream, Hana, Maui."[1] The Makapipi Stream Bridge spans Makapipi Stream, which divides Honolulu Iki Ahupuaa and Makapipi Ahupuaa,[2, 3] and cuts through Nahiku Homesteads.

Nahiku was a fertile *ahupuaa*, which was cleared and terraced with irrigated taro cultivated in the tradition of Native Hawaiians.[4] In ancient times, the settlement at Nahiku spread over gently rising ground above the shore, with a number of groups of loi watered from Makapipi Stream.[5] Along the shore there was a *hala* forest that extended from Ulaino to Hana.[6] The region above Nahiku was traditionally forested with native trees such as *koa*, *ohia lehua*, and sandalwood. According to Handy, many plants that were used for native medicine also grew there.

In the late 1890s, sugar was grown in the Nahiku region. The Nahiku Sugar Company completed the construction of a landing for the government of Hawaii in 1901, and laid rails for construction of a derrick at the landing. Although the Hana Plantation began railroad operations in 1883,[7] there appears to be no record of the use of locomotives at the Nahiku Sugar Company. In 1902 there was talk of a planned merger with the Hana Sugar Plantation, by which the Hana Plantation would pay an annual rental of $4,500 over a 26-year lease which included a valuable set of water rights.[8] The sugar plantation land at Nahiku was acquired by the Hawaiian Commercial & Sugar Company and the East Maui Irrigation Company in 1921.[9]

In the early 1900s, Nahiku became the site for a number of competing rubber plantations. At that time, there was a growing demand for rubber for automobile tires.[10] The Nahiku Rubber Company was in operation in 1905. The Koolau Plantation operated in the region in 1907. The American-Hawaiian Rubber Company operated in the region in the mid-1910s, and became the largest employer in the region. A decline in the price of rubber doomed the industry. After testing for several years, the rubber growers came to the conclusion that it would not be profitable to continue. It was found that the temperature was hardly warm enough for rubber to grow best, and that labor was much more expensive than in Malaysia.[11] The oldest of the rubber plantations, The Nahiku Rubber Company, Ltd., which had been managed by David Colville Lindsay, was closed on January 20, 1915.[12]

1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

3 W. D. Alexander, "Map of the Koolau Coast Maui: From Wailuanui to Keaa," registered map no. 1066 (1878).

4 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

5 Ibid.

6 Robert Wenkam, *Maui: The Last Hawaiian Place* (San Francisco: Friends of the Earth, 1970).

7 Jesse C. Conde, "Fowler Locomotives in the Kingdom of Hawaii," *The Narrow Gauge*, Special Issue, The Narrow Gauge Railway Society (1993).

8 W. J. Thompsom, *Hawaii Vol. 37*, Louisiana Planter and Sugar Manufacturer Company (New Orleans: 1902).

9 Frederick Hatch, *Moody's Manual of Railroads and Corporation Securities* (New York: Poor's Publishing Company, 1922).

10 D. C. Lindsay, "Rubber in Hawaii," *The Hawaiian Forester and Agriculturist IV* (October 1907).

11 Otis Willard Freeman, "The Economic Geography of Hawaii," *Research Publications no. 2* (Honolulu: University of Hawaii, 1927).

12 John William Siddall, "Men of Hawaii: Being a Biographical Reference Library, Complete and Authentic," vol. I (Territory of Hawaii: Honolulu Star-Bulletin, 1917).

Refer to Section G, Appendix 1, Section 3.1.2.8 for the regional history of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[13]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Makapipi Stream Bridge.

13 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Right Object Marker (Vandalized, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Right Object Markers (OM3-R)
Apron	None
Civil Utilities	• Sewer: None • Water: Utility pipes upstream
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead telephone lines and other unidentified communication type cables located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.42
Condition	Functionally Obsolete

Civil & Traffic

Makapipi Stream Bridge is located at mile point 24.92 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the Type 3 Object Marker (Right) is bent on the eastbound approach to the bridge. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass nearby on the downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 22, 2014. The overall condition rating of the bridge at the time of inspection was fair.[14] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 29 inches and 31 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.42.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

14 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Makapipi Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 22, 2014 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Makapipi Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Makapipi Stream Bridge currently meets the width standards of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Existing deck
Courtesy of NOEI

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information).

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Hana approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining three approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are good intact examples of these component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Existing CRM wingwall on upstream Kahului side
Courtesy of NOEI

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5 *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete pier wall and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the reinforced concrete pier cap and columns is a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate, it is recommended to be replaced in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, CRM wingwalls, and concrete pier wall, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic & Signage

In regard to visibility of the oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that "Left/Right Object Marker" signs are added to the bridge end treatments at the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the Ma*nual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition* by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Object Marker Type 3 - Left (OM3-L)
- Replace Object Marker Type 3 - Right (OM3-R)

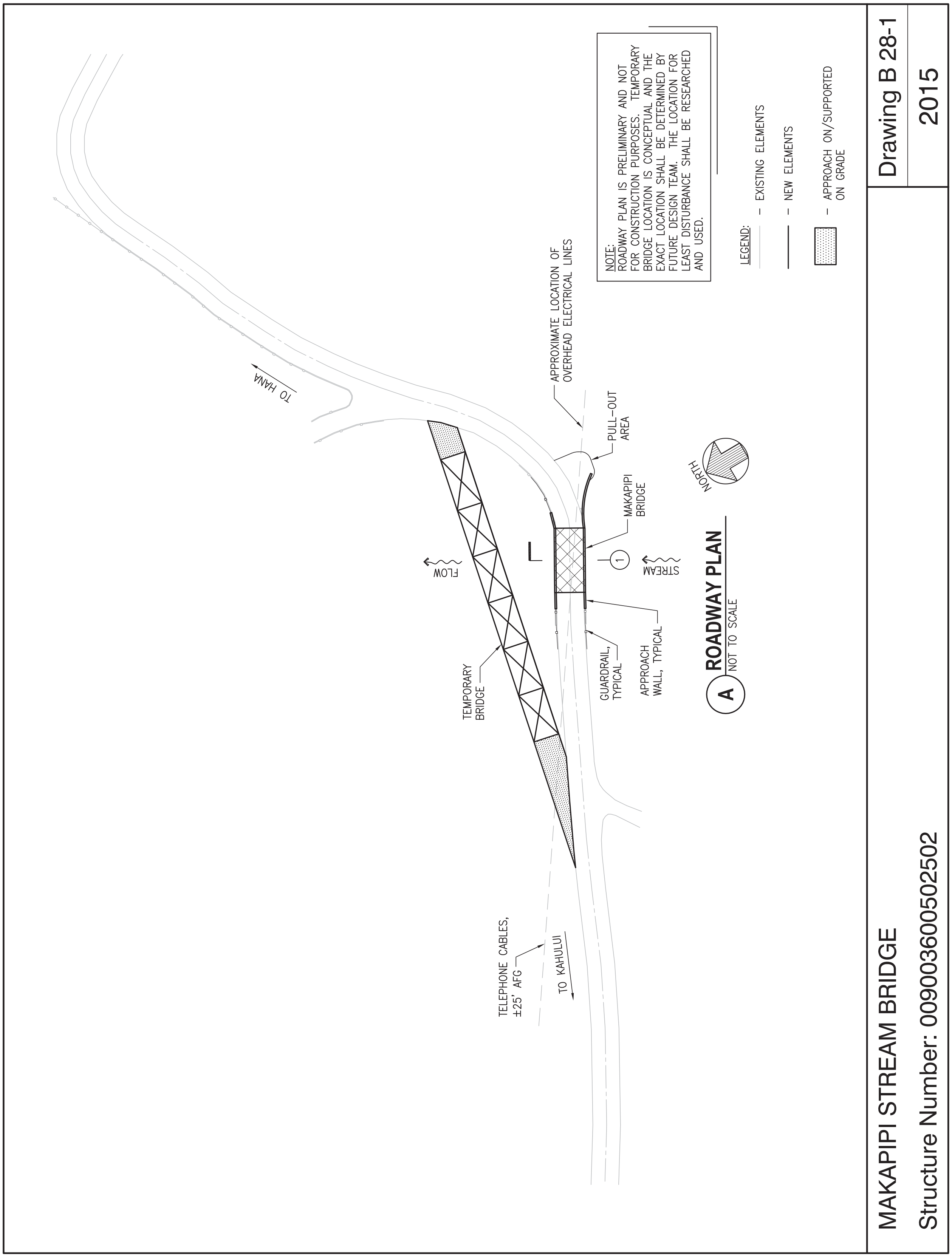
East Bridge Approach

- Type 3 - Left (OM3-L)

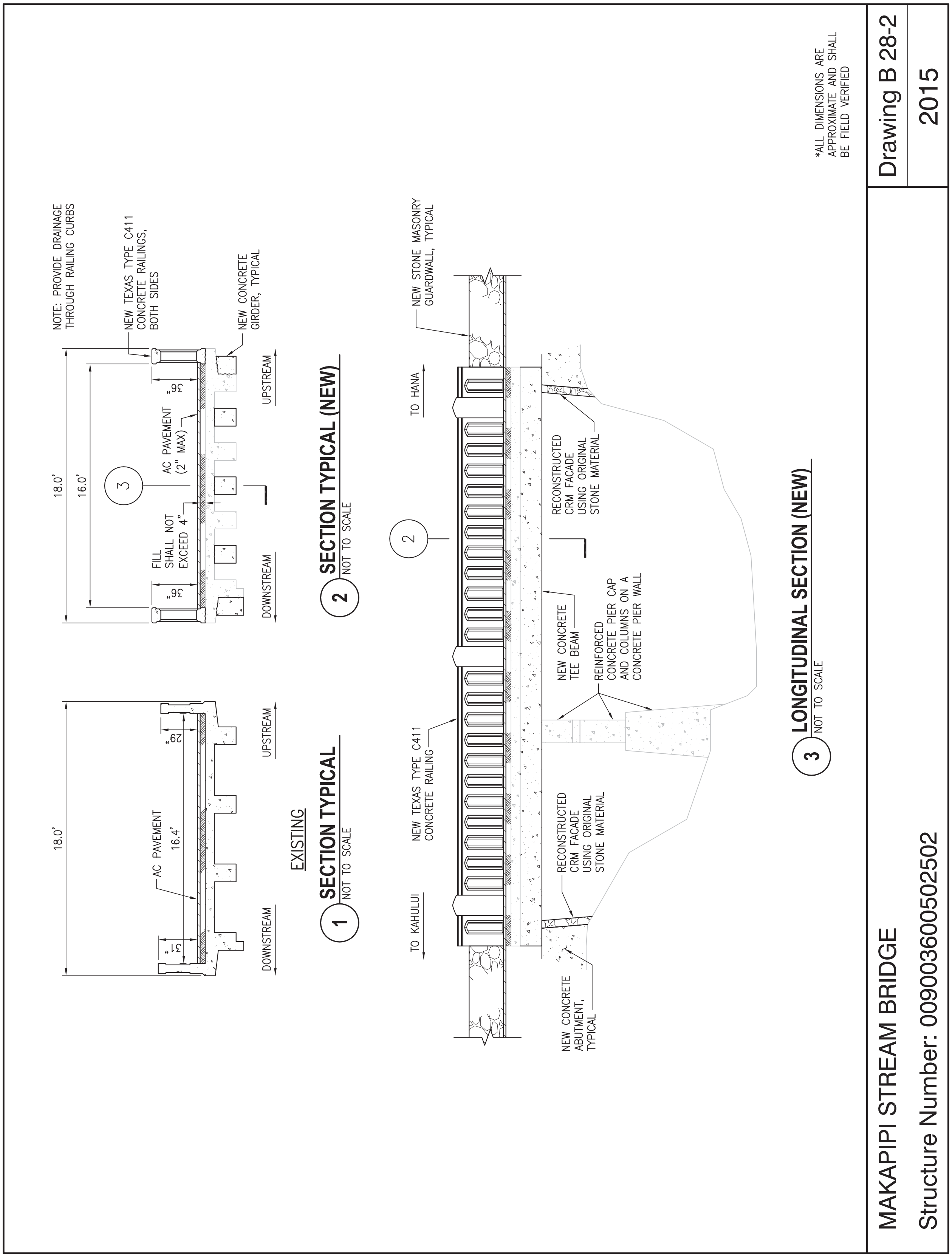
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Telephone lines are over the area of work but the contractor can coordinate with the utility companies and take steps to ensure the safety of his crew and that the existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI

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29

Kuhiwa Stream Bridge

29

KUHIWA STREAM BRIDGE

Bridge Number	009003600502523			**Island**	Maui		
Date of Construction	1926; *Maui News* Indicates 1927			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 22s
Longitude	156d 05m 40s
Mile Point	25.14
Location	0.18 miles east of Lower Nahiku Road
Feature Crossed	Kuhiwa Stream

Bridge Features

Bridge Type	Concrete Arch - Deck
Total Length	60.04 feet
Number of Spans	1
Maximum Span	36.1 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.37 feet
Abutment Material	Reinforced Concrete Arch Ring
Wingwall Material	Boulder Concrete Wingwalls
Floor / Decking Material	AC Pavement
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	5
Parapet / Railing Height	• Upstream Railing Height = 28 inches • Downstream Railing Height = 31 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 18 inches on-center • Intermediate posts = 10 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Cap Profile	• Rectangular cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kuhiwa Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1926 (*The Maui News* reports a completion date of 1927). The reinforced concrete structure is covered with AC pavement overlay and there is fill between the AC pavement and the reinforced concrete arch ring. The wingwalls are comprised of boulder concrete. The Kahului and Hana skewbacks bear directly on natural rock formation.

Setting of Kuhiwa Stream Bridge
Courtesy of NOEI

Kuhiwa Stream
Courtesy of FAI

Hana approach to Kuhiwa Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kuhiwa Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railings, downstream side
Courtesy of NOEI

Concrete open vertical railings, upstream side
Courtesy of NOEI

Upstream CRM approach wall, Hana side
Courtesy of NOEI

Reinforced concrete arch ring
Courtesy of NOEI

Reinforced concrete arch ring
Courtesy of NOEI

CRM in-fill cavity at bridge base
Courtesy of NOEI

Significance & Context

Ahupuaa	Makapipi and Kuhiwa
Designer / Builder	A. H. Wong of County Engineer's Office
Historic Drawings	August 1926
Alterations	None
Replacement	None
Preservation Priority	Exceptional Arched Bridge
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Arch bridges are an uncommon bridge type • Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good example of closed spandrel arch bridge on Hana Highway • Good intact example of concrete arch ring on Hana Highway • Good intact example of boulder concrete wingwalls on Hana Highway • Exemplary example of natural rock formation with CRM in-fill cavity at foundation on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None documented
Geographical Features / Setting	• Dramatic approach to bridge, although bridge superstructure is not immediately visible • Adjacent to Kuhiwa State Forest Reserve • Adjacent to private residence (Hana side) • Wooded area with tall bamboo trees, dramatic, picturesque tiered waterfall and pond arrangement • Large rocky streambed below bridge
Character Defining Features	• Closed Spandrel Arch Bridge with Board Form Texture • Board Formed Texture at Reinforced Concrete Arch Ring • Concrete Open Vertical Railings • CRM foundation at the bottom of the bridge
Detracting Features	• Excessive asphalt • Non-historic cementitious materials on face of CRM foundation

Significance & Context

Bridge Site Context

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he present bridge, built in 1926, replaced an earlier timber bridge characterized by a center pier, trestle bents and a wooden deck. This earlier bridge serviced an unpaved trail to Keanae. The County apparently built the concrete arch bridge in 1926-7 as part of the Keanae-Nahiku extension worked on in the 1920s."[1] Other "[s]imilar replacement projects were conducted at Naʻiliʻilihaele, Keaʻaiki, Oiliwai [*sic*], [and] Manawaikeae…"[2]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[3]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the Superintendent of Public Works stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[4]

At this time, the early Department of Public Works began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[5]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[6] By 1927, the local newspaper Maui News observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[7] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

According to the HAER HI-75 report, a *Maui News* article establishes the date of construction for Kuhiwa Stream Bridge as November 1927; however, HDOT records indicate the bridge was constructed in 1926.[8]

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1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 45.

2 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 30.

3 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

4 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

5 Ibid.

6 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

7 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

8 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 47-48.

Refer to Section A, Chapter 7. iv. *Design & Construction of Bridges on the Road to Hana* for further discussion of this bridge.

Archaeological / Cultural Significance

The Hawaiian word *kuhiwa* is defined as, "Special taboo made by a chief; to be subject to this taboo."[9] The Kuhiwa Stream Bridge spans Kuhiwa Stream, which runs through Nahiku Homesteads,[10] 48 and divides Kuhiwa Ahupuaa and Makapipi Ahupuaa.[11]

Nahiku was a fertile *ahupuaa*, which was cleared and terraced with irrigated taro cultivated in the tradition of Native Hawaiians.[12] In ancient times, the settlement at Nahiku spread over gently rising ground above the shore, with a number of groups of loi watered from Makapipi Stream.[13] Along the shore there was a *hala* forest that extended from Ulaino to Hana.[14] The region above Nahiku was traditionally forested with native trees such as *koa*, *ohia lehua*, and sandalwood. According to Handy, many plants that were used for native medicine also grew there.

In the late 1890s, sugar was grown in the Nahiku region. The Nahiku Sugar Company completed the construction of a landing for the government of Hawaii in 1901, and laid rails for construction of a derrick at the landing. Although the Hana Plantation began railroad operations in 1883,[15] there appears to be no record of the use of locomotives at the Nahiku Sugar Company. In 1902 there was talk of a planned merger with the Hana Sugar Plantation, by which the Hana Plantation would pay an annual rental of $4,500 over a 26-year lease which included a valuable set of water rights.[16] The sugar plantation land at Nahiku was acquired by the Hawaiian Commercial & Sugar Company and the East Maui Irrigation Company in 1921.[17]

In the early 1900s, Nahiku became the site for a number of competing rubber plantations. At that time, there was a growing demand for rubber for automobile tires.[18] The Nahiku Rubber Company was in operation in 1905. The Koolau Plantation operated in the region in 1907. The American-Hawaiian Rubber Company operated in the region in the mid-1910s, and became the largest employer in the region. A decline in the price of rubber doomed the industry. After testing for several years, the rubber growers came to the conclusion that it would not be profitable to continue. It was found that the temperature was hardly warm enough for rubber to grow best, and that labor was much more expensive than at Malaysia.[19] The oldest of the rubber plantations, The Nahiku Rubber Company, Ltd., which had

9 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

10 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

11 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," registered map no. 2649 (1897).

12 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

13 Ibid.

14 Robert Wenkam, *Maui: The Last Hawaiian Place* (San Francisco: Friends of the Earth, 1970).

15 Jesse C. Conde, "Fowler Locomotives in the Kingdom of Hawaii," *The Narrow Gauge*, Special Issue, The Narrow Gauge Railway Society (1993).

16 W. J. Thompsom, *Hawaii Vol. 37*, Louisiana Planter and Sugar Manufacturer Company (New Orleans: 1902).

17 Frederick Hatch, *Moody's Manual of Railroads and Corporation Securities* (New York: Poor's Publishing Company, 1922).

18 D. C. Lindsay, "Rubber in Hawaii," *The Hawaiian Forester and Agriculturist IV* (October 1907).

19 Otis Willard Freeman, "The Economic Geography of Hawaii," *Research Publications no. 2* (Honolulu: University of Hawaii, 1927).

been managed by David Colville Lindsay, was closed on January 20, 1915.[20]

Refer to Section G, Appendix 1, Section 3.1.2.8 for the regional history of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[21]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kuhiwa Stream Bridge.

20 John William Siddall, “Men of Hawaii: Being a Biographical Reference Library, Complete and Authentic,” vol. I (Territory of Hawaii: Honolulu Star-Bulletin, 1917).

21 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	East Bridge Approach • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left Object Markers (OM3-L)
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	No visible existing overhead electrical installations
Load Rating	• Method of Load Rating Calculations • Inventory Rating = 0.65 • Operating Rating = 0.96
Condition	Functionally Obsolete

Civil & Traffic

Kuhiwa Stream Bridge is located at mile point 25.14 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.37 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are no visible existing overhead electrical installations.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 7, 2014. The overall condition rating of the bridge at the time of inspection was fair.[22] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 28 inches and 31 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.65 and the operating rating is 0.96.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

22 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kuhiwa Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 7, 2014, record drawings,[23] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kuhiwa Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix G4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Kuhiwa Stream Bridge currently meets the width standards of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Existing deck
Courtesy of NOEI

23 County Engineer's Office, Kuhiwa Arch Bridge 50.0 Miles, Hana District, Maui, T. H., August 1926.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used refer to (Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing which will be supported by a new concrete beam constructed adjacent to the interior face of the arch ring headwall. New concrete beam shall be detailed to recreate the existing exterior appearance. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Arch Ring

Although the boulder concrete wingwalls are good intact examples of these component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the boulder concrete wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. Prior to removal, future design team shall document the existing appearance and condition of the boulder concrete wingwalls.

It is recommended to investigate the current material composition of the concrete arch ring and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan.

The natural rock formation with CRM in-fill cavity at the foundation of this bridge are unique in the bridge's construction and contribute to the overall setting of the bridge. Therefore, all efforts should be made to preserve the appearance of the natural rock with CRM in-fill cavity during bridge rehabilitation work. Documentation of the existing natural rock formation with CRM in-fill cavity is strongly recommended if it is not feasible to retain them in future projects.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the natural rock formation with CRM in-fill cavity at foundation, concrete arch ring, and boulder concrete wingwalls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

CRM in-fill cavity at bridge base
Courtesy of NOEI

The natural rock foundations of this bridge are unique in the bridge's construction and contribute to the overall setting of the bridge. Therefore, all efforts should be made to preserve the appearance of the natural rock during bridge rehabilitation work. Documentation of the existing foundations is strongly recommended if it is not feasible to retain the natural rock foundations in future projects.

Natural rock formation
Courtesy of NOEI

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted. After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic & Signage

In regard to visibility to oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)

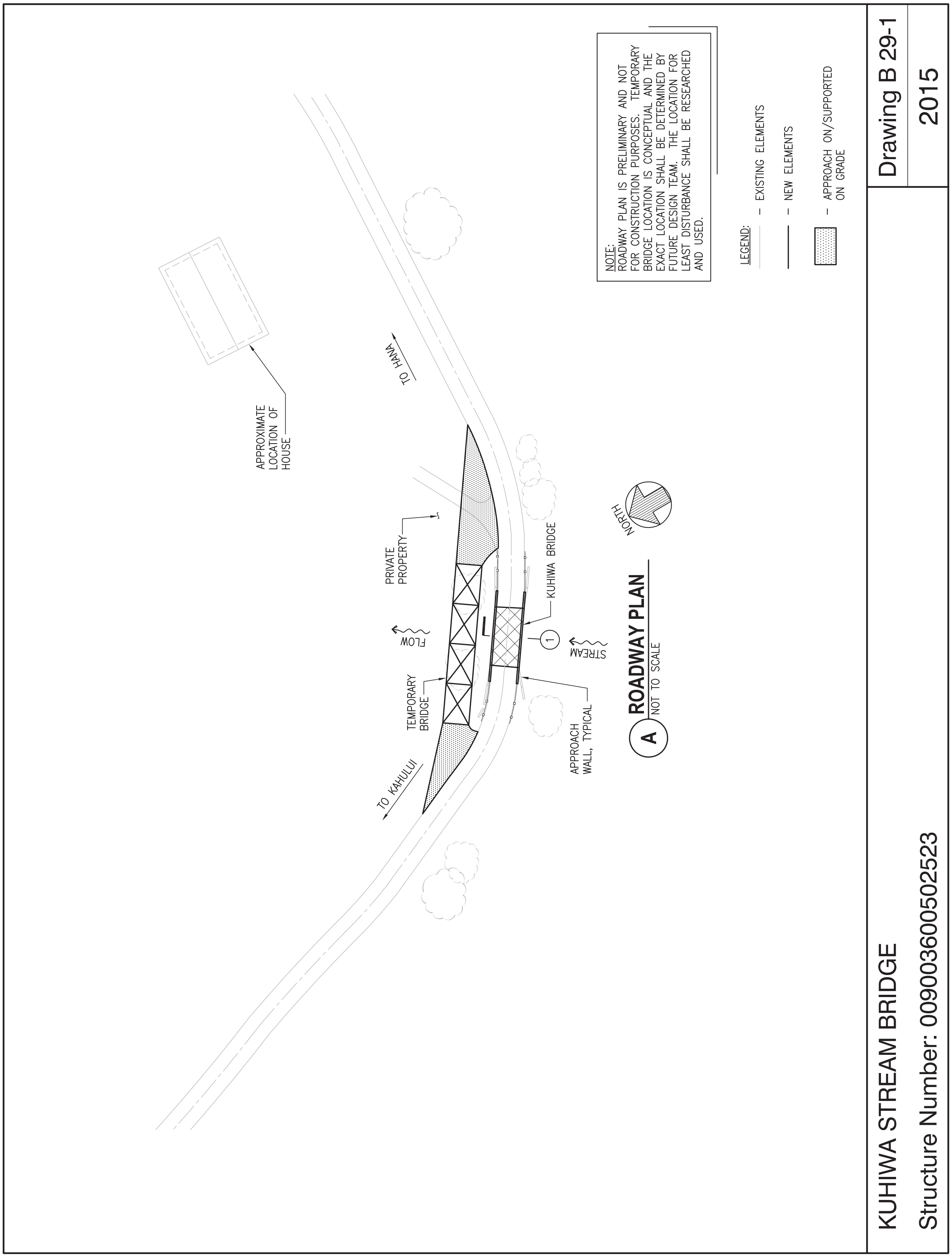
East Bridge Approach

- Add Object Marker Type 3 - Right (OM3-R)

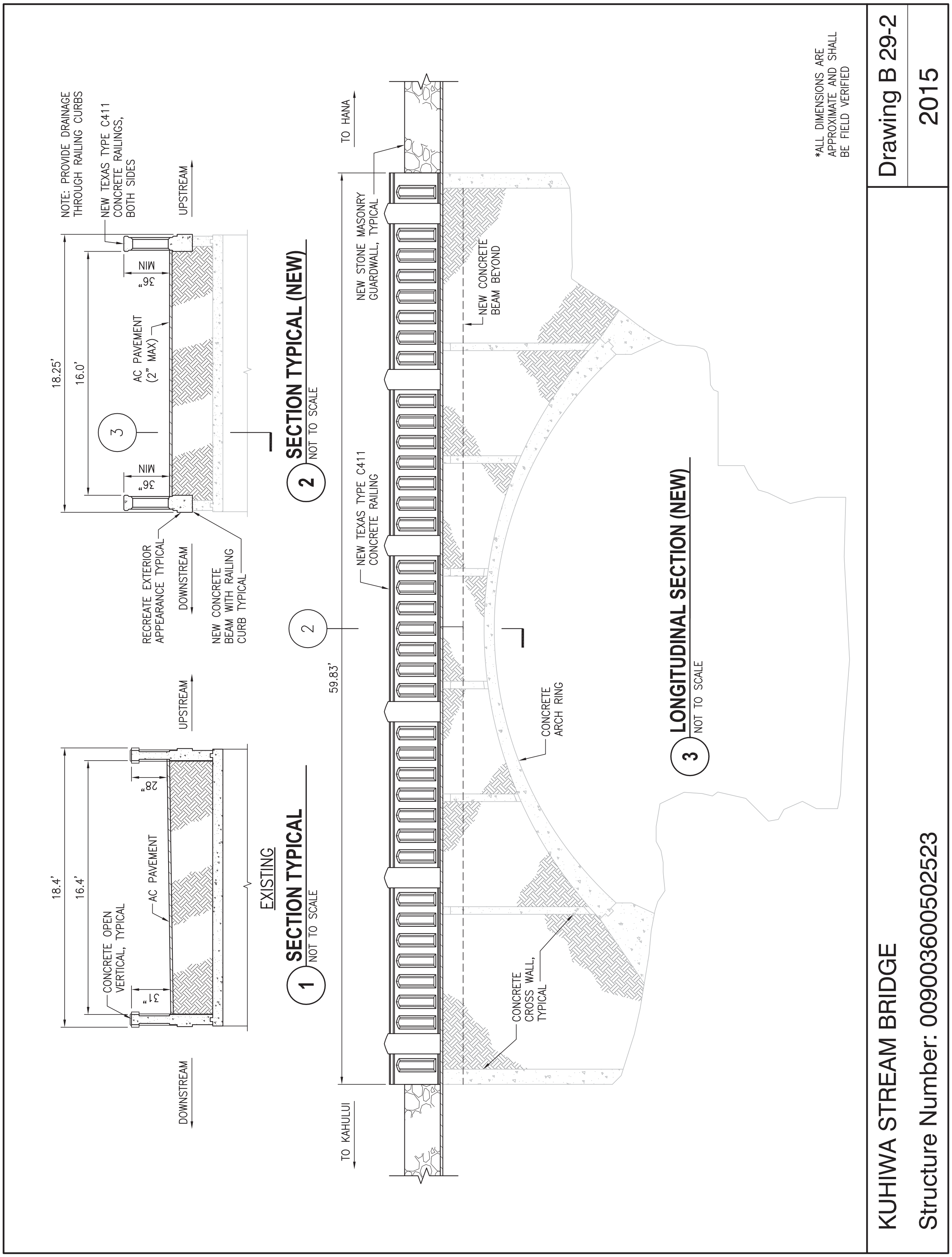
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

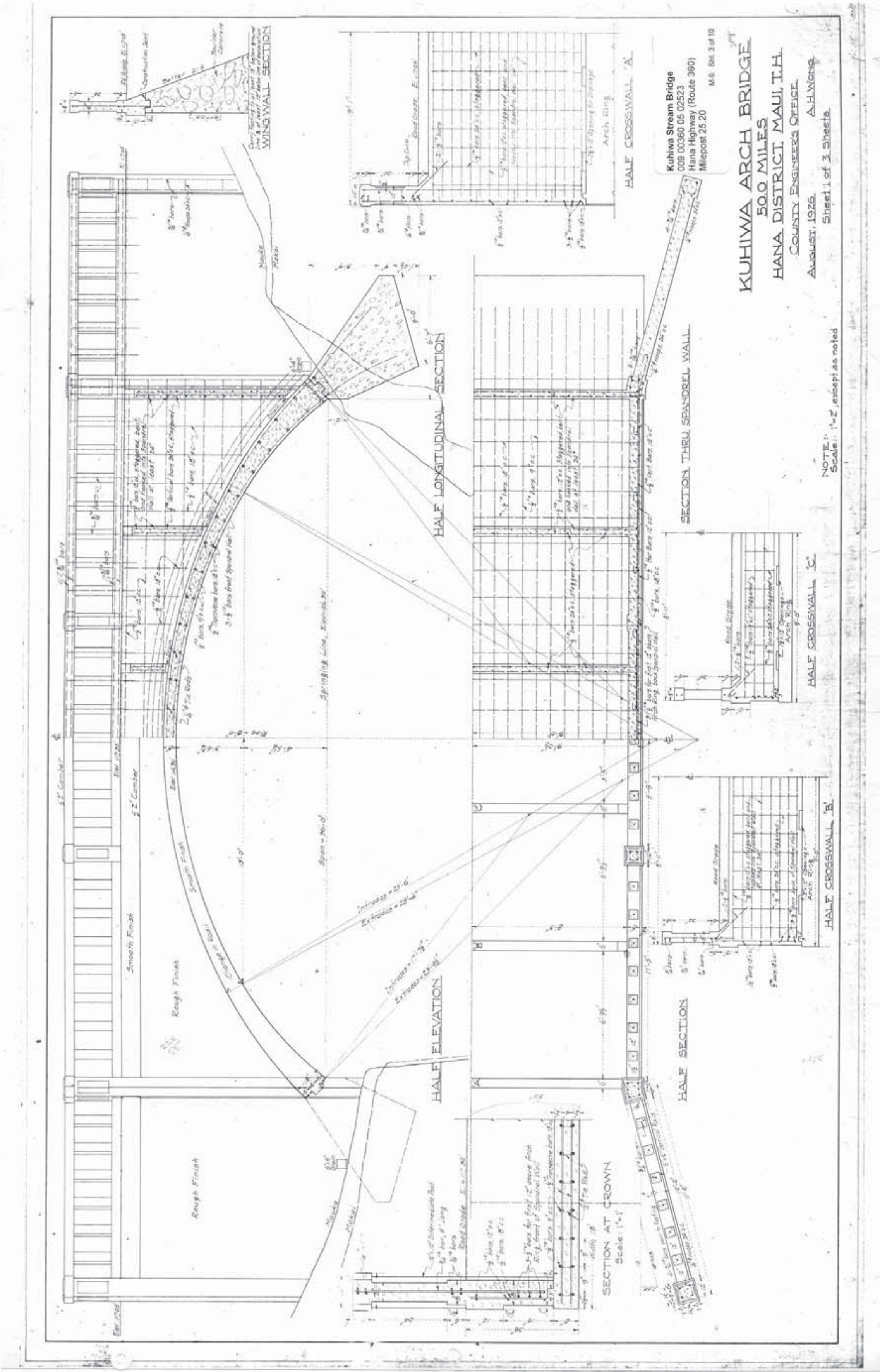
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Kuhiwa Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



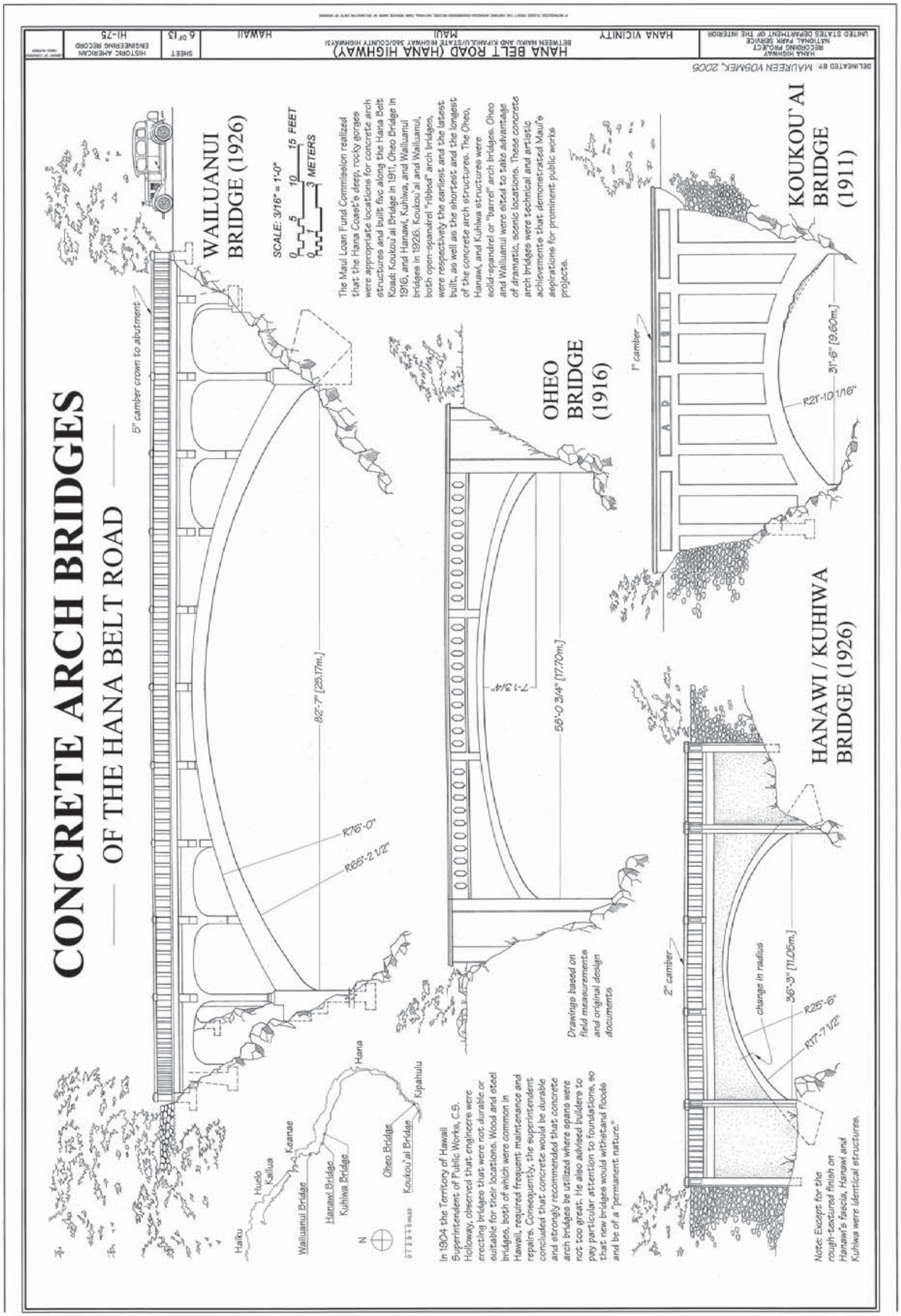
Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation



Courtesy of HAER HI-75

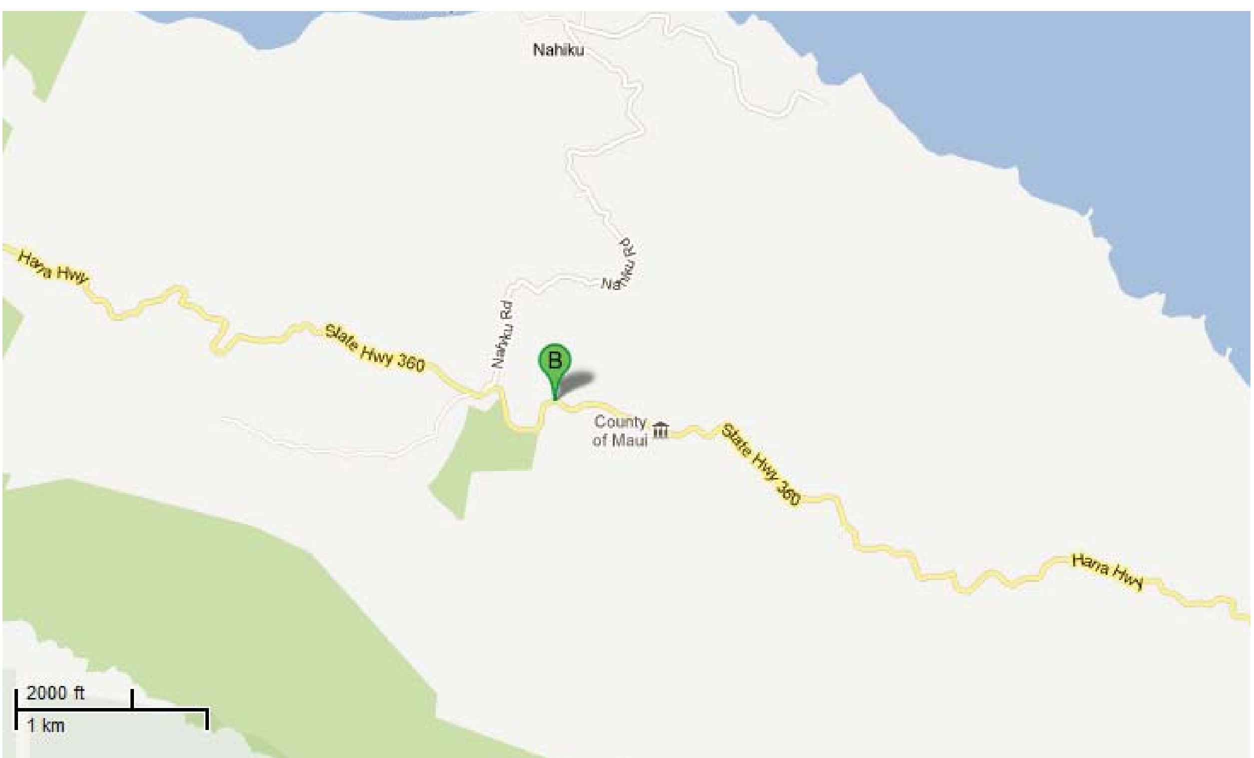
30

Kupukoi Stream Bridge

30 KUPUKOI STREAM BRIDGE

Bridge Number	009003600502546			Island	Maui		
Date of Construction	1926			Route	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 48m 25s
Longitude	156d 05m 31s
Mile Point	25.36
Location	0.41 miles east of Lower Nahiku Road
Feature Crossed	Kupukoi Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	23.95 feet
Number of Spans	1
Maximum Span	21.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 23 inches • Downstream Railing Height = 22 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17.5 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kupukoi Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of Kupukoi Stream Bridge
Courtesy of FAI

Kupukoi Stream Bridge upstream elevation
Courtesy of NOEI

Hana approach to Kupukoi Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kupukoi Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of FAI

Missing approach wall adjacent downstream railing
Courtesy of FAI

End post detail, downstream railing, Hana side
Courtesy of FAI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Kuhiwa
Designer / Builder	County Engineer's Office - Unknown Designer
Historic Drawings	August 1925
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Spans a narrow gorge • Road width in the area is less than two lanes • Rural with a few residences • Lush vegetation and dense growth on upstream side hills in this wooded area • Small stream on downstream side, framed by grassy hills and a view towards distant trees and the horizon • Stream-carved channel at the upstream portion beyond the bridge
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Missing approach wall • Yellow caution tape tied to end post • Cones and traffic road barricades • Excessive asphalt

Significance & Context

Archaeological / Cultural Significance

No translation of the Hawaiian word *kupukoi* could be determined. The individual words *ku, pu, kupu,* and *koi* have far too many possible translations to derive one specific meaning for the compound word *kupukoi*. "Claiming tribute" is one possible translation, derived from the words *hookupu*, meaning "tribute to a high chief,"[1] and *koi*, meaning, "claims for damage."[2] The Kupukoi Stream Bridge spans Kupukoi Stream, which runs through Nahiku Homesteads,[3] and Kuhiwa Ahupuaa.[4]

Nahiku was a fertile *ahupuaa*, which was cleared and terraced with irrigated taro cultivated in the tradition of Native Hawaiians.[5] In ancient times, the settlement at Nahiku spread over gently rising ground above the shore, with a number of groups of *loi* watered from Makapipi Stream.[6] Along the shore there was a *hala* forest that extended from Ulaino to Hana.[7] The region above Nahiku was traditionally forested with native trees such as *koa, ohia lehua,* and sandalwood. According to Handy, many plants that were used for native medicine also grew there.

In the late 1890s, sugar was grown in the Nahiku region. The Nahiku Sugar Company completed the construction of a landing for the government of Hawaii in 1901, and laid rails for construction of a derrick at the landing. Although the Hana Plantation began railroad operations in 1883,[8] there appears to be no record of the use of locomotives at the Nahiku Sugar Company. In 1902 there was talk of a planned merger with the Hana Sugar Plantation, by which the Hana Plantation would pay an annual rental of $4,500 over a 26-year lease which included a valuable set of water rights.[9] The sugar plantation land at Nahiku was acquired by the Hawaiian Commercial & Sugar Company and the East Maui Irrigation Company in 1921.[10]

In the early 1900s, Nahiku became the site for a number of competing rubber plantations. At that time, there was a growing demand for rubber for automobile tires.[11] The Nahiku Rubber Company was in operation in 1905. The Koolau Plantation operated in the region in 1907. The American-Hawaiian Rubber Company operated in the region in the mid-1910s, and became the largest employer in the region. A decline in the price of rubber doomed the industry. After testing for several years, the rubber growers came to the conclusion that it would not be profitable to continue. It was found that the temperature was hardly warm enough for rubber to grow best, and that labor was much more

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1 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

2 Ibid.

3 U.S. Geological Survey, ed., *Nahiku Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

4 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," registered map no. 2649 (1897).

5 Handy, E. S. Craighill, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, Revised ed. Honolulu,: Bishop Museum Press, 1991, 1995, 1972.

6 Ibid.

7 Robert Wenkam, *Maui: The Last Hawaiian Place* (San Francisco: Friends of the Earth, 1970).

8 Jesse C. Conde, "Fowler Locomotives in the Kingdom of Hawaii," *The Narrow Gauge Special Issue*, The Narrow Gauge Railway Society (1993).

9 W. J. Thompsom, *Hawaii Vol. 37*, Louisiana Planter and Sugar Manufacturer Company (New Orleans: 1902).

10 Frederick Hatch, *Moody's Manual of Railroads and Corporation Securities* (New York: Poor's Publishing Company, 1922).

11 D. C. Lindsay, "Rubber in Hawaii," *The Hawaiian Forester and Agriculturist IV* (October 1907).

expensive than at Malaysia.[12] The oldest of the rubber plantations, The Nahiku Rubber Company, Ltd., which had been managed by David Colville Lindsay, was closed on January 20, 1915.[13]

Refer to Section G, Appendix 1, Section 3.1.2.8, for the regional history of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[14]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kupukoi Stream Bridge.

12 Otis Willard Freeman, "The Economic Geography of Hawaii," *Research Publications no. 2* (Honolulu: University of Hawaii, 1927).

13 John William Siddall, "Men of Hawaii: Being a Biographical Reference Library, Complete and Authentic," vol. I (Territory of Hawaii: Honolulu Star-Bulletin, 1917).

14 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Right Object Markers (OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line
Apron	None
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead telephone lines and other unidentified communication type cables located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.69 • Operating Rating = 0.90
Condition	Structurally Deficient

Civil & Traffic

Kupukoi Stream Bridge is located at mile point 25.36 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass nearby on the downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 7, 2014. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[15] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. This bridge is also *structurally deficient* due to a rating of 4 for the *substructure*. CRM walls are located at each corner of the approaches to the bridge, but at the time of inspection collision damage had caused the removal of the CRM wall at the Hana downstream approach.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 23 inches and 22 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.60 and the operating rating is 0.90.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

15 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kupukoi Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 7, 2014, record drawings,[16] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kupukoi Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck & Superstructure

The Kupukoi Stream Bridge currently meets the standard width of a one lane bridge; therefore, no widening is needed. The bridge substructure is structurally deficient. Until future rehabilitation work is determined, repairs to the substructure shall include, but not be limited to, replacing the missing stones, re-grouting loose stones, and removing vegetation growing between stones (refer to “Foundations, Wingwalls, & Abutments” section for more information).

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

16 County Engineer's Office, “Kupakoe Bridge 50.3 Miles,” Hana District Maui, Historic Drawings, August 1925.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted. After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to visibility to oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Object Marker Type 3 - Left (OM3-L)

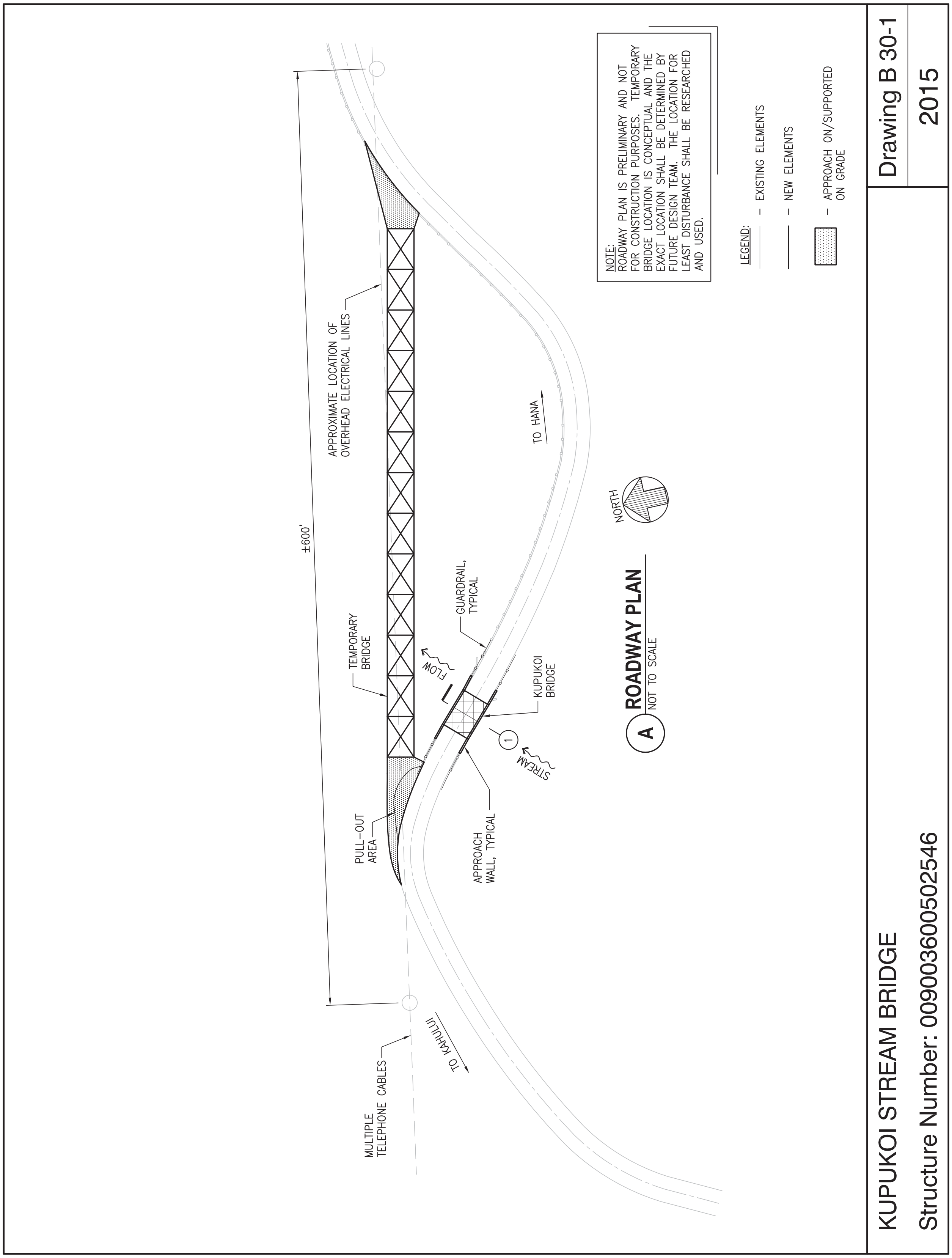
East Bridge Approach

- Add Object Marker Type 3 - Left and Right (OM3-R)

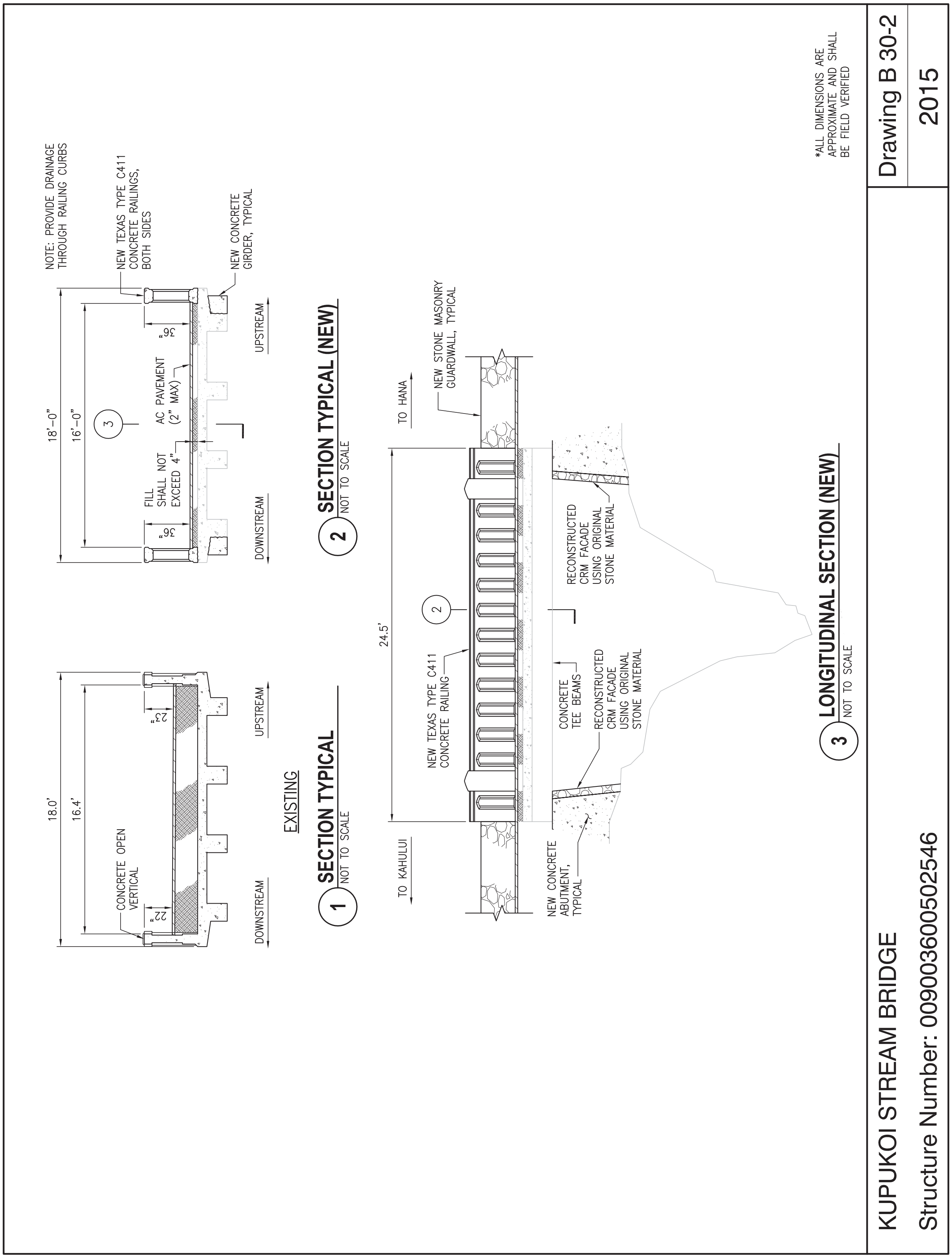
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Telephone lines are over the area of work but the contractor can coordinate the work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



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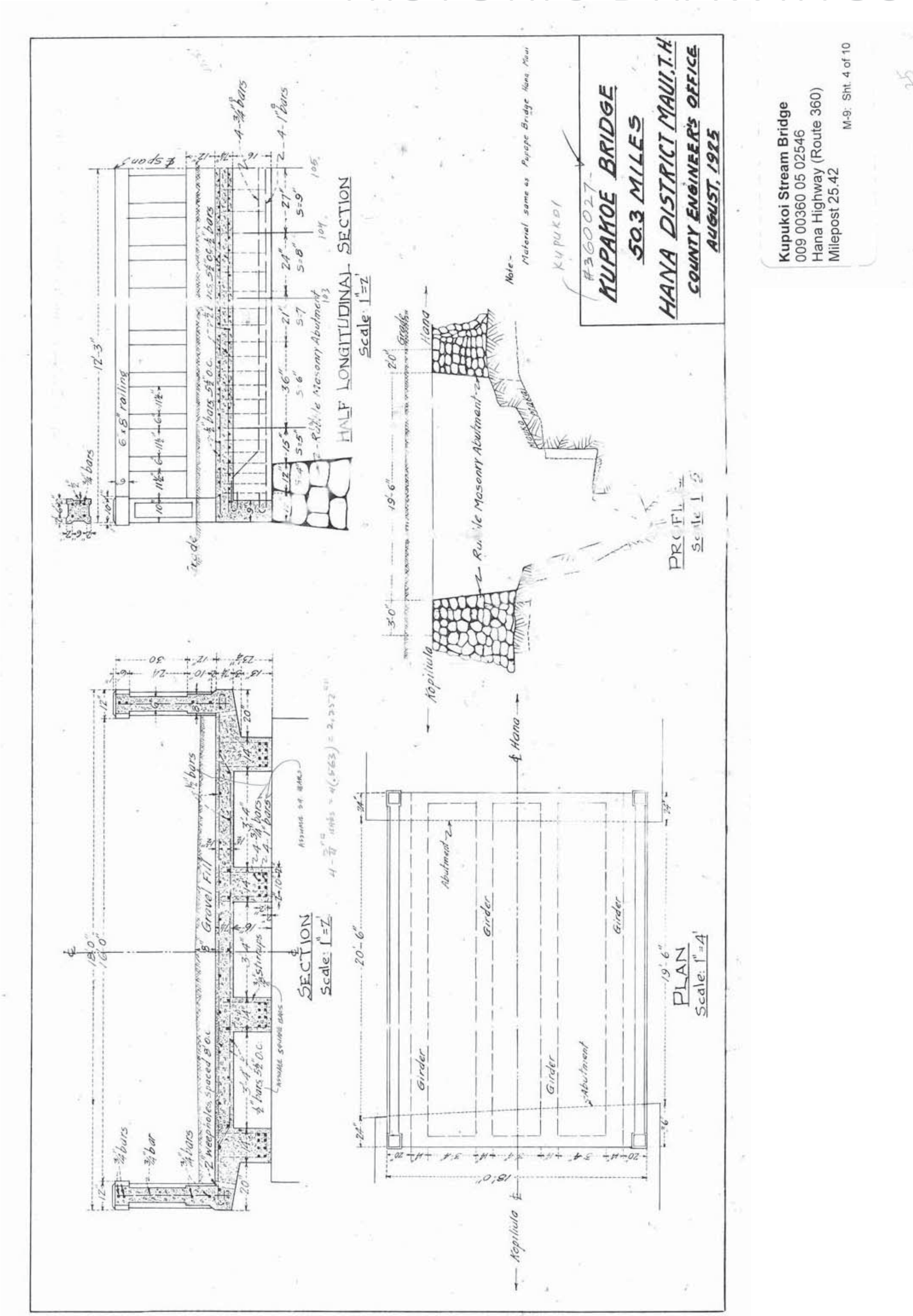


Courtesy of State of Hawaii Department of Transportation

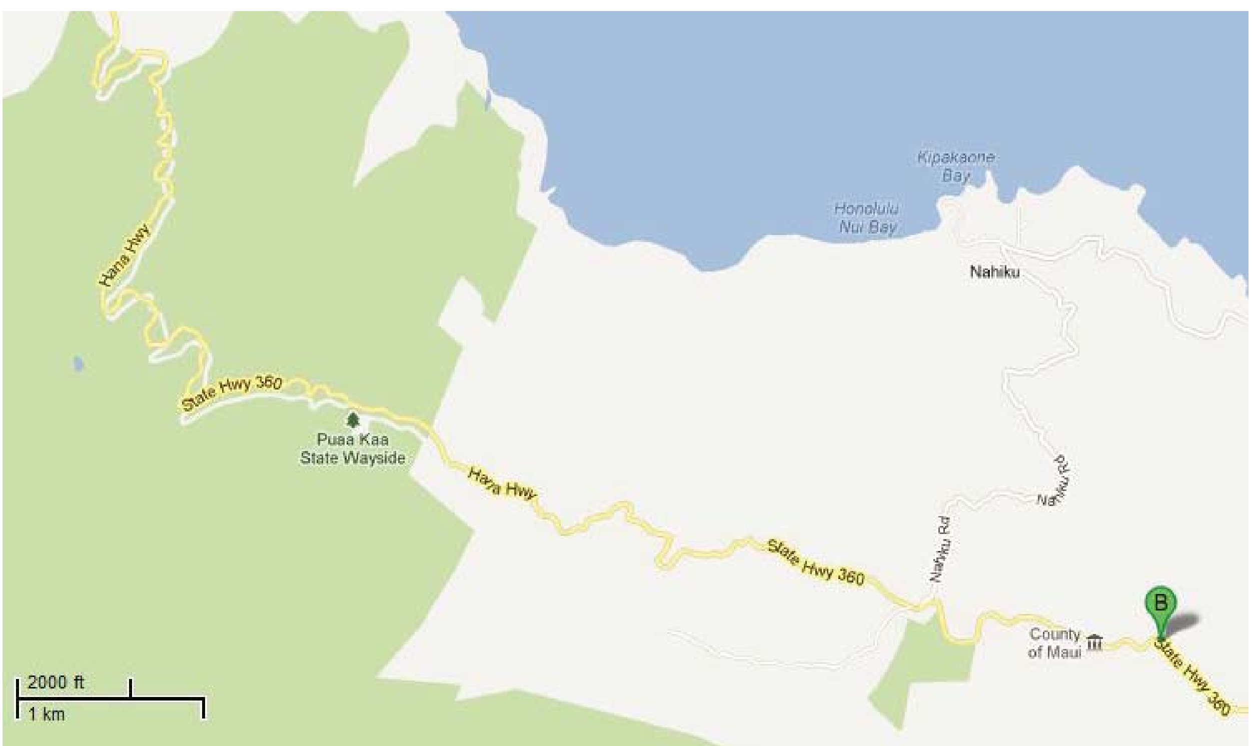
31

Kahalaowaka Stream Bridge

31 KAHALAOWAKA STREAM BRIDGE

Bridge Number	009003600502598			Island	Maui	
Date of Construction	1926			Route	Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 20s
Longitude	156d 05m 04s
Mile Point	25.89
Location	0.93 miles east of Lower Nahiku Road
Feature Crossed	Kahalaowaka Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	23.95 feet
Number of Spans	1
Maximum Span	22.0 feet
Deck Width	• Curb-to-Curb = 16.00 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 25 inches • Downstream Railing Height = 29 inches
Baluster Dimensions	• Posts: 6 inches x 6 inches • Posts spaced approx. 17 inches on-center • End posts: 10 inches x 10 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kahalaowaka Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Upstream stream bed of Kahalaowaka Stream Bridge
Courtesy of NOEI

Kahalaowaka Stream Bridge upstream elevation
Courtesy of NOEI

Hana approach to Kahalaowaka Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kahalaowaka Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Post detail
Courtesy of NOEI

End post detail
Courtesy of FAI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Waiahole and Maino
Designer / Builder	County Engineer's Office - Unknown Designer
Historic Drawings	August 1925
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Heavily overgrown, wooded area with mature trees and ferns • Mossy growth and vegetation on bridge components • Quiet brook and waterfall is not visible until immediately upon bridge
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Overgrown approach walls

Significance & Context

Archaeological / Cultural Significance

No translation of the Hawaiian work *kahalaowaka* could be determined. The individual words *kahala*, meaning, "A species of amber fish (*Seriola purpurascens*),"[1] and *owaka*, meaning, "To open, as a flower"[2] could be interpreted together as, "to open an amber fish," or "the opening of an amber fish." The Kahalaowaka Stream Bridge spans Kahalaowaka Stream (or Kalepalehua Gulch on the 1897 map of the Nahiku Coffee Lands[3]), which divides Waiahole Ahupuaa and Maino Ahupuaa.[4]

During the battle between the brothers Lono a Piilani and Kiha a Piilani, fighting commenced at:

> *Ulaino, at Makaolehua, and in Akiala at Laahana, at Kawaikau, at Nenewepue, at Kamehaikanas kukui tree and all the way along to Honokalani and Wakiu, into the pandanus grove of Kahalaoweke [Kahalaowaka], down to Pihehe, to the flats of Kalani and the spring of Punahoa.*[5]

Finally, the Hawaii warriors were able to gain the advantage when they invaded Kauiki at night. The army of Umi a Liloa pursued the escaping Hoolae makua across Koolau, where he was caught directly back of Nahiku at a place called Kapipiwai. He was killed. Kiha a Piilani then turned toward Wailuku, where Lono a Piilani ruled Maui. When Lono a Piilani learned of the death of Hoolae makua, he died of fear that he would be the next one tortured by the forces of Umi a Liloa and Kiha a Piilani.[6]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.7, for the story of Kiha a Piilani, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[7]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kahalaowaka Stream Bridge.

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Ibid.

3 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," registered map no. 2649 (1897).

4 Ibid.

5 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

6 Ibid.

7 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Yield Sign (R1-2) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (Vandalized, OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.73 • Operating Rating = 0.95
Condition	Functionally Obsolete

Civil & Traffic

Kahalaowaka Stream Bridge is located at mile point 25.89 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the east bound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Primary lines pass over the area of work on the downstream side.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 7, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[8] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 25 inches and 29 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.73 and the operating rating is 0.95.

The current curb-to-curb dimension is 16.00 feet, which for a one-lane bridge is adequate for this project’s design criteria of 16 feet.

8 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kahalaowaka Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 7, 2014, record drawings,[9] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kahalaowaka Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

In addition to providing a temporary bridge, the location of the entry ways to the temporary bridge will require pruning trees and vegetation in the gulch. At the time of construction, the location of the entry ways will need to be investigated to determine the best location with the least amount of flora and cultural disturbance.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Kahalaowaka Stream Bridge currently meets the standard width of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

9 County Engineer's Office, "Kahalaowaka Bridge 50.8 Miles," Hana District Maui, Historic Drawings, July 1925.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/ Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing many be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM abutments are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments.

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to visibility to the oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), and a yield line are to be added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add "To On Coming Traffic" plaque (R1-2a)

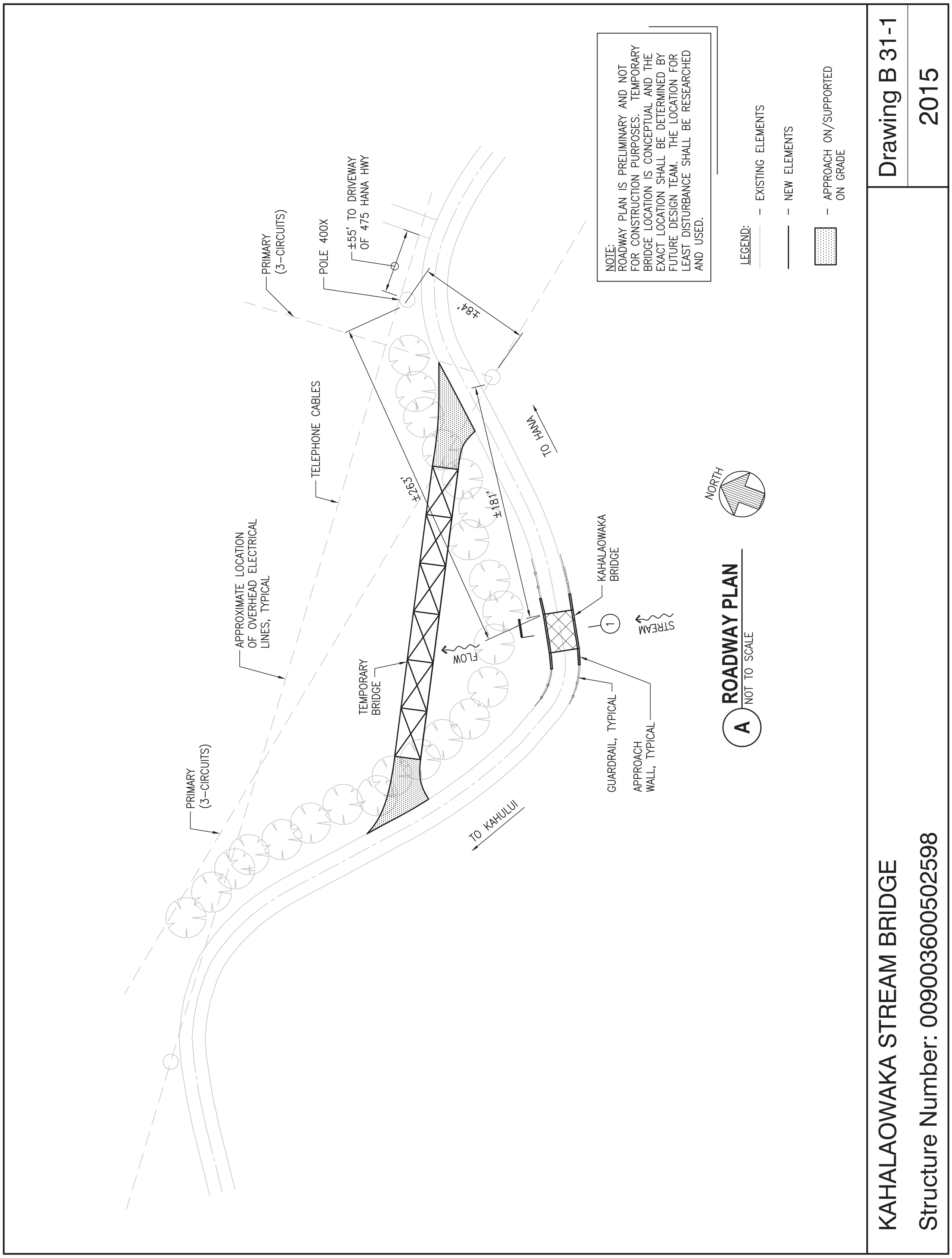
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Replace Object Marker Type 3 - Left and Right (OM3-L, OM3-R)
- Prune roadside brush and trees

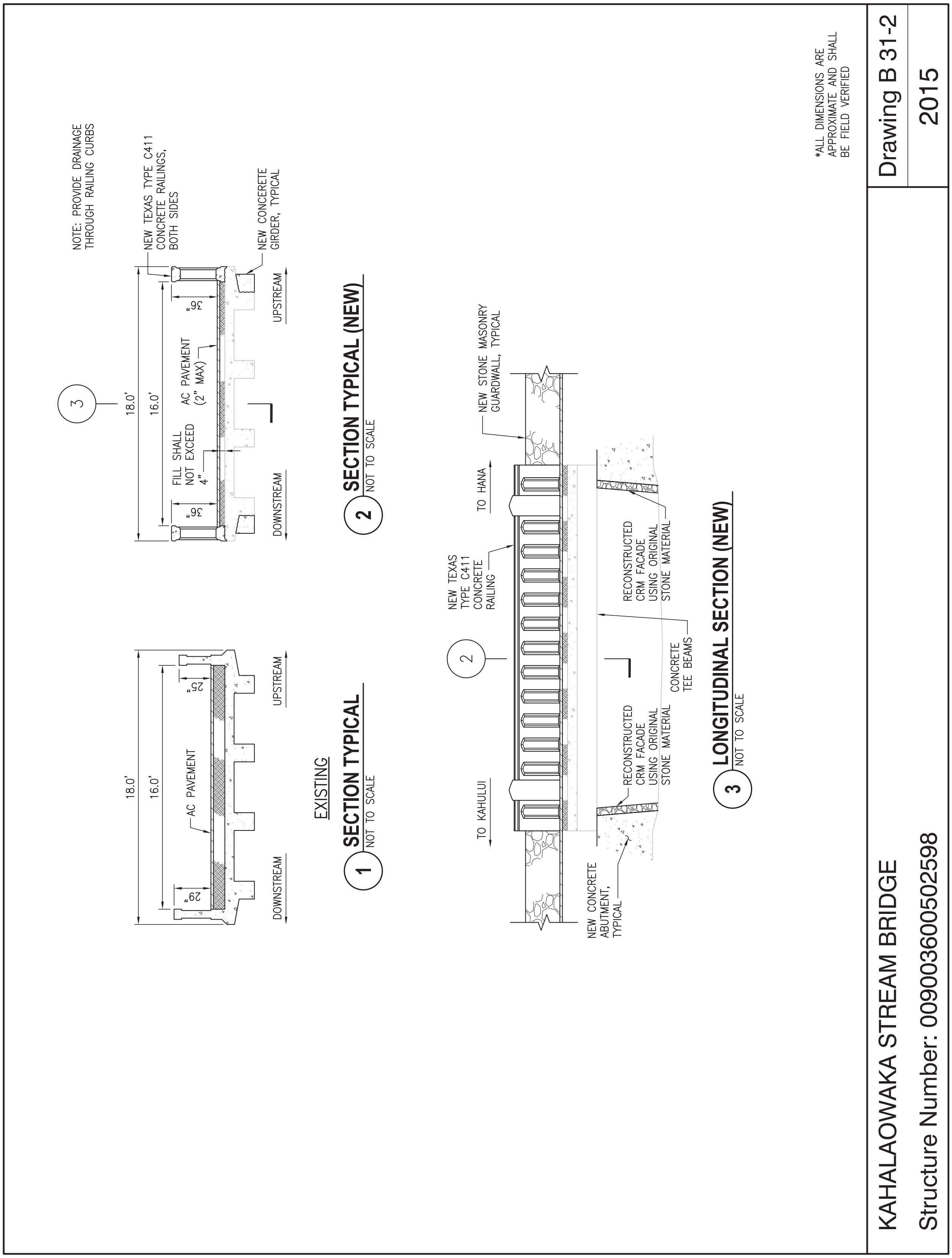
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

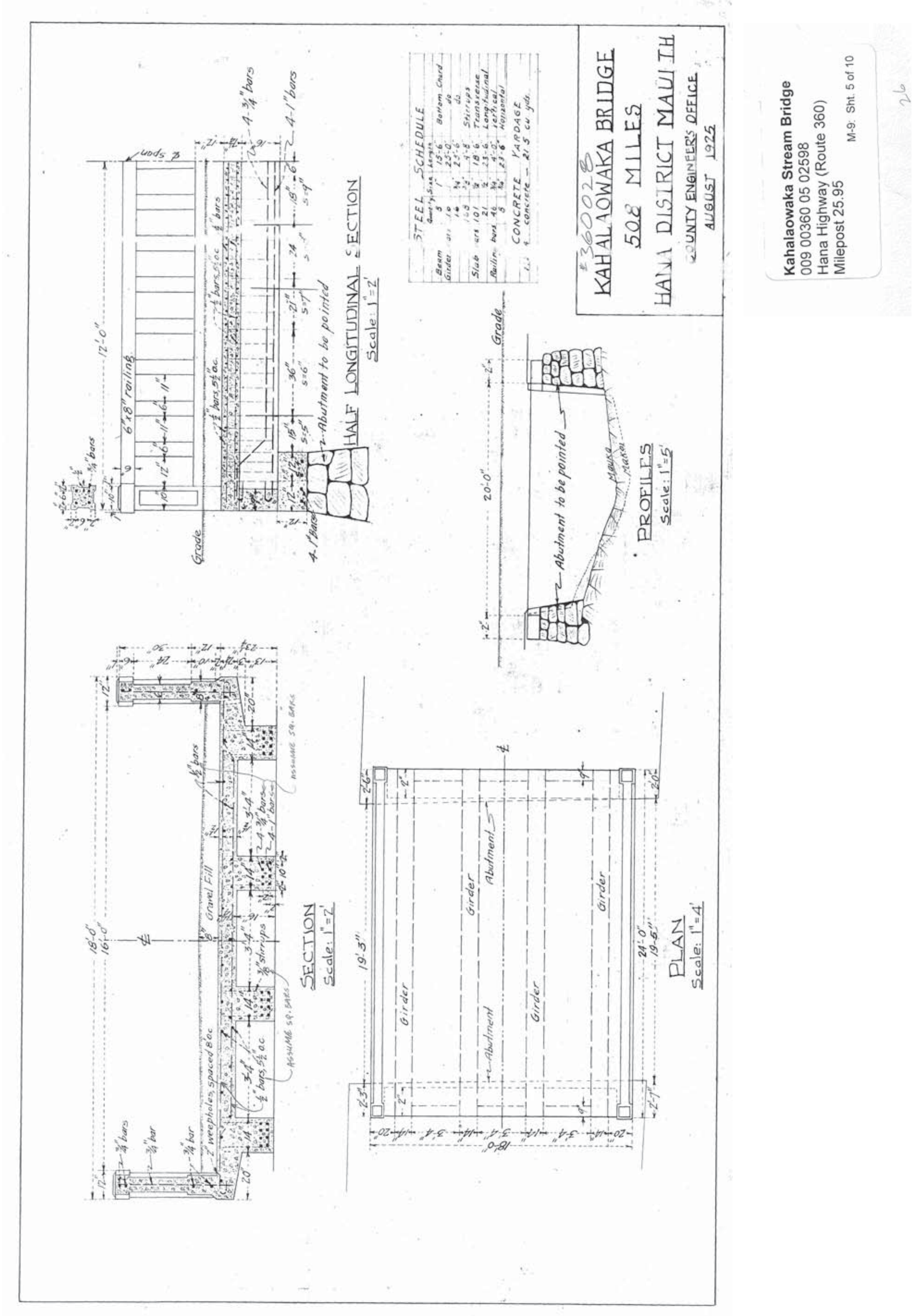
Primary lines are over the area of work but the contractor can coordinate the work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

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32

Pupape Stream Bridge

32

PUPAPE STREAM BRIDGE

<table>
<tr><th>Bridge Number</th><td colspan="3">009003600502652</td><th>Island</th><td colspan="2">Maui</td></tr>
<tr><th>Date of Construction</th><td colspan="3">1926</td><th>Route</th><td colspan="2">Hana Highway</td></tr>
<tr><th>Treatment Recommendation</th><td>X</td><td>Preservation</td><td>X</td><td>Rehabilitation</td><td></td><td>Restoration</td></tr>
</table>

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Courtesy of NOEI

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 10s
Longitude	156d 04m 42s
Mile Point	26.42
Location	1.47 miles east of lower Nahiku Road
Feature Crossed	Manawaikeae Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	23.95 feet
Number of Spans	1
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	• Concrete Abutment (Kahului side) • CRM Abutment (Hana side)
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 30 inches • Downstream Railing Height = 24 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. = 17.5 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Pupape (Manawaikeae Stream) Bridge is a single-span reinforced concrete tee beam bridge built in 1926. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center. The substructure consists of concrete (Kahului) abutment, CRM (Hana) abutment, and CRM wingwalls. The abutments bear directly on natural rock formations.

Setting of Pupape Stream Bridge
Courtesy of NOEI

Pupape Stream Bridge
Courtesy of NOEI

Hana approach to Pupape Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Pupape Stream Bridge toward Hana
Courtesy of FAI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of FAI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

Concrete abutment set on natural rock, Kahului side
Courtesy of NOEI

Broken approach wall, Kahului downstream side
Courtesy of NOEI

Approach wall, Hana downstream side
Courtesy of NOEI

Significance & Context

Ahupuaa	Maino and Puupaipaia
Designer / Builder	County Engineer's Office - Unknown Designer
Historic Drawings	August 1925
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM wingwalls on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii
Adjacent Cultural Sites	None documented
Geographical Features / Setting	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutment (Hana) • CRM Wingwalls • Concrete Open Vertical Railings • Natural Rock Formation
Detracting Features	• Excessive asphalt • Bullet holes in signs

Significance & Context

Bridge Site History

The present bridge replaced a timber bridge on concrete or rock piers constructed between 1906 and 1909, which in turn had replaced an earlier wood truss structure at this location.[1] Other "[s]imilar replacement projects were conducted at [Kailua,] Naʻiliʻilihaele, Keaʻaiki, Oiliwai, … and Kuhiwa."[2]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[3]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[4]

At this time, the early DPW Works began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[5]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[6] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[7] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

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1 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 30.

2 Ibid.

3 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

4 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

5 Ibid.

6 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

7 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

No translation of the Hawaiian word *pupape* could be determined. The Pupape Stream Bridge spans Manawaikeae Stream, which divides Maino Ahupuaa and Puupaipaia Ahupuaa.[8] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Section 3.1.2.8, for the regional background of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[9]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Pupape Stream Bridge.

8 Hugh Howell, “Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.,” registered map no. 2649 (1897).

9 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed due to road geometry • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign (Bent, R1-2) • Yield Line
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.69 • Operating Rating = 0.90
Condition	Functionally Obsolete

Civil & Traffic

Pupape Stream Bridge is located at mile point 26.42 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound approach to the bridge is currently obstructed due to the difficult road geometry. The westbound approach to the bridge is currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except on the Westbound approach to the bridge the Yield sign is bent. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass over bridge from one side to the other.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 7, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[10] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 30 inches and 24 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.69 and the operating rating is 0.90.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Pupape Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 7, 2014, record drawings,[11], [12] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Pupape Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Pupape Stream Bridge currently meets the standard width of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of

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11 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

12 County Engineer's Department, "Pupape Bridge 51.3 Miles," Hana District Maui, Historic Drawings, July 1925.

the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing many be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM wingwalls.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM wingwalls (in particular the upstream Kahului side), which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

The concrete abutment (Kahului side) is recommended to be replaced in-kind with a reinforced concrete structure. The CRM abutment (Hana side) is recommended to be replaced with a reinforced concrete structure with a new natural rock façade. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutment and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the foundations and the concrete Kahului abutment to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to visibility to the oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1) and a "To Oncoming Traffic" sign (R1-2a) are added to the west bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

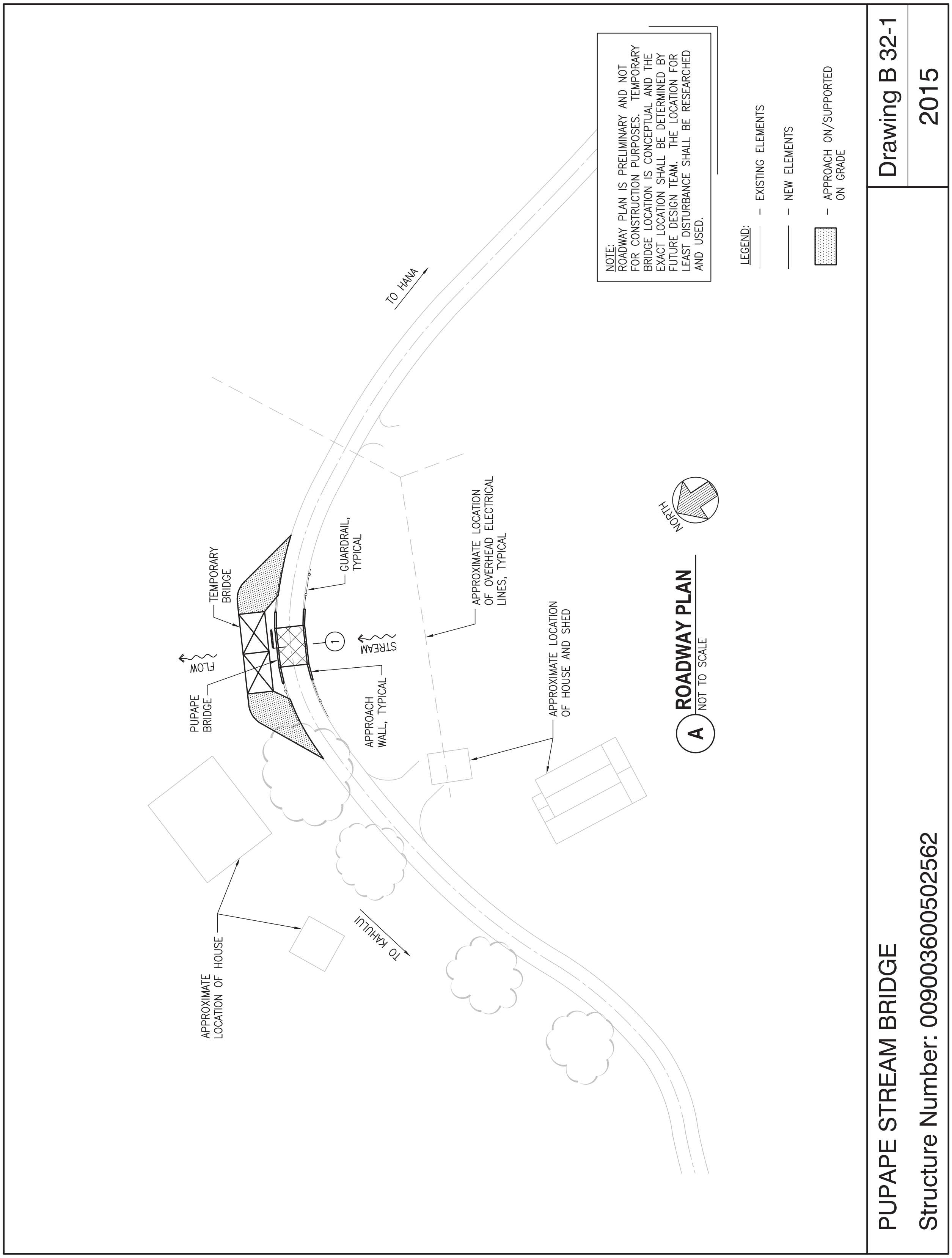
East Bridge Approach

- Replace Yield sign (R1-2)
- Add "To On Coming Traffic" plaque (R1-2a)
- Add Object Marker Type 3 – Left and Right (OM3-R)

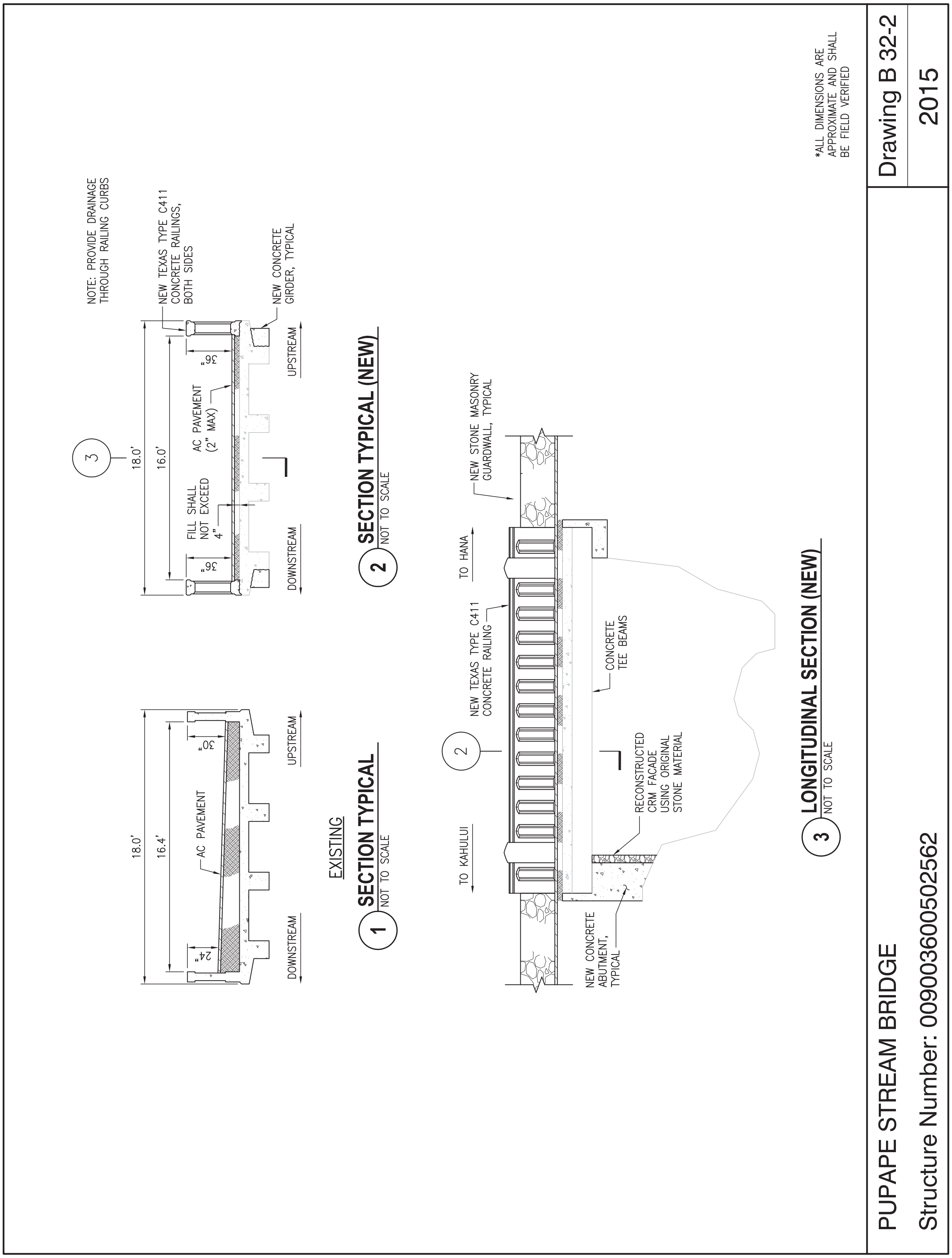
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

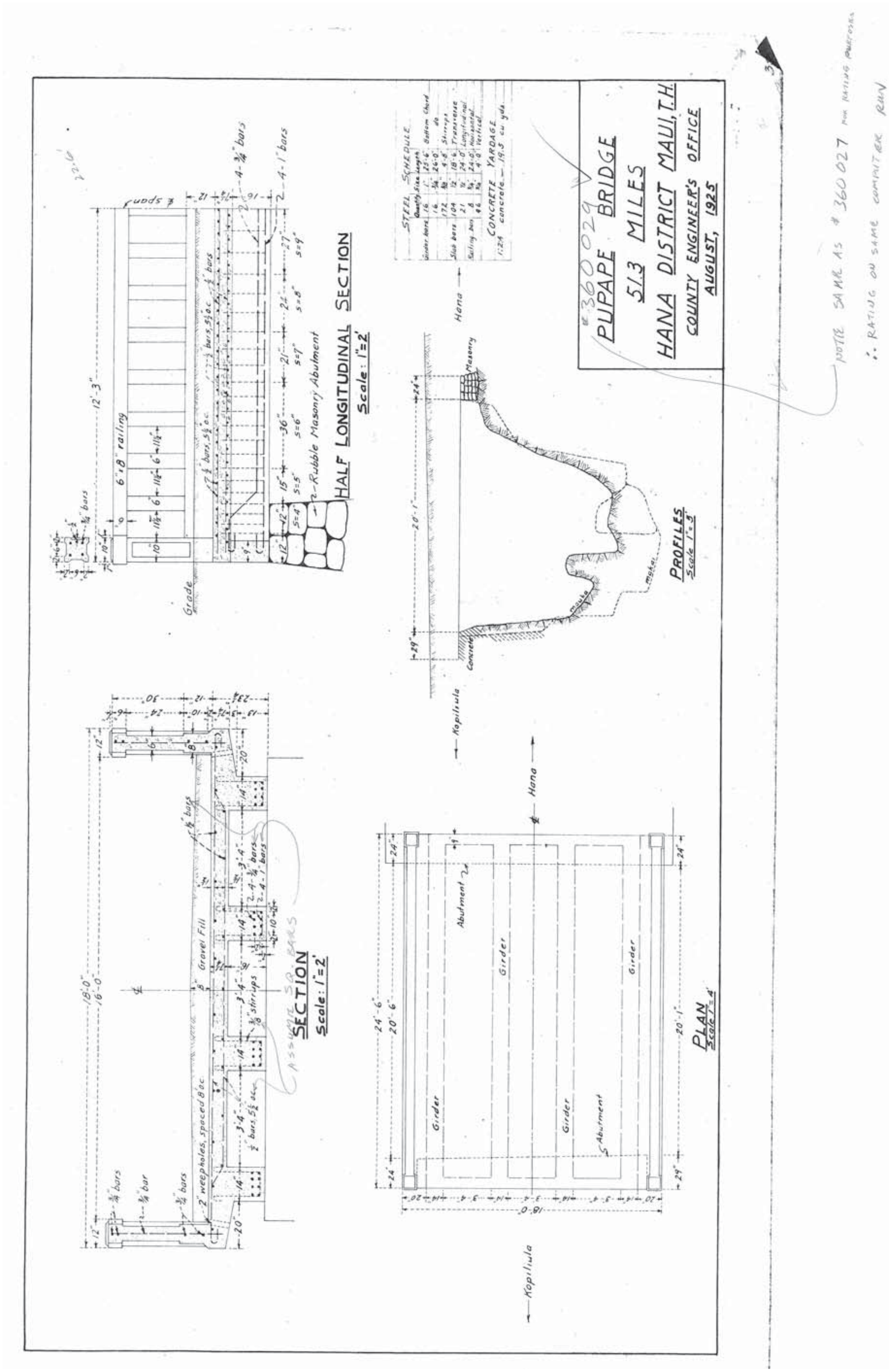
Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Pupape Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

33

Kahawaihapapa Stream Bridge

33 KAHAWAIHAPAPA STREAM BRIDGE

Bridge Number	009003600502664			**Island**	Maui		
Date of Construction	1925			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI

Courtesy of Google Maps

Location

Latitude	20d 48m 04s
Longitude	156d 04m 39s
Mile Point	26.54
Location	1.59 miles east of Lower Nahiku Road
Feature Crossed	Kahawaihapapa Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	60.04 feet
Number of Spans	3
Maximum Span	17.1 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.00 feet
Abutment Material	• CRM Abutments • Reinforced Concrete Pier Cap and Columns on a Concrete Pier Wall (Kahului Pier) • Concrete Pier Wall (Hana Pier)
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	3
Parapet / Railing Height	• Upstream Railing Height = 36 inches • Downstream Railing Height = 37 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17.75 inches on-center • Intermediate posts = 10 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Kahawaihapapa Stream Bridge is a triple-span reinforced concrete tee beam bridge built in 1922. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments, two piers, and CRM wingwalls. The Kahului pier has a reinforced concrete pier cap and columns supported on a concrete pier wall. The Hana pier is a concrete pier wall. The abutments and piers bear directly on natural rock formations.

Setting of Kawaihapapa Stream Bridge
Courtesy of FAI

Kawaihapapa Stream Bridge
Courtesy of FAI

Hana approach to Kawaihapapa Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kawaihapapa Stream Bridge toward Hana
Courtesy of FAI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of FAI

Damaged Hana end post
Courtesy of FAI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Concrete pier, Kahului side
Courtesy of NOEI

Concrete pier, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Puupaipaia and Keaa
Designer / Builder	County Engineer's Office - Unknown Designer
Historic Drawings	July 1925
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Good intact examples of pier walls on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Adjacent to Nahiku Discover Tours • Dry topography with hills in the distance; this area exhibits a greater depth of scenery • A window between very tall bamboo trees and vegetation on the downstream side of the bridge provides a view to the horizon • Unique cavernous rock formations • A trickling stream flows over the rocky gorge landscape and outcroppings, forming tidepools below
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Reinforced Concrete Pier Cap and Columns on a Concrete Pier Wall (Kahului Pier) • Concrete Pier Wall (Hana Pier) • Concrete Open Vertical Railings
Detracting Features	Damaged Kahului end post

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[p]rior to the construction of a paved belt road through Nahiku, only private trail connected Nahiku with Keanae through the Koolau Forest. This trail, owned by the Koolau Ditch Company, included a 50-foot, single-span timber truss bridge built in the 19th century over Kahawaihapapa Stream. In 1906, the timber truss bridge was rebuilt with the addition of three concrete piers. In 1920s, this bridge was again rebuilt with concrete by the County Engineer's Office to carry the paved belt road through the ditch country."[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 133.

2 Ibid, 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The Hawaiian word *kahawaihapapa* is defined as, "shallow aqueduct."[7] The Kahawaihapapa Stream Bridge spans Kahawaihapapa Stream, which cuts through Nahiku Homesteads[8] and divides Puupaipaia Ahupuaa and Keaa Ahupuaa.[9] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Section 3.1.2.8, for the regional background of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[10]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kahawaihapapa Stream Bridge.

7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

9 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," registered map no. 2649 (1897).

10 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (Vandalized, OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.77 • Operating Rating = 1.00
Condition	Structurally Deficient

Civil & Traffic

Kahawaihapapa Stream Bridge is located at mile point 26.54 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.00 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the west bound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the Type 3 Object Marker (Right) on the westbound approach to the bridge has been vandalized. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type cables pass over Kahawaihapapa Bridge from one side to the other.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 7, 2014. The overall condition rating of the bridge at the time of inspection varied between poor and good.[11] This one-lane bridge is *structurally deficient* due to a rating of 4 for the *superstructure*. This bridge is also *functionally obsolete* due to a rating of 2 for *deck geometry* and *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 36 inches and 37 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.77 and the operating rating is 1.00.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

11 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kahawaihapapa Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 7, 2014, record drawings,[12], [13] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kahawaihapapa Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Although the Hawaii Heritage Center's *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* states that the bridge was rebuilt in 1922, HDOT's historic drawing shows it was drawn in 1925. Therefore it is recommended to change the HDOT database to 1925.

Team recommendations have been identified per bridge component, as follows:

Deck

The Kahawaihapapa Stream Bridge currently meets the standard width of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

12 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

13 County Engineer's Department, "Kawaihapapa Bridge 51.5 Miles," Hana District Maui, Historic Drawings, July 1925.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Superstructure

The bridge superstructure is structurally deficient. Repairs to the superstructure shall include, but not be limited to, epoxy injection crack repairs, chipping out and replacing exposed severely corroded reinforcing, and chipping out and patching delaminated and spalled areas with an epoxy non-shrink grout. Finish of the repaired area shall match the original condition of the bridge. Sprayed shotcrete finish shall not be permitted.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream

Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge.

Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Intermediate posts, matching the original historic railing, should be incorporated within the railing above each pier. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete piers and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A chloride concentration analysis is recommended to be conducted on the concrete core samples. Based on the results of the chloride concentration analysis, cathodic protection should be considered as a method to prolong the bridge's lifespan. Although the concrete pier walls are a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier walls, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, CRM wingwalls, and pier walls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to visibility to the oncoming traffic at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), a yield line are added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

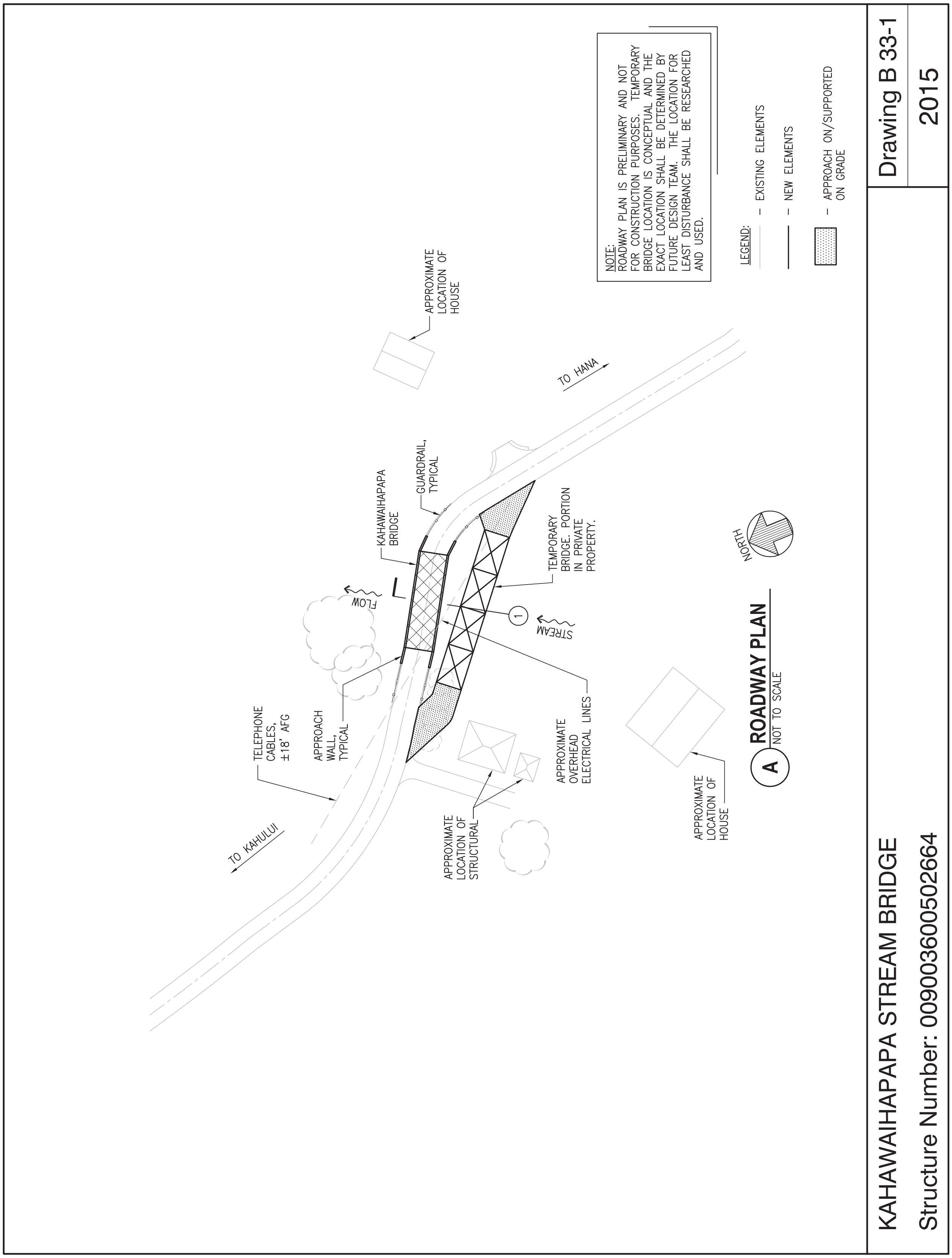
East Bridge Approach

- Replace Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

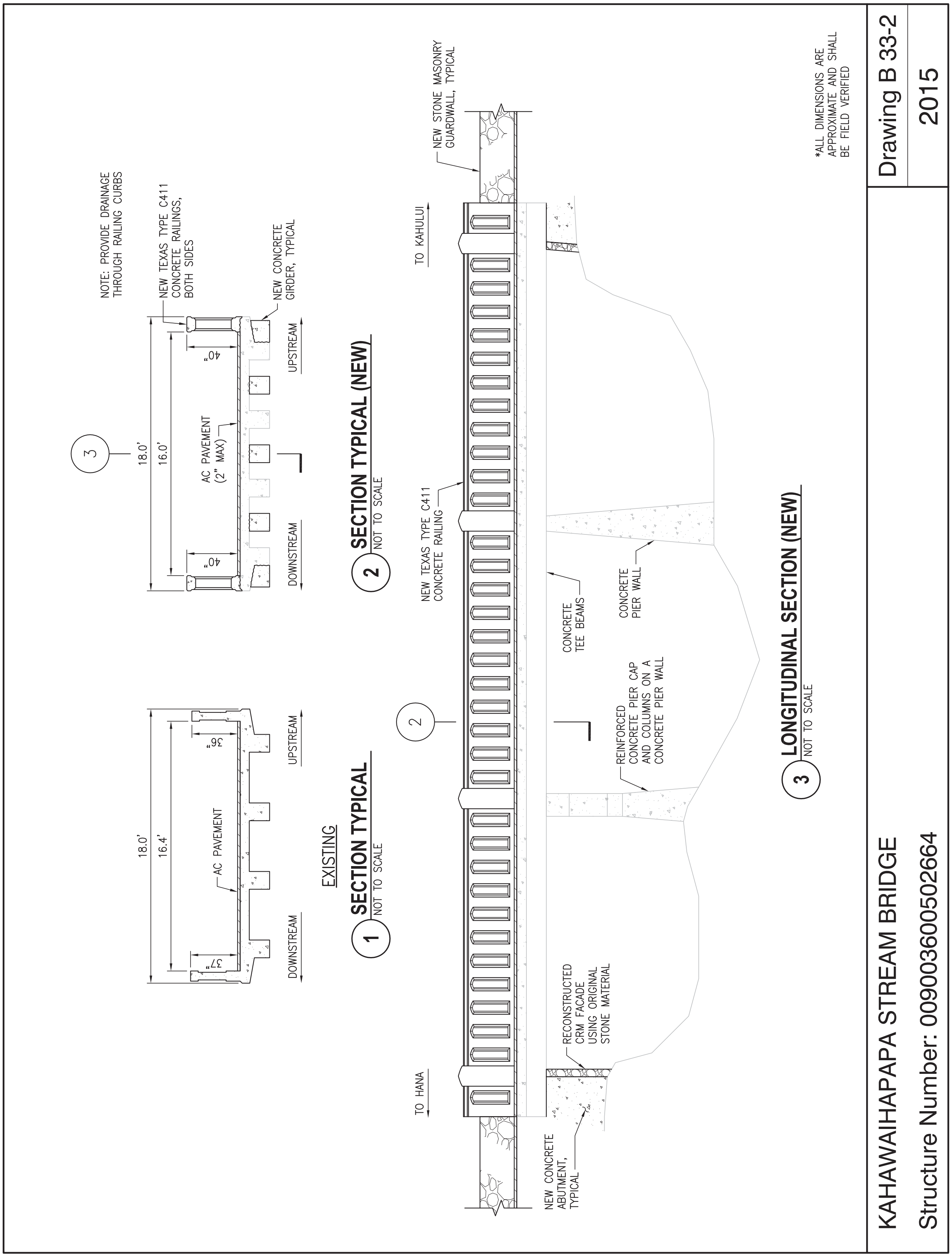
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

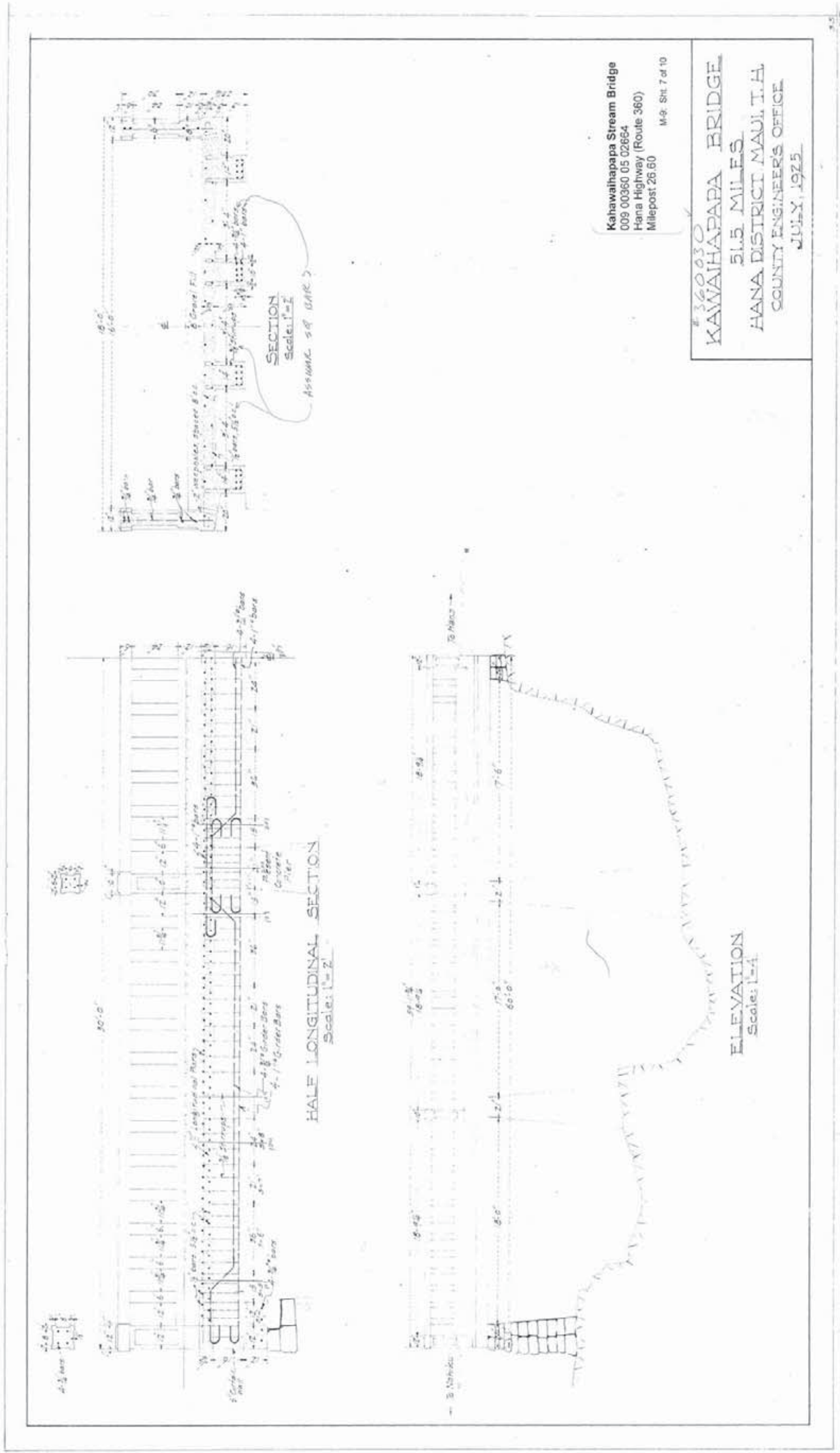
Telephone lines are over the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



Courtesy of NOEI



Courtesy of State of Hawaii Department of Transportation

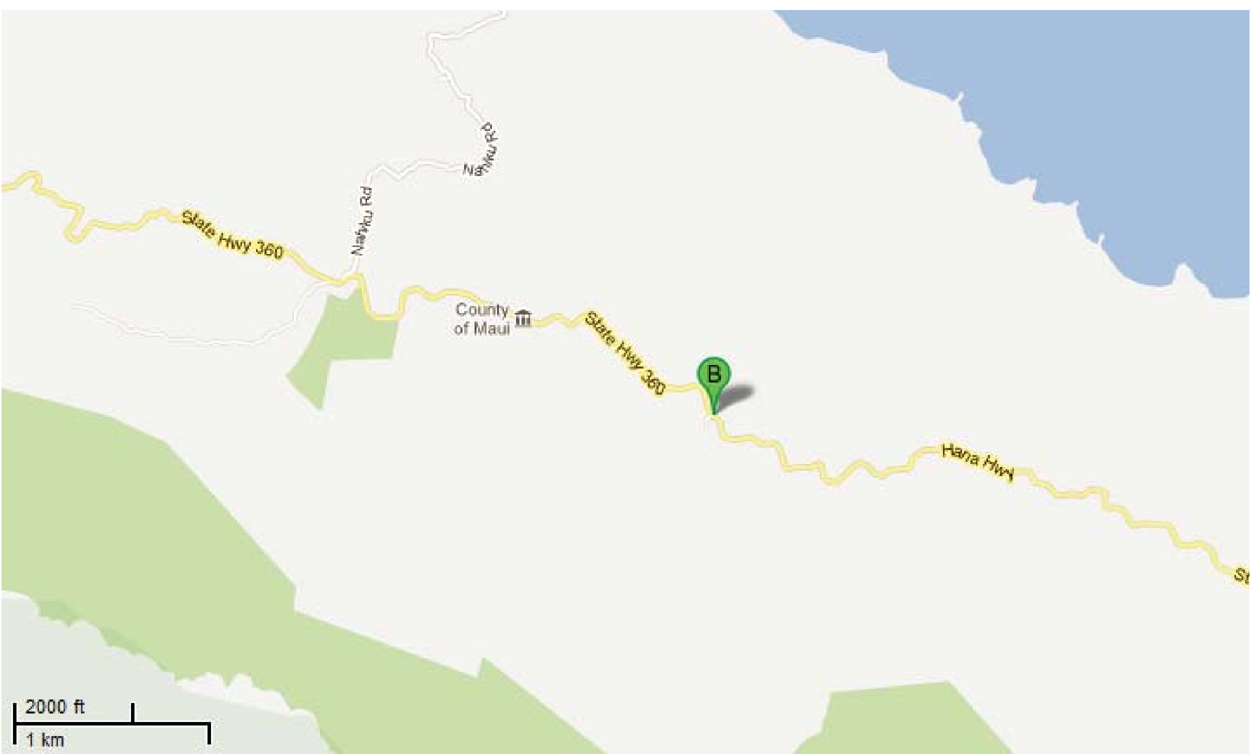
34

Keaaiki Stream Bridge

34 KEAAIKI STREAM BRIDGE

Bridge Number	009003600502681			**Island**	Maui		
Date of Construction	1921			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 48m 01s
Longitude	156d 04m 32s
Mile Point	26.70
Location	1.76 miles east of Lower Nahiku Road
Feature Crossed	Keaaiki Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	21.98 feet
Number of Spans	1
Maximum Span	21.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 28 inches • Downstream Railing Height = 24 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 18.5 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Keaaiki Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1921. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of Keaaiki Stream Bridge (with upstream Hana approach wall)
Courtesy of NOEI

Keaaiki Stream Bridge
Courtesy of NOEI

Hana approach to Keaaiki Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Keaaiki Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Damaged railing with exposed rebar, upstream side
Courtesy of NOEI

Approach wall, Kahului downstream side
Courtesy of NOEI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Keaa
Designer / Builder	County Engineer's Office - Unknown Designer
Historic Drawings	May 1925
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential area with tropical flower farms • Lush growth • No pull-out space
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Damaged upstream parapet with exposed rebar • Excessive asphalt

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[i]n 1906, a 19th century wooden truss bridge over Keaaiki Stream was rebuilt with new timber and reinforcing abutments made of boulder rock from the surrounding areas. At the time the timber bridge, like nearby bridges around Nahiku, carried an unpaved trail through the ditch country. When the Country began paving a macadam belt road to Hana in the 1920s, the bridge was again rebuilt with the placement of a concrete deck and gravel filling. The County Engineer's Office probably added a new concrete deck over the original boulder abutments."[1] Other "[s]imilar replacement projects were conducted at [Kailua,] Naʻiliʻilihaele, … Oiliwai, Manawaikeae, and Kuhiwa."[2]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[3]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[4]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[5]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[6] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[7] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 135.

2 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 30.

3 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

4 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

5 Ibid.

6 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

7 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The Hawaiian word *keaa* is defined as, "the scoria lava,"[8] and the place name is defined as, "Land sections, Hana qd., Maui."[9] The Hawaiian word *iki* translates as, "Small, little, slightly."[10] The Keaaiki Stream Bridge spans Keaaiki Stream, which cuts through Nahiku Homesteads and lies within Keaa Ahupuaa.[11] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Section 3.1.2.8, for the regional background of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[12]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Keaaiki Stream Bridge.

8 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

9 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

10 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

11 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

12 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Poor sight distance and cannot see cars approaching bridge • West Bound: No yield, clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Electrical lines (primary and telephone) located to the side
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.90 • Operating Rating = 1.17
Condition	Functionally Obsolete

Civil & Traffic

Keaaiki Stream Bridge is located at mile point 26.70 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound approach to the bridge does not have a clear sight distance, therefore causing poor visibility of oncoming traffic. The westbound approach to the bridge is currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are electrical lines (primary and telephone) that are close to the potential area of work.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on January 7, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[13] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 28 inches and 24 inches, respectively. Neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.90 and the operating rating is 1.17.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

13 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Keaaiki Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated January 7, 2014, record drawings,[14, 15] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Keaaiki Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Although the Hawaii Heritage Center's *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* states that the bridge was rebuilt in 1922, HDOT's historic drawing shows it was drawn in 1925. Therefore it is recommended to change the HDOT database to 1925.

Recommendations have been identified per bridge component, as follows:

Deck

The Keaaiki Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of

14 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

15 County Engineer's Office, "Keaiki Bridge 51.8 Mile," Hana District Maui, Historic Drawings, July 1925.

the existing railings and lowers the height below code minimum. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Hana approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining three approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM abutments are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and it was determined that this bridge does not need to be posted and the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), and a yield line are added to the west bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

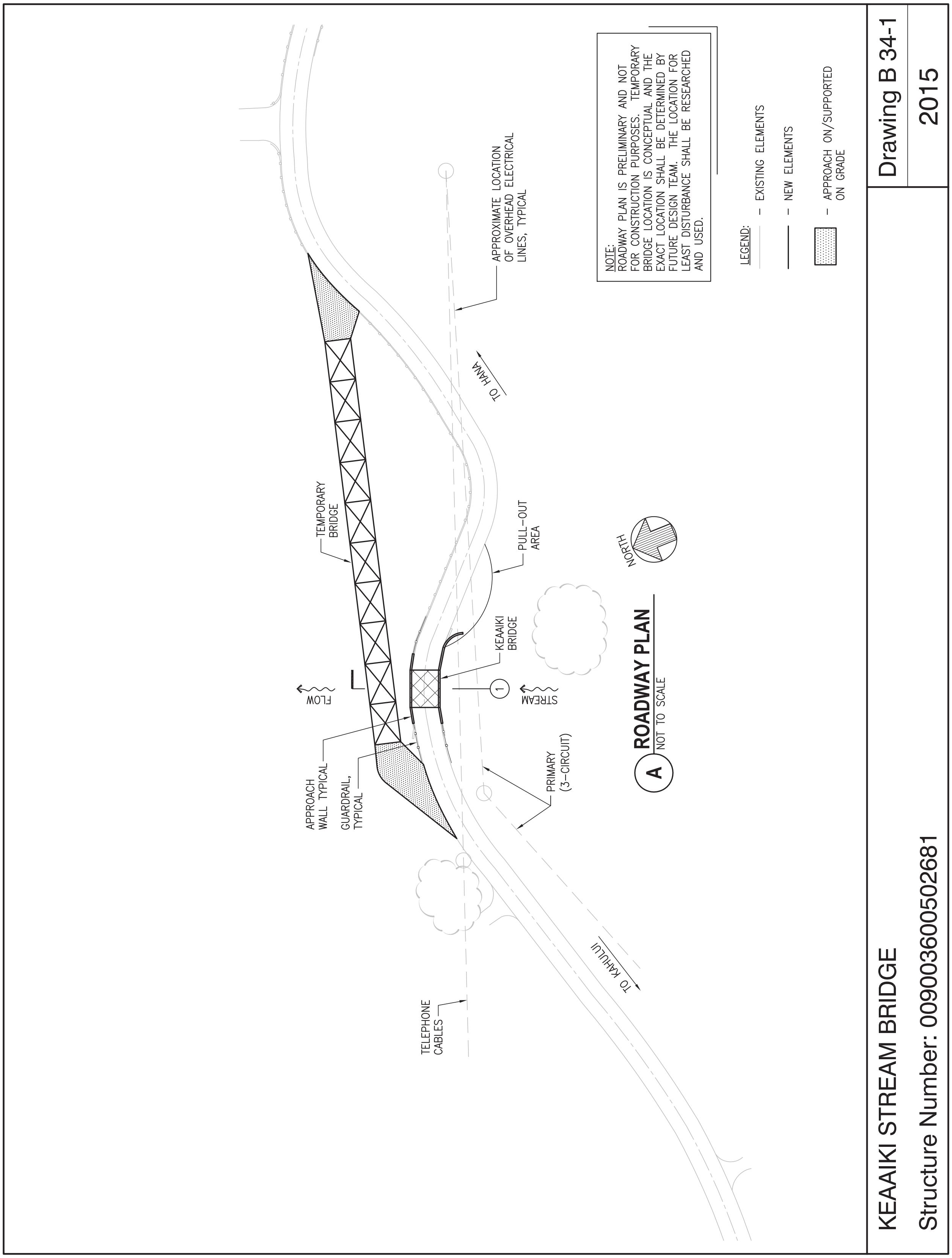
West Bridge Approach

- Prune roadside brush and trees

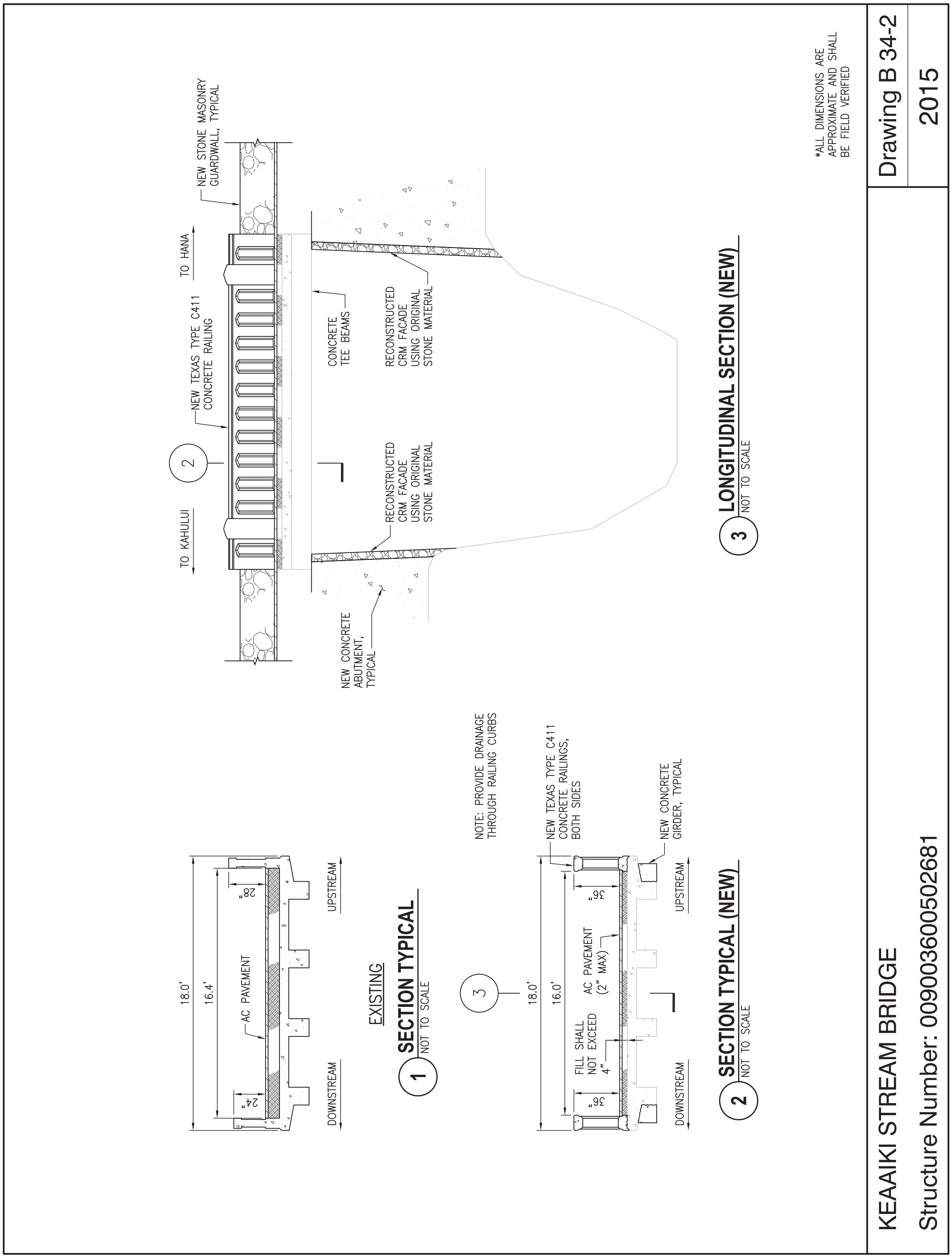
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

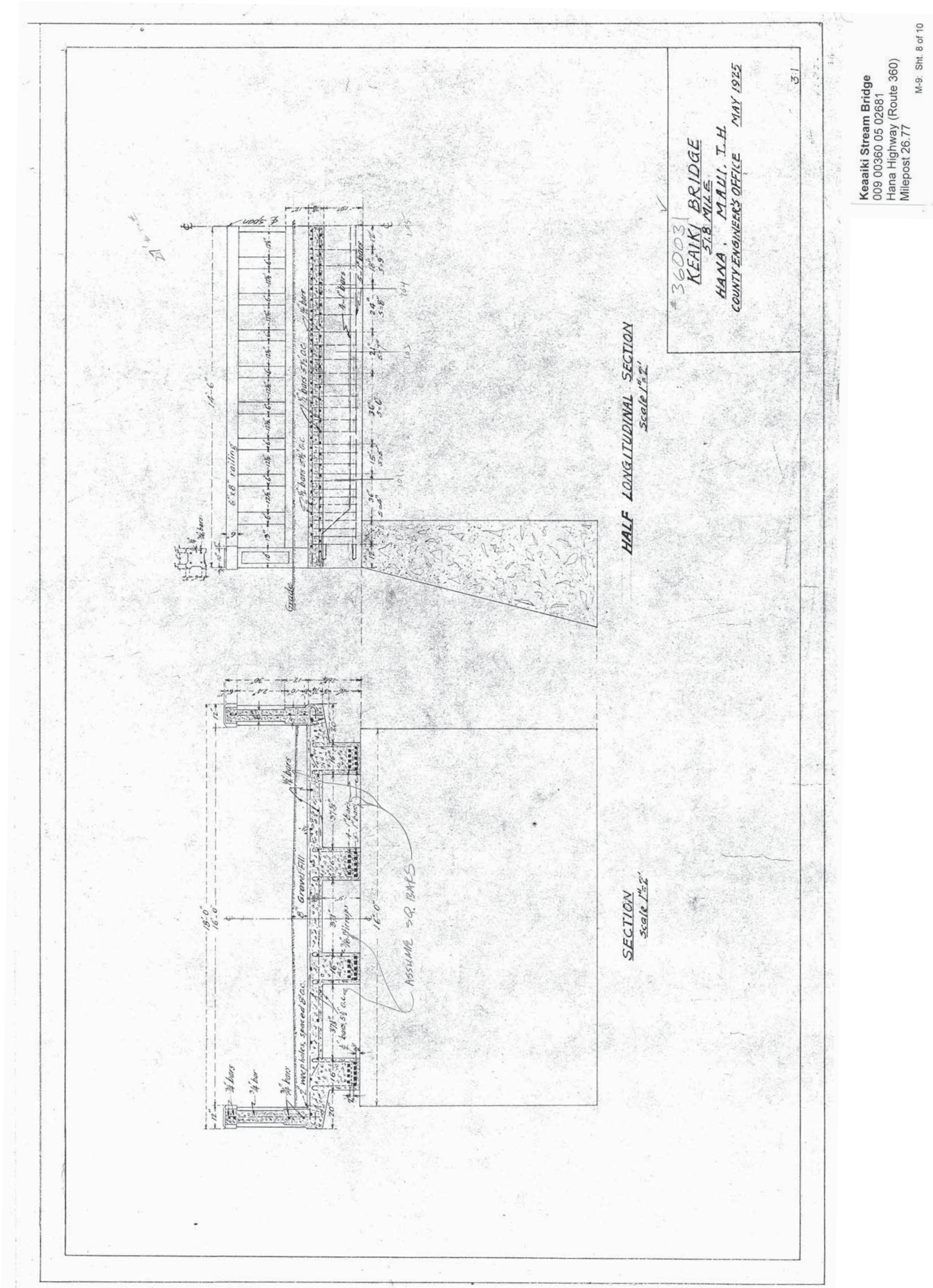
Primary and telephone lines are over the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI



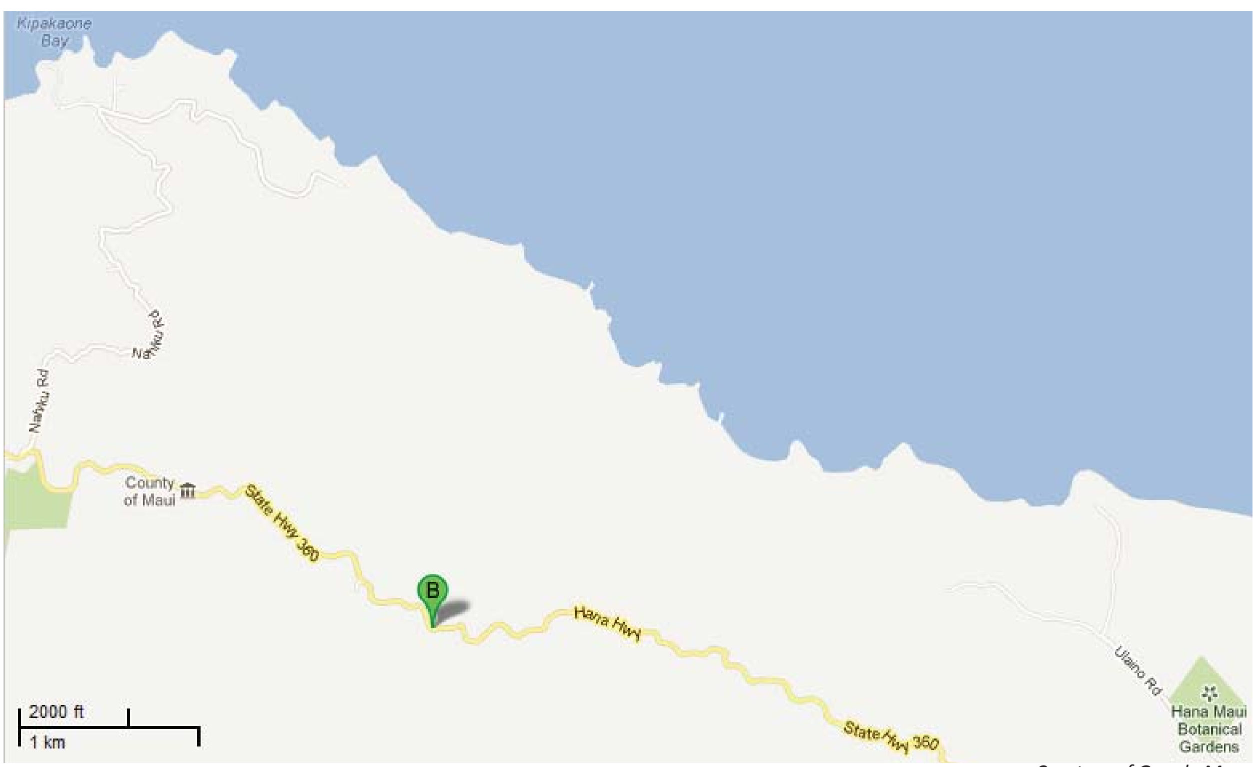
Courtesy of State of Hawaii Department of Transportation

35
West Waioni Stream Bridge

35 WEST WAIONI STREAM BRIDGE

Bridge Number	009003600502697			**Island**	Maui
Date of Construction	1920			**Route**	Hana Highway
Treatment Recommendation	X Preservation	X Rehabilitation		Restoration	Replacement

Courtesy of FAI



Courtesy of Google Maps

Location

Latitude	20d 47m 56s
Longitude	156d 04m 27s
Mile Point	26.87
Location	1.92 miles east of Lower Nahiku Road
Feature Crossed	West Waioni Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	28.87 feet
Number of Spans	1
Maximum Span	24.0 feet
Deck Width	• Curb-to-Curb = 16.73 feet • Out-to-Out = 18.40 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 34 inches • Downstream Railing Height = 36 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

West Waioni Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1920. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Setting of West Waioni Stream Bridge
Courtesy of NOEI

West Waioni Stream Bridge
Courtesy of FAI

Hana approach to West Waioni Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to West Waioni Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of FAI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Unconnected concrete remnant (left) with CRM abutment set on natural rock (right) , Hana side
Courtesy of NOEI

Downstream approach wall, Hana side
Courtesy of FAI

Downstream wingwall, Kahului side
Courtesy of FAI

Significance & Context

Ahupuaa	Keaa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential • Coconut stand nearby • Unconnected concrete remnant in stream
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	None

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[l]ike the Keaaiki Bridge, the West Waioni Bridge's concrete deck is supported by boulder rock abutments which date back to the early 1900s. The concrete deck and rails replaced an earlier timber deck as the Belt Road was paved in the 1920s. … Curiously there is an unconnected concrete pier standing in the middle of the stream bed."[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 137.

2 Ibid, 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The place name *Waioni* is defined as, "moving water. Land section, Koolau, Maui."[7] The West Waioni Stream Bridge spans West Waioni Stream, which cuts through Nahiku Homesteads and lies within Keaa Ahupuaa.[8] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Section 3.1.2.8, for the regional background of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[9]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the West Waioni Stream Bridge.

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7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

9 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear, No yield • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Left and Right Object Markers (OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.34 • Operating Rating = 0.44
Condition	Functionally Obsolete

Civil & Traffic

West Waioni Stream Bridge is located at mile point 26.87 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.40 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are telephone and other unidentified communication type cables that pass on the far downstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 4, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[10] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 34 inches and 36 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.34 and operating rating is 0.44.

The current curb-to-curb dimension is 16.73 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of West Waioni Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 4, 2014, record drawings,[11, 12] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If West Waioni Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The West Waioni Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay

11 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

12 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Hana approach corner has adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision occurring. The remaining three approaches do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

The CRM abutments are recommended to be replaced with reinforced concrete structures with a reconstructed CRM rock façade. To achieve this, the existing façades of the CRM abutments are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM abutments are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM abutments are to be placed in front of the new reinforced concrete abutments, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship.

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

The existing CRM abutments are exemplary examples of these bridge components. Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, which show evidence of exemplary historic craftsmanship, is recommended through preservation and routine maintenance.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

It is recommended to investigate the unconnected concrete remnant to determine its origins. If found to be historic, it is recommended to preserve the historic unconnected remnant.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to oncoming traffic visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), and a yield line are added to the west bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

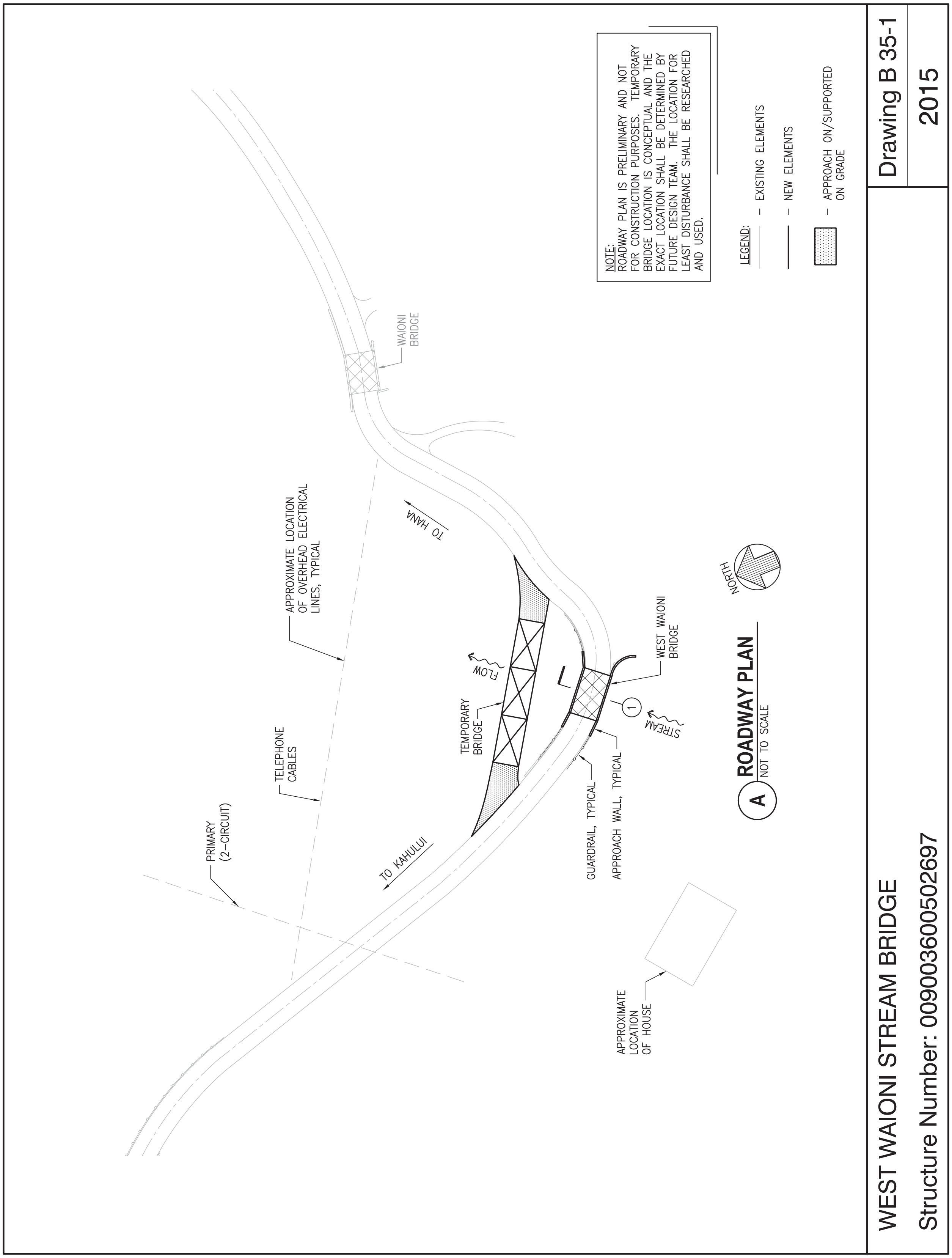
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line

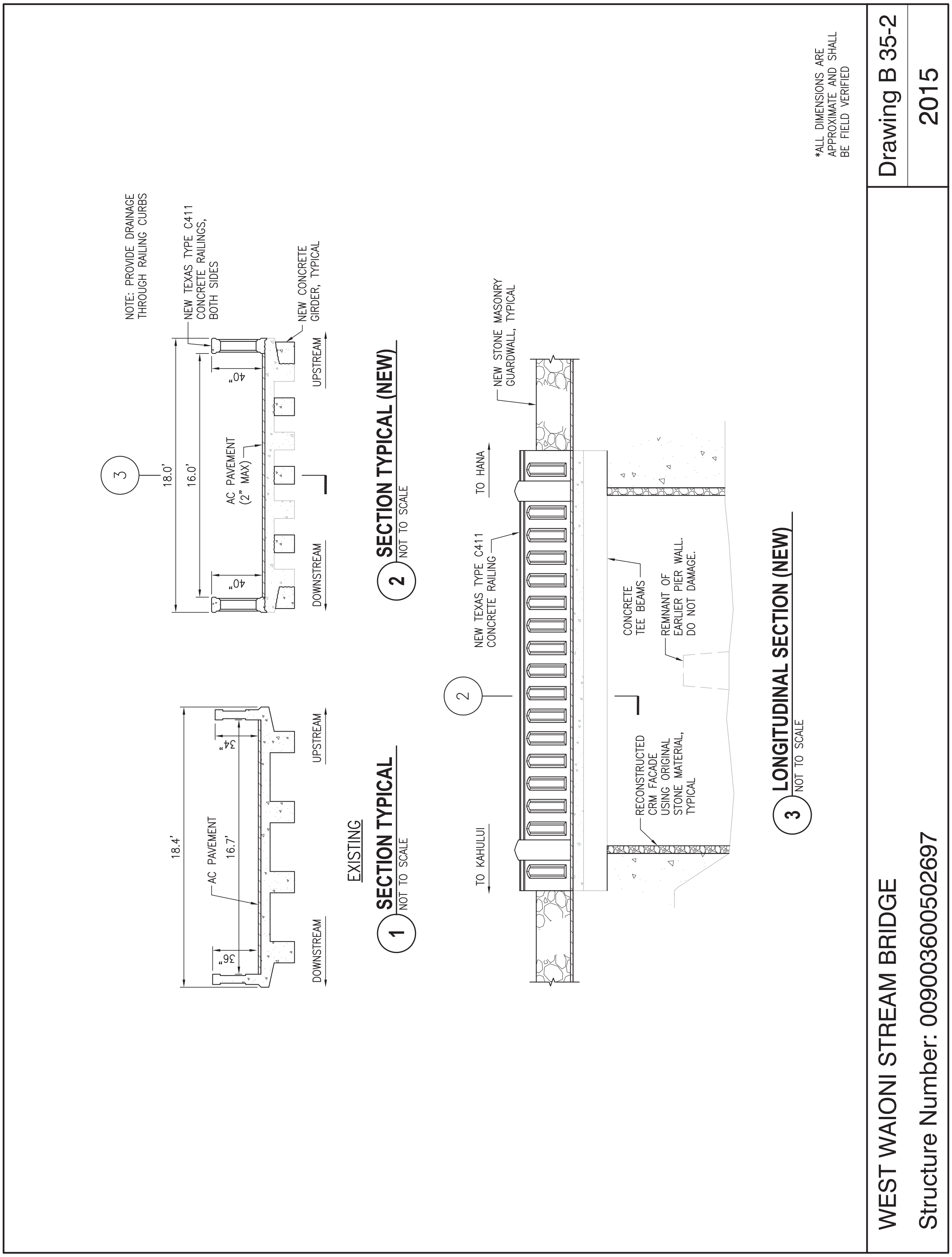
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for West Waioni Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

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36

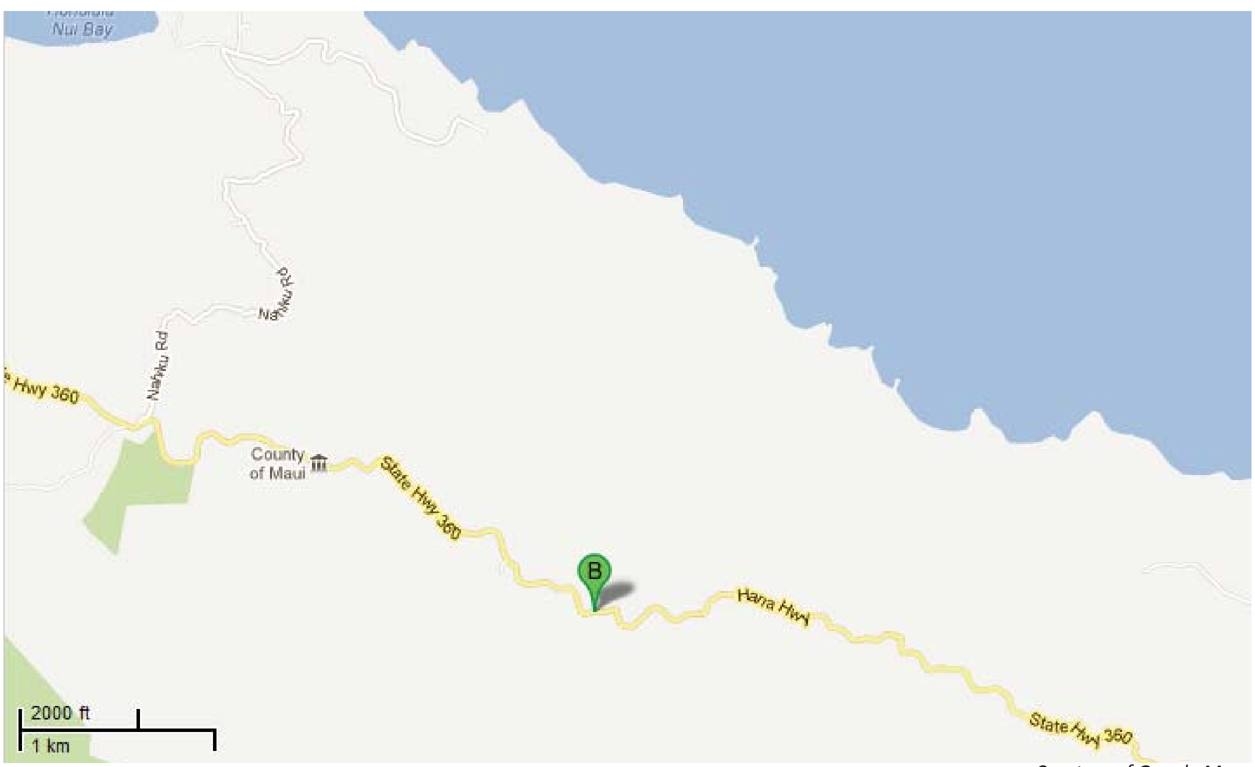
Waioni Stream Bridge

36

WAIONI STREAM BRIDGE

Bridge Number	009003600502702			**Island**	Maui		
Date of Construction	1920			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of HAER HI-75



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 47m 56s
Longitude	156d 04m 25s
Mile Point	26.92
Location	1.97 miles east of Lower Nahiku Road
Feature Crossed	Waioni Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	23.95 feet
Number of Spans	1
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 16.10 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutments
Wingwall Material	None
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 36 inches • Downstream Railing Height = 35 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Waioni Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1920. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments. The abutments bear directly on natural rock formations.

Waioni Stream Bridge upstream elevation
Courtesy of NOEI

Waioni Stream Bridge downstream elevation
Courtesy of NOEI

Hana approach to Waioni Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Waioni Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Damaged upstream approach wall, Kahului side
Courtesy of NOEI

Downstream approach wall, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Keaa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential • Coconut stand • Shaded, heavy overgrowth, and mature trees • Driveway nearby
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • Concrete Open Vertical Railings
Detracting Features	• Damaged approach wall

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he history of the Waioni Stream Bridge is similar to those of adjacent Nahiku bridges. It consists of a concrete deck supported by boulder rock abutments which were probably placed in 1906 to support a wagon road. The concrete deck and railings replaced a[n] old timber deck in 1920."[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 139.

2 Ibid, 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905*, Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The place name *Waioni* is defined as, "moving water. Land section, Koolau, Maui."[7] The Waioni Stream Bridge spans Waioni Stream, which cuts through Nahiku Homesteads and lies within Keaa Ahupuaa.[8] No other specific cultural or archaeological background information could be found for this particular location.

Refer to Section G, Appendix 1, Section 3.1.2.8, for the regional background of Nahiku, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[9]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Waioni Stream Bridge.

7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

9 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear, No yield
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Right Object Markers (OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	Electrical lines (telephone) located to the side
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.43
Condition	Functionally Obsolete

Civil & Traffic

Waioni Stream Bridge is located at mile point 26.92 along Hana Highway and its existing conditions are as follows. This bridge is an observed one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are electrical lines (telephone) that are close to the potential area of work on the immediate upstream side of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 4, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[10] The SI&A sheet for this bridge describe it as having two-lanes on the structure. Bridge inspection photos show that the structure is not stripped for two lanes and is posted with a “Yield to oncoming traffic” sign at the Kahului approach; therefore, this bridge is being utilized as a one-lane bridge. This bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 36 inches and 35 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.43.

The current curb-to-curb dimension is 16.10 feet, which for a two-lane bridge does not meet the design criteria minimum of 24 feet.

10 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Waioni Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 4, 2014, record drawings,[11, 12] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Waioni Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Waioni Stream Bridge currently does not meet the minimum standard width of 24 feet for a two-lane bridge. Due to the curb-to-curb width and the curvature of the approach to this bridge, it is recommended to re-classify the number of lanes on the bridge from 2 to 1 for the NBI Item 28A, provide the appropriate signage and striping for a one-lane two-way traffic bridge, and to not widen the bridge. By re-classifying the number of lanes, widening the bridge to meet the 24 feet requirement for a two-lane bridge would no longer be necessary.

11 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

12 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the upstream Kahului, upstream and downstream Hana approach corners to the bridge after the stone masonry guardwall. The downstream Kahului approach corner can be curved slightly into the adjacent private property bordering the bridge. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations & Abutments

The CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), and a yield line are added to the east bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

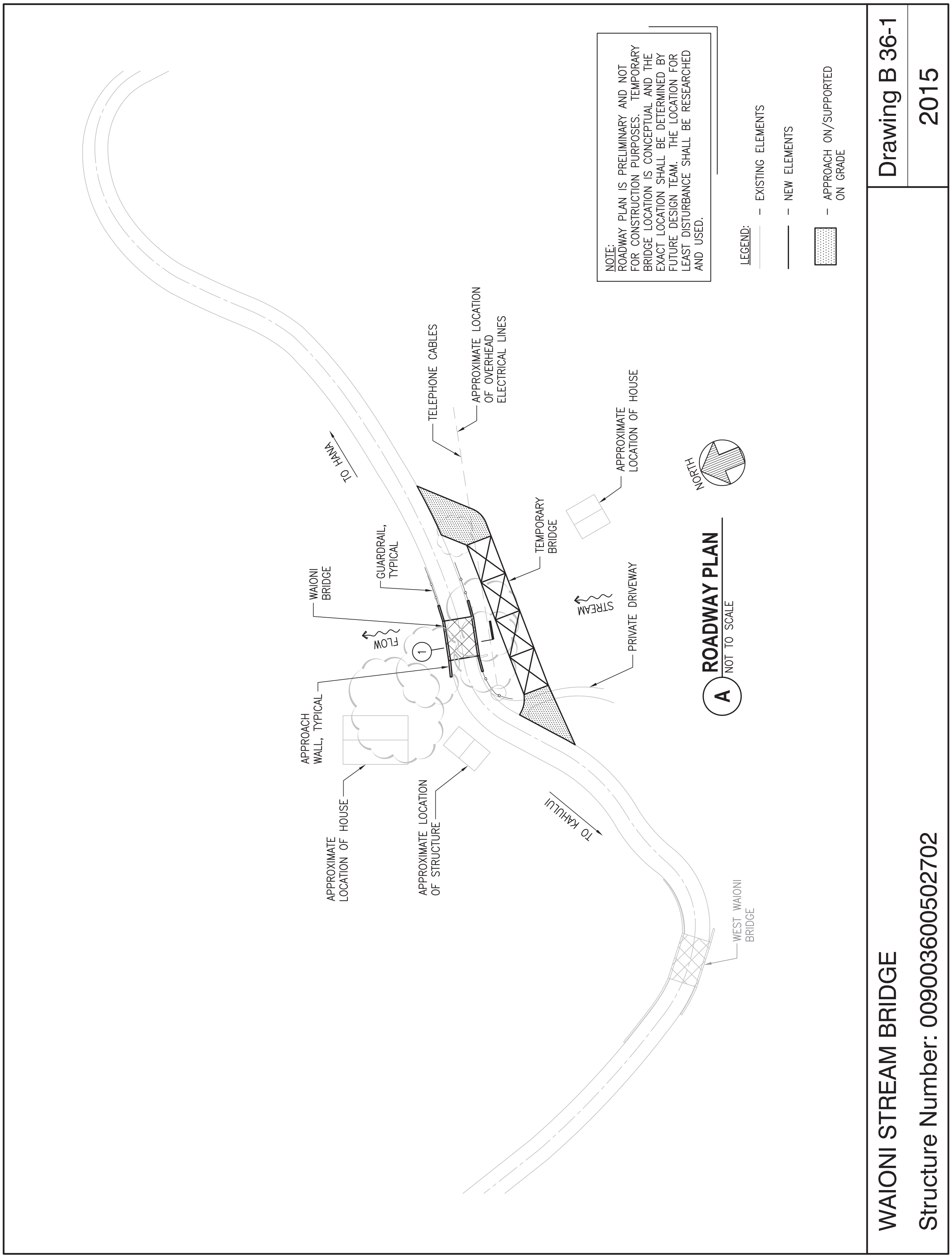
East Bridge Approach

- Add Yield sign (R1-2) and "To On Coming Traffic" plaque (R1-2a)
- Add Yield Line
- Add Object Marker Type 3 - Left (OM3-L)

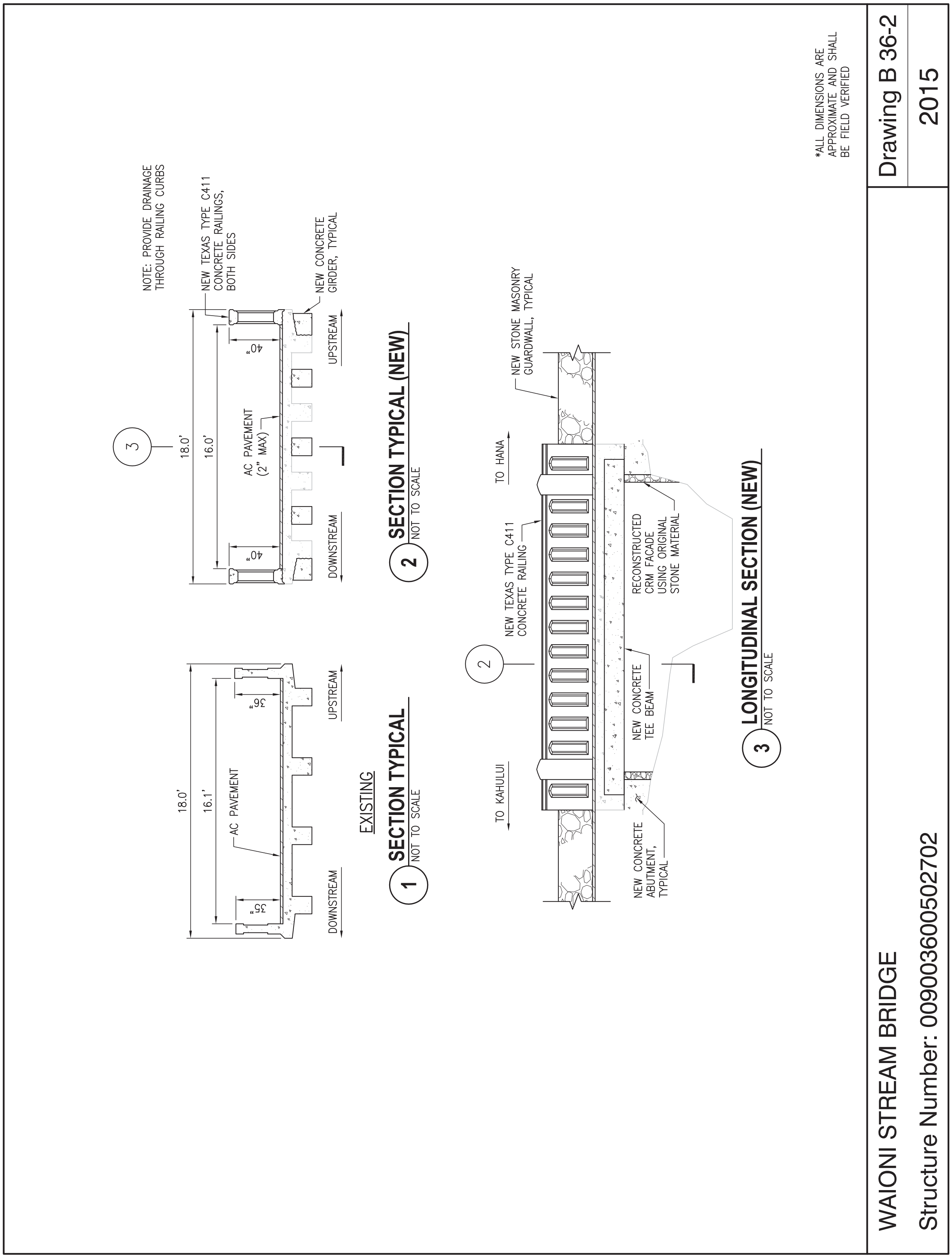
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Telephone lines are over the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI

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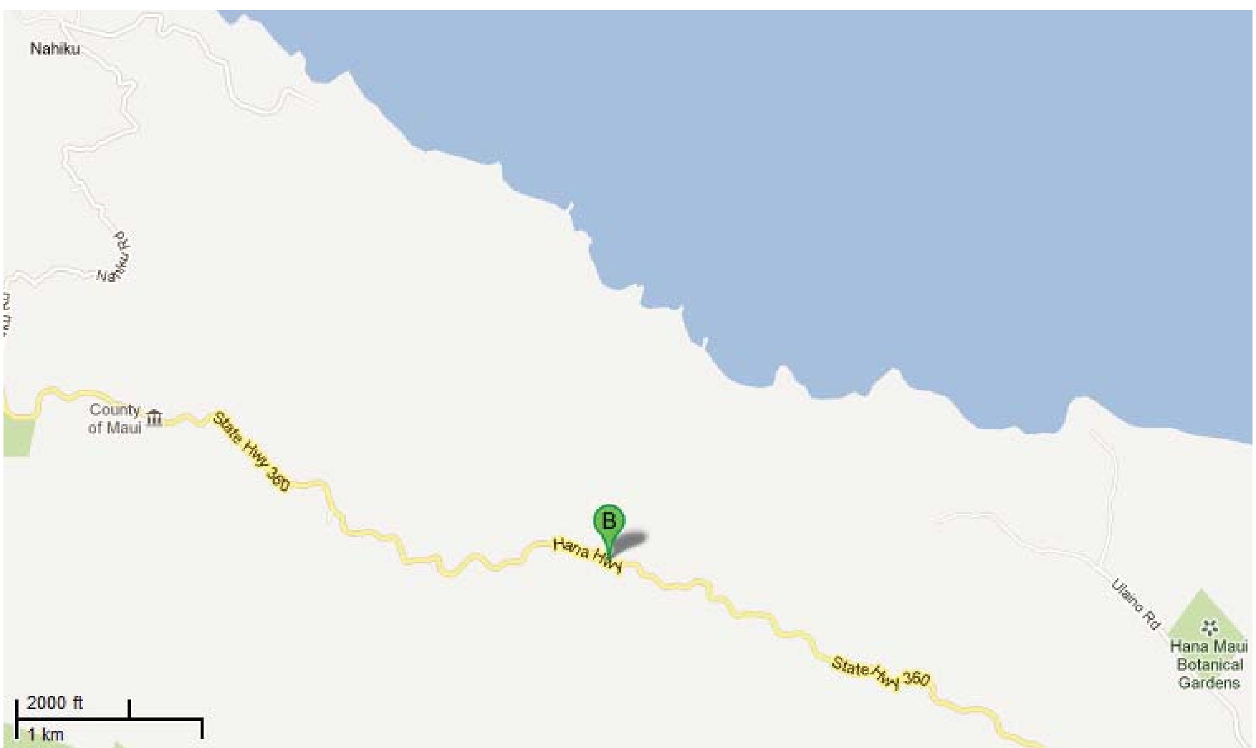
37 Lanikele Stream Bridge

37

LANIKELE STREAM BRIDGE

Bridge Number	009003600502779			Island	Maui	
Date of Construction	1925			Route	Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of FAI



Courtesy of Google Maps

Location

Latitude	20d 47m 56s
Longitude	156d 03m 49s
Mile Point	27.69
Location	2.74 miles east of Lower Nahiku Road
Feature Crossed	Heleleikeoho Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	50.85 feet
Number of Spans	2
Maximum Span	22.0 feet
Deck Width	• Curb-to-Curb = 16.10 feet • Out-to-Out = 18.04 feet
Abutment Material	• CRM Abutments • Concrete Pier Wall
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	2
Parapet / Railing Height	• Upstream Railing Height = 27 inches • Downstream Railing Height = 27 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 17.5 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Lanikele Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1925.[1] The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments, concrete pier wall, and CRM wingwalls. The Kahului abutments and pier bear directly on natural rock formations.

Lanikele Stream Bridge upstream elevation
Courtesy of NOEI

Lanikele Stream Bridge downstream elevation
Courtesy of NOEI

Hana approach to Lanikele Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Lanikele Stream Bridge toward Hana
Courtesy of NOEI

1 It should be noted that the construction date of 1925 is based on the historic drawings provided by HDOT. Previously this bridge was believed to be built in 1917 according to the National Bridge Inventory and *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990).

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Concrete pier wall, Kahului side
Courtesy of NOEI

Downstream CRM wingwall, Kahului side
Courtesy of NOEI

CRM abutment resting on natural rock, Hana side
Courtesy of NOEI

CRM abutment resting on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Heleleikeoho and Ulaino
Designer / Builder	County Engineer's Office - A.P. Low, Designer
Historic Drawings	February 1925
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Good intact example of solid concrete pier wall on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential • Open with mature trees at Kahului end • Driveways nearby
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Pier Wall • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Overgrown flora/fauna along railing edge

Significance & Context

Archaeological / Cultural Significance

The place name *Lanikele* is defined as, "moist heavens. Land section, Kohala, Hawaii."[2] The Lanikele Stream Bridge spans Heleleikeoho Stream, which divides Heleleikeoho Ahupuaa and Ulaino Ahupuaa.[3]

In ancient times, the shoreline along the Nahiku region was covered in a *hala* forest that extended from Ulaino to Hana.[4] The region above Nahiku was traditionally forested with native trees such as *koa, ohia lehua*, sandalwood, and many plants that were used for native medicine also grew there.[5]

In this traditional story of Aikanaka, Hina's children's excrement had to be carried to the north side of the water hole at Ulaino. Hina soon wearied of the task and the *tapu* involved in the disposition of the excrement. To escape this duty, Hina lept to the moon from a place called Wanaikulani on the night of Hoku (Full moon). As her husband lept to catch her, Hina's leg broke off in his hand. Thereafter she is called Lonomuku, and she hangs in the moon to this day.[6]

During the battle between the brothers Lono a Piilani and Kiha a Piilani, fighting commenced at:

> *Ulaino, at Makaolehua, and in Akiala at Laahana, at Kawaikau, at Nenewepue, at Kamehaikanas kukui tree and all the way along to Honokalani and Wakiu, into the pandanus grove of Kahalaoweke [Kahalaowaka], down to Pihehe, to the flats of Kalani and the spring of Punahoa.*[7]

Finally, the Hawaii warriors were able to gain the advantage when they invaded Kauiki at night. The army of Umi a Liloa pursued the escaping Hoolae makua across Koolau, where he was caught directly back of Nahiku at a place called Kapipiwai. He was killed. Kiha a Piilani then turned toward Wailuku, where Lono a Piilani ruled Maui. When Lono a Piilani learned of the death of Hoolae makua, he died of fear: that he would be the next one tortured by the forces of Umi a Liloa and Kiha a Piilani.[8]

In Native Hawaiian legends, the battles of Kapalipilo describe the assault by the combined forces of Maui, Molokai, and Lanai on the fort at Kauiki that were meant to dislodge the Hawaii forces.[9] According to Kamakau, the field of battle started with the massing of the Maui armies from Heleleikeoha to Nahiku. Wananalua soon became the battlefield. At a signal from the islet of Mokuhano, the fortified walls of Kauiki were attacked. Soon, the battlefield shifted to the districts of Akiala and Keawaikau. The fighting soon came down to a challenge between Kaohele, a chief from Molokai, and Kamakaukii, a famous fighter from Hawaii. After a time, Kaohele gained the advantage, and Kamakaukii attempted to escape the battlefield, but the Molokai chief chased the Hawaii fighter and thrust

2 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

3 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," registered map no. 2649 (1897).

4 Robert Wenkam, *Maui: The Last Hawaiian Place* (San Francisco: Friends of the Earth, 1970).

5 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233 rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

6 Thomas G. Thrum, ed., "More Hawaiian Folk Tales," *A Collection of Native Legends* (Chicago: A. C. McClung, 1923).

7 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

8 Ibid.

9 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

him through the scrotum with a spear. Despite the victory by Kaohele, the fort did not surrender. Kamehamehanui retired, leaving Hana in the hands of the warriors of Hawaii.[10]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.4, for the story of Aikanaka; Section 3.1.3.3.1.6, for the story of the battles of Kapalipilo; Section 3.1.3.3.1.7, for the story of Kiha a Piilani; Section 3.1.2.8, for the broader regional background of the Nahiku area; and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[11]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Lanikele Stream Bridge.

10 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

11 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	Electrical lines (telephone) located to the side
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.66 • Operating Rating = 0.85
Condition	Functionally Obsolete

Civil & Traffic

Lanikele Stream Bridge is located at mile point 27.69 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition on both approaches to the bridge. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are electrical lines (telephone) that are close to the potential area of work on the upstream side of the bridge. They cross Hana Highway (upstream to downstream) just east of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 4, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[12] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 27 inches. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.66 and the operating rating is 0.85.

The current curb-to-curb dimension is 16.10 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

12 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Lanikele Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 4, 2014, record drawings,[13] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Lanikele Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

It is also recommended that there be more research into the origins of Lanikele Stream bridge. The bridge has been said to be built in 1917, however historical drawings from HDOT refers to this bridge as "Heleleikeoho Bridge" with a drawing date of February 1925. Refer to historic drawings for this bridge. The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Lanikele Stream Bridge currently meets the standard width of a one lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck

13 County Engineer's Office, "Heleleikeoho Bridge 52.65 Mile," Hana, Historic Drawings, February 1925.

and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Foundations, Pier, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete pier and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete pier wall is a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier wall, it is recommended to be replaced in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, CRM wingwalls, and pier wall which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. Also, the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

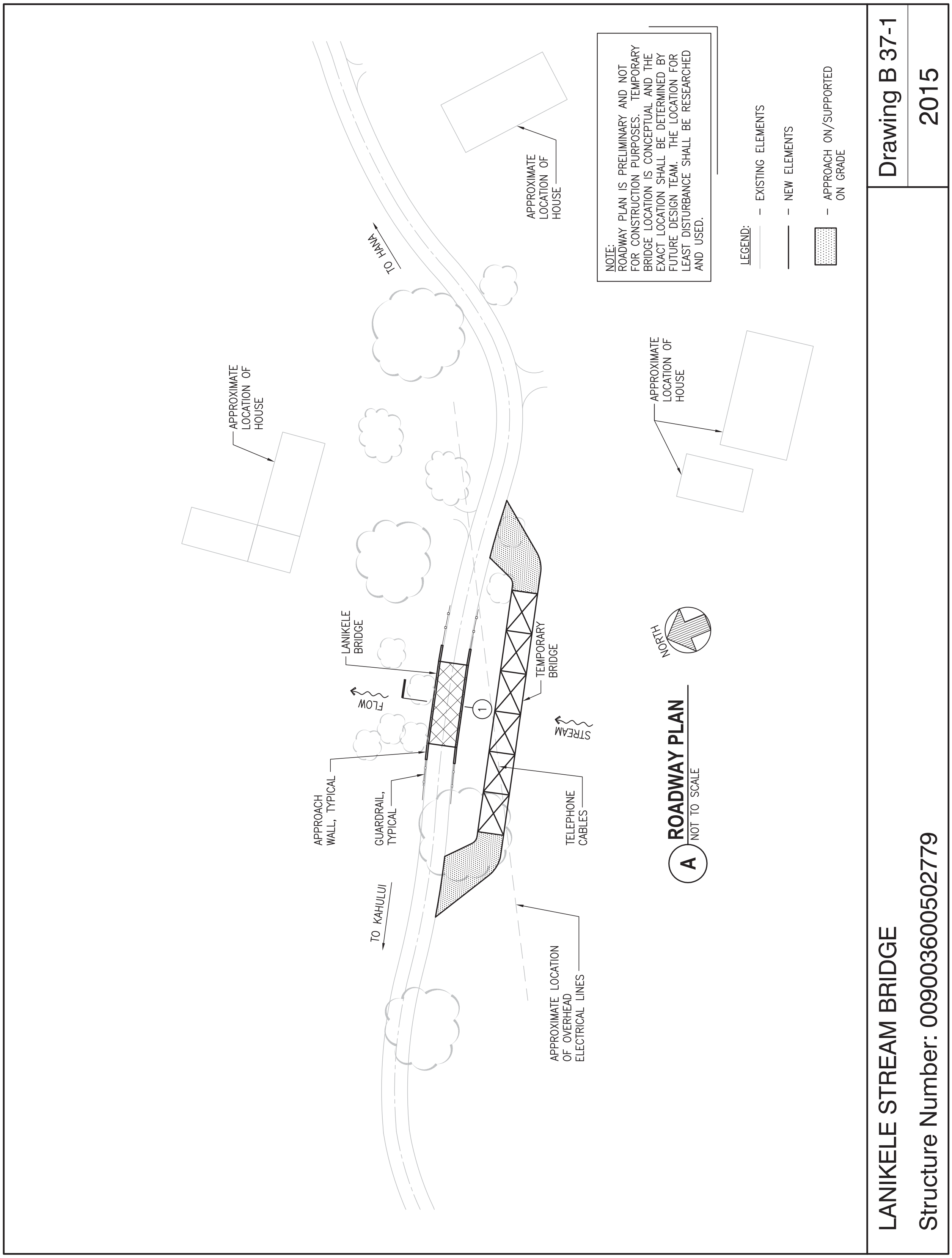
In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that a "Yield" sign (R1-1), a "To Oncoming Traffic" sign (R1-2a), and a yield line are added to the west bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book.

There are no signage, visibility, and traffic recommendations for this bridge.

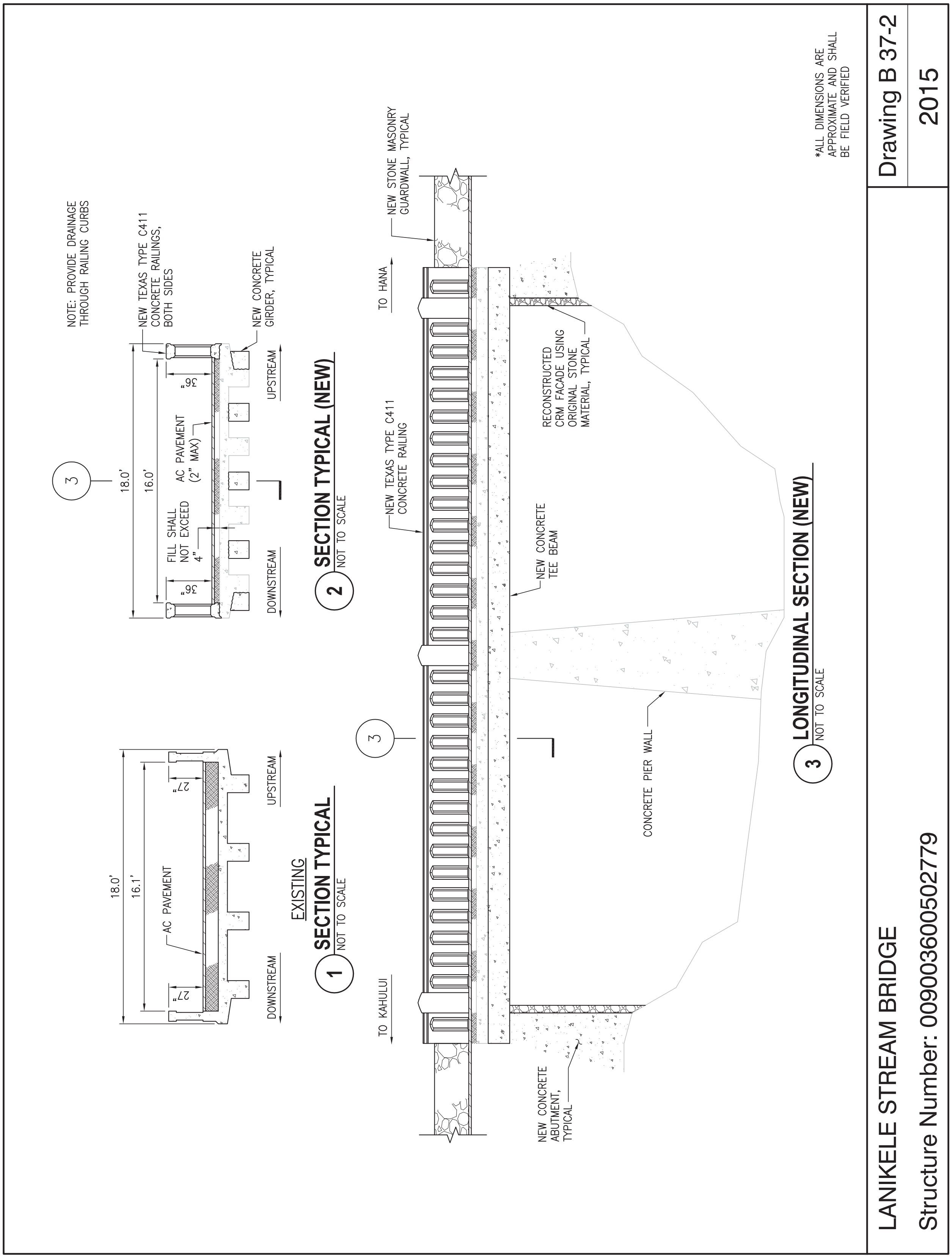
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

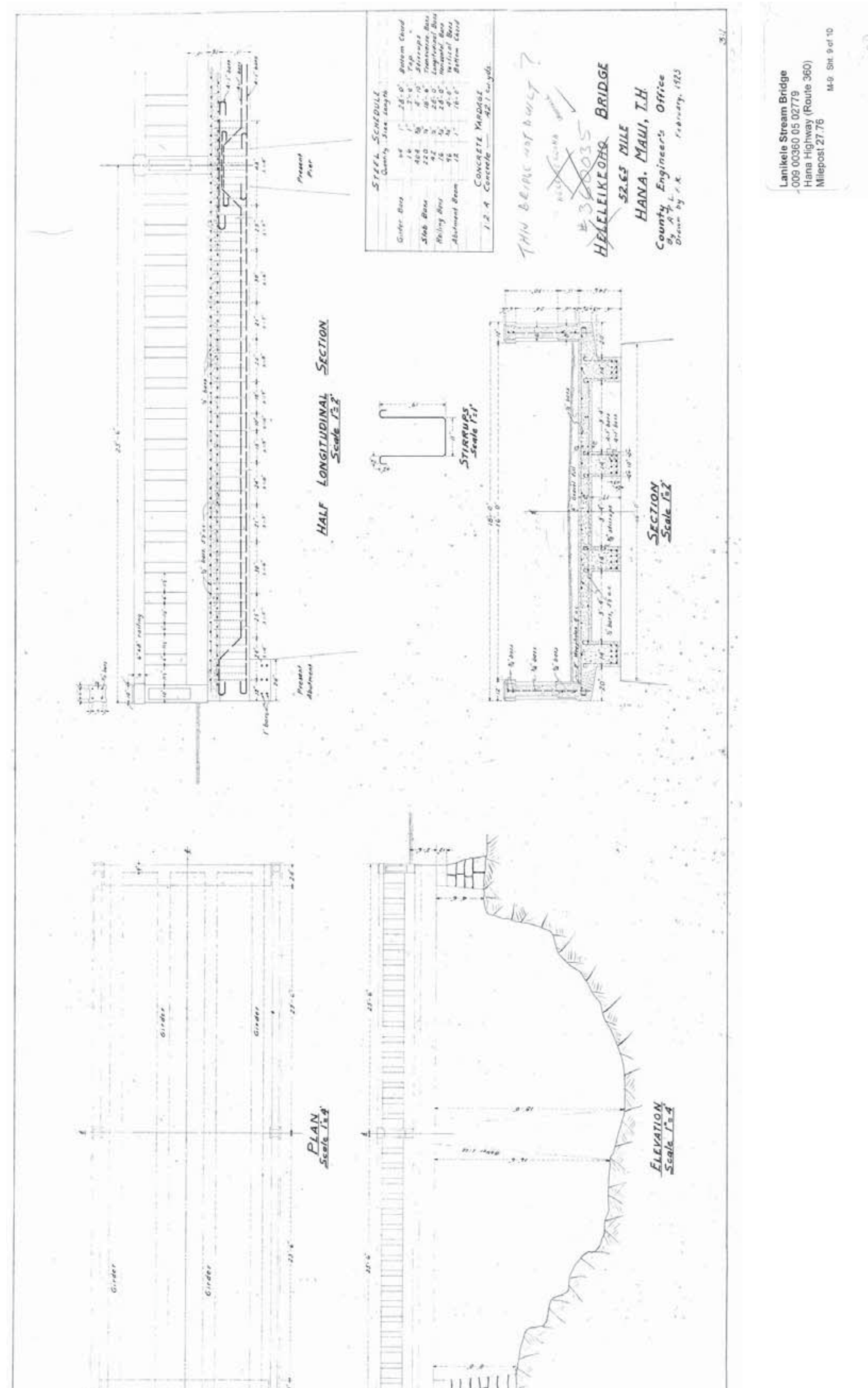
Telephone lines are to the side of the area of work but the contractor can coordinate the work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI



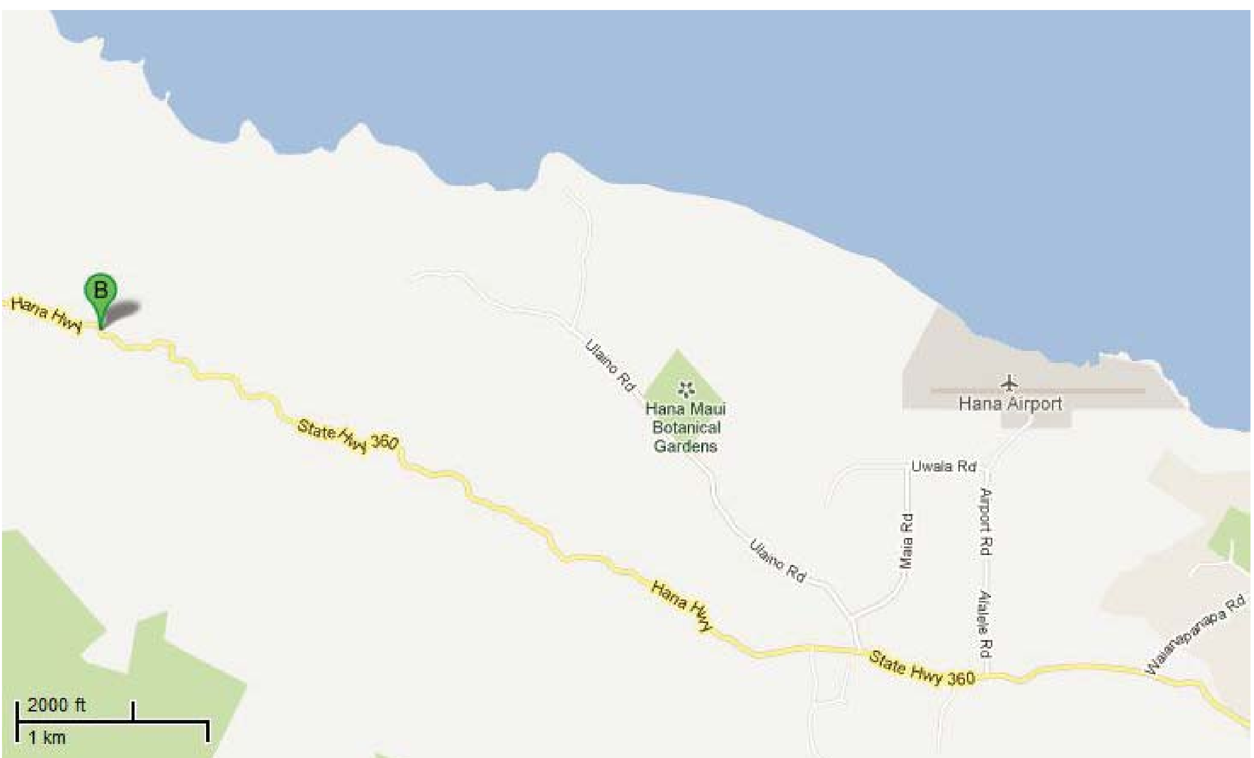
Courtesy of State of Hawaii Department of Transportation

38 Heleleikeoha Stream Bridge

38 HELELEIKEOHA STREAM BRIDGE

Bridge Number	009003600502795			Island		Maui	
Date of Construction	1917			Route		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 47m 54s
Longitude	156d 03m 42s
Mile Point	27.85
Location	2.90 miles east of Lower Nahiku Road
Feature Crossed	Kakamalaole Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	27.89 feet
Number of Spans	1
Maximum Span	23.0 feet
Deck Width	• Curb-to-Curb = 16.10 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 36 inches • Downstream Railing Height = 38 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Heleleikeoha Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1917. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Heleleikeoha Stream Bridge
Courtesy of NOEI

Heleleikeoha Stream Bridge downstream elevation
Courtesy of NOEI

Hana approach to Heleleikeoha Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Heleleikeoha Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Bridge name painted on cap
Courtesy of FAI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

CRM abutment set upon natural rock, Hana side
Courtesy of NOEI

Unconnected concrete remnant with CRM abutment set upon natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	Ulaino
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential • Coconut stand • Open clearing • Unconnected concrete remnant in stream • Driveways nearby
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Non-continuous Hana downstream approach wall

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]his 28-foot long bridge is supported by boulder rock abutments at either end, probably built in 1906 which corresponds to the building period of the abutments of the preceding Hana Belt Road bridges. The concrete deck and railing were built in 1917 to replace a timber deck. The County Engineer at the time was R. P. (Paul) Low. There is an old unconnected concrete pier near the west abutment."[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 143.

2 Ibid, 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905,* Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The place name *Heleleikeoha* is defined as, "dropping the small taro-sprigs. Land section, Koolau, Maui,"[7] or as, "Stream, Hana qd., Maui. Probably *lit.,* the taro sprout falls."[8] The Heleleikeoha Stream Bridge spans Kakamalaole Stream, which runs through Ulaino Ahupuaa.[9]

In ancient times, the shoreline along the Nahiku region was covered in a *hala* forest that extended from Ulaino to Hana.[10] The region above Nahiku was traditionally forested with native trees such as *koa, ohia lehua*, sandalwood, and many plants that were used for native medicine also grew there.[11]

In this traditional story of Aikanaka, Hina's children's excrement had to be carried to the north side of the water hole at Ulaino. Hina soon wearied of the task and the *tapu* involved in the disposition of the excrement. To escape this duty, Hina leapt to the moon from a place called Wanaikulani on the night of Hoku (Full moon). As her husband leapt to catch her, Hina's leg broke off in his hand. Thereafter she is called Lonomuku, and she hangs in the moon to this day.[12]

During the battle between the brothers Lono a Piilani and Kiha a Piilani, fighting commenced at:

> *Ulaino, at Makaolehua, and in Akiala at Laahana, at Kawaikau, at Nenewepue, at Kamehaikanas kukui tree and all the way along to Honokalani and Wakiu, into the pandanus grove of Kahalaoweke [Kahalaowaka], down to Pihehe, to the flats of Kalani and the spring of Punahoa.*[13]

Finally, the Hawaii warriors were able to gain the advantage when they invaded Kauiki at night. The army of Umi a Liloa pursued the escaping Hoolae makua across Koolau, where he was caught directly back of Nahiku at a place called Kapipiwai. He was killed. Kiha a Piilani then turned toward Wailuku, where Lono a Piilani ruled Maui. When Lono a Piilani learned of the death of Hoolae makua, he died of fear: that he would be the next one tortured by the forces of Umi a Liloa and Kiha a Piilani.[14]

In Native Hawaiian legends, the battles of Kapalipilo describe the assault by the combined forces of Maui, Molokai, and Lanai on the fort at Kauiki that were meant to dislodge the Hawaii forces.[15] According to Kamakau, the field of battle started with the massing of the Maui armies from Heleleikeoha to Nahiku. Wananalua soon became the battlefield. At a signal from the islet of Mokuhano, the fortified walls of Kauiki were attacked. Soon, the battlefield

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7 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

8 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

9 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," Registered Map No. 2649 (1897).

10 Robert Wenkam, *Maui: The Last Hawaiian Place* (San Francisco: Friends of the Earth, 1970).

11 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

12 Thomas G. Thrum, *More Hawaiian Folk Tales: A Collection of Native Legends and Traditions* (Chicago: A. C. McClung, 1923).

13 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

14 Ibid.

15 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

shifted to the districts of Akiala and Keawaikau. The fighting soon came down to a challenge between Kaohele, a chief from Molokai, and Kamakaukii, a famous fighter from Hawaii. After a time, Kaohele gained the advantage, and Kamakaukii attempted to escape the battlefield, but the Molokai chief chased the Hawaii fighter and thrust him through the scrotum with a spear. Despite the victory by Kaohele, the fort did not surrender. Kamehamehanui retired, leaving Hana in the hands of the warriors of Hawaii.[16]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.4, for the story of Aikanaka; Section 3.1.3.3.1.6, for the story of the battles of Kapalipilo; Section 3.1.3.3.1.7, for the story of Kiha a Piilani; Section 3.1.2.8, for the broader regional background of the Nahiku area; and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[17]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Heleleikeoha Stream Bridge.

16 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

17 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L,Vandalized, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.34 • Operating Rating = 0.44
Condition	Structurally Deficient

Civil & Traffic

Heleleikeoha Stream Bridge is located at mile point 27.85 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the Type 3 Object Marker (Right) on the westbound approach to the bridge has been vandalized. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are overhead telephone lines on the upstream side of the bridge. They cross Hana Highway (downstream to upstream) just east of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 4, 2014. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[18] This one-lane bridge is *structurally deficient* due to a rating of 4 for the *superstructure*. This bridge is also *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 36 inches and 38 inches, respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.34 and operating rating is 0.44.

The current curb-to-curb dimension is 16.10 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

18 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Heleleikeoha Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 4, 2014, record drawings,[19, 20] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Heleleikeoha Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck & Superstructure

The Heleleikeoha Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed.

The bridge superstructure is structurally deficient. Repairs to the superstructure shall include, but not be limited to, epoxy injection crack repairs, chipping out and replacing exposed severely corroded reinforcing, and chipping out and patching delaminated and spalled areas with an epoxy non-shrink grout. Finish of the repaired area shall match the original condition of the bridge. Sprayed shotcrete finish shall not be permitted.

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19 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

20 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on the following figures so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary downstream Hana CRM approach wall
Courtesy of NOEI

CRM Approach Walls

This bridge has a CRM approach wall of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance. Approach walls of similar quality are shown in the following bridges and may be used for reference: current existing approach walls to this bridge, #19 Kopiliula Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Exemplary upstream Kahului CRM approach wall
Courtesy of NOEI

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a reconstructed rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To achieve the reconstructed rock façades appearances, the existing CRM façades are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM approach walls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM approach walls are to be placed in front of the new reinforced concrete approach walls, functioning as their new façade. The appearance of the reconstructed façades

Exemplary upstream Hana CRM approach wall
Courtesy of FAI

shall closely match that of the original historic craftsmanship. The surface of the rock façade shall not exceed 0.5 inches in variation. All of the approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Railings / Parapet

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

The CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information). It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

It is recommended to investigate the unconnected concrete remnant to determine its origins. If found historic, it is recommended to preserve the historic unconnected remnant.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

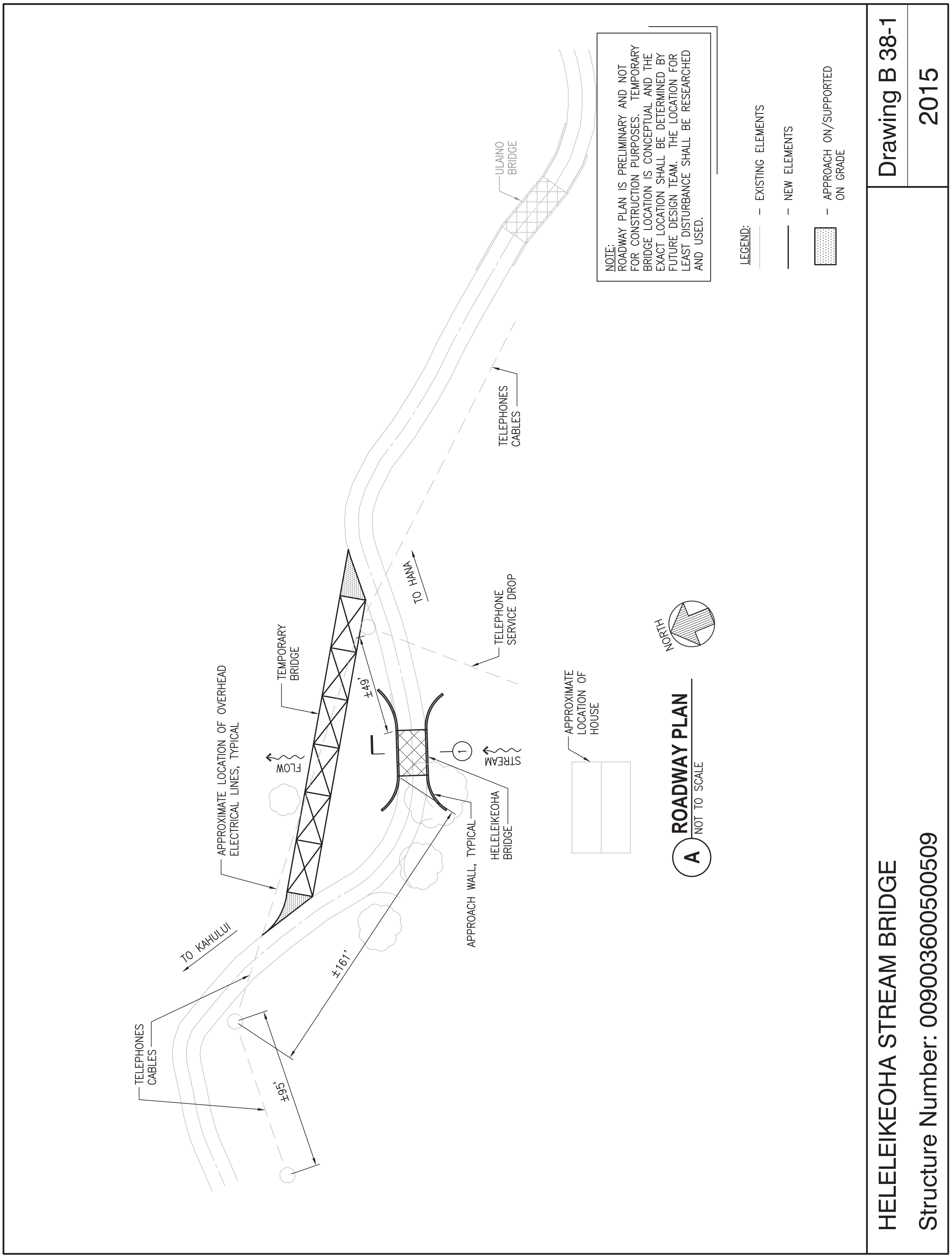
East Bridge Approach

- Replace the Object Marker Type 3 - Right (OM3-R)

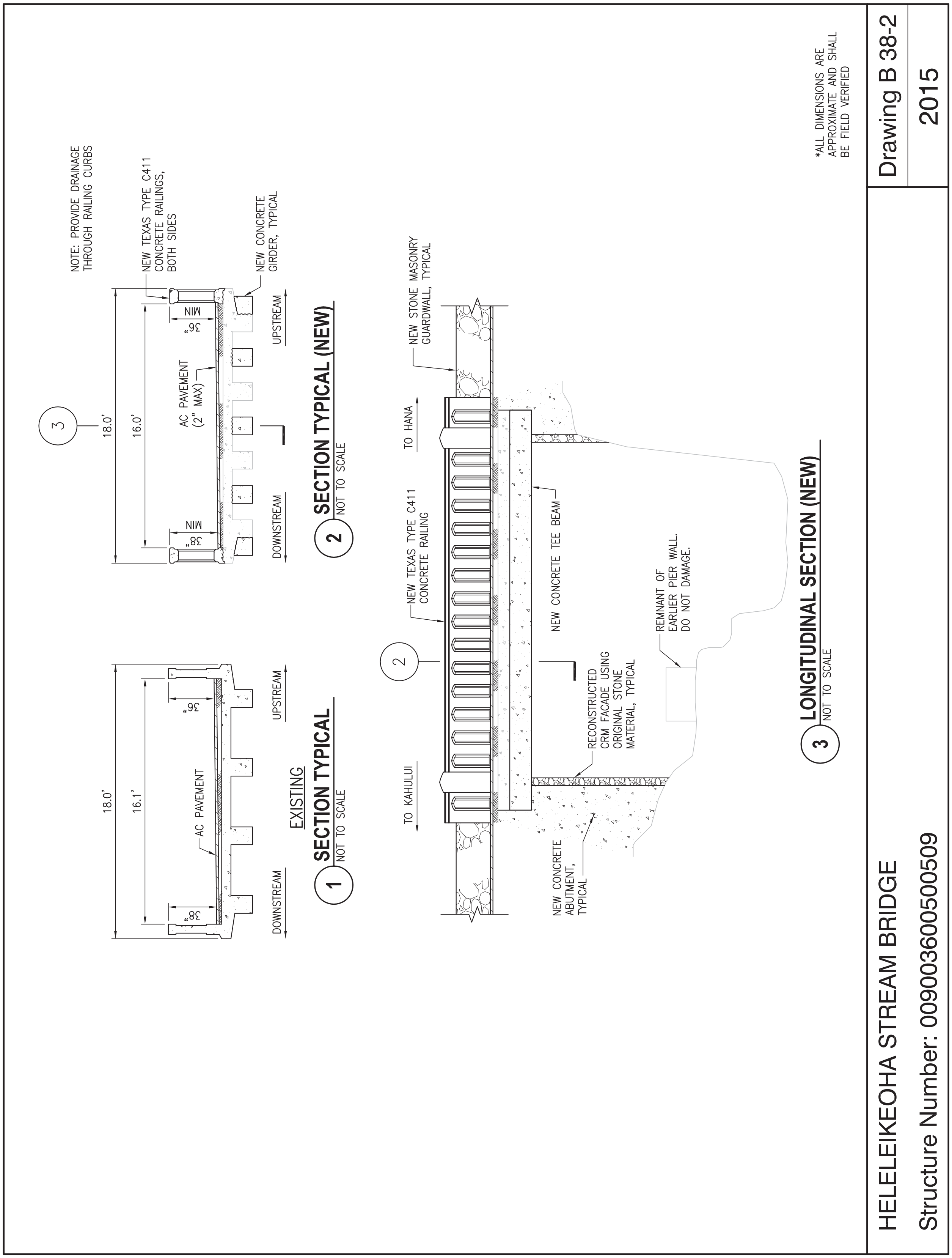
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Telephone lines are over the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



Courtesy of NOEI

39

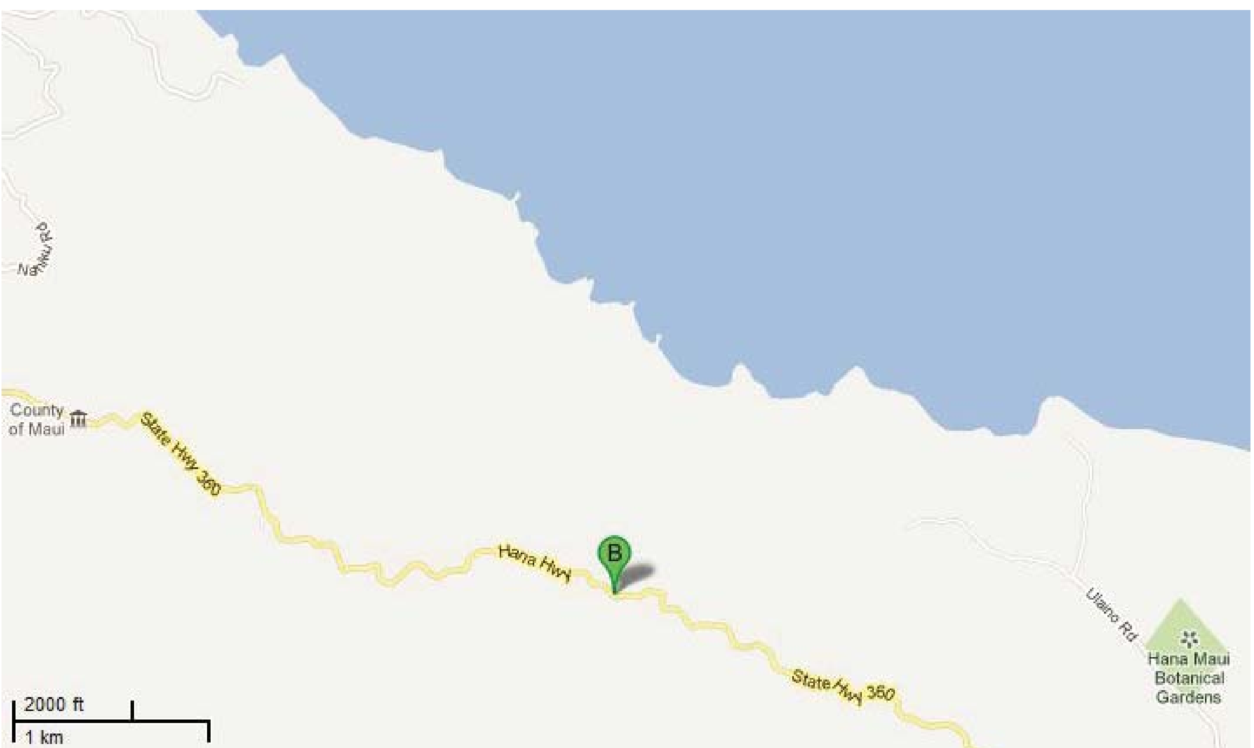
Ulaino Stream Bridge

39

ULAINO STREAM BRIDGE

Bridge Number	009003600502801				**Island**		Maui	
Date of Construction	1914				**Route**		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 47m 52s
Longitude	156d 03m 38s
Mile Point	27.92
Location	2.96 miles east of Lower Nahiku Road
Feature Crossed	Ulaino Stream

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	39.04 feet
Number of Spans	2
Maximum Span	23.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	• CRM Abutments • Reinforced Concrete Pier Cap and Columns on a Concrete Pier Wall
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	2
Parapet / Railing Height	• Upstream Railing Height = 38 inches • Downstream Railing Height = 36 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • Intermediate posts = 12 inches x 10 inches • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Ulaino Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1914. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span, which are spaced approximately 4.5 feet on-center. The substructure consists of CRM abutments, a reinforced concrete pier cap and columns supported on a concrete pier wall, and CRM wingwalls. The abutments and pier bear directly on natural rock formations.

Setting of Ulaino Stream Bridge
Courtesy of FAI

Ulaino Stream Bridge upstream elevation
Courtesy of NOEI

Hana approach to Ulaino Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Ulaino Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Concrete pier
Courtesy of NOEI

Upstream CRM wingwall, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Ulaino
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of pier wall on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Spans lava rock stream • Rural residential neighborhood • Open sloping terrain, with views of stream below • Adjacent residence and driveways nearby
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Reinforced Concrete Pier Cap and Columns on a Concrete Pier Wall • Concrete Open Vertical Railings
Detracting Features	Non-continuous Hana downstream approach wall

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he 39-foot bridge was built in 1914. The concrete deck and railings are supported by a single concrete pier. The current bridge probably replaced an earlier timber bridge used for an unpaved wagon road to Hana."[1]

> *Howell's communications to the Maui County Board of Supervisors indicated that early wood structures along the Hana Coast were built using truss systems. Howell's program from 1906 to circa 1909 was to replace these failing structures with bridges built on concrete or rock piers, which eliminated the need for high-maintenance trusses. In constructing wood bridges with concrete foundations, Howell was following the advice of SPW C. S. Holloway, who strongly recommended that concrete or wood bridges, rather than steel, be built wherever possible. Holloway further emphasized that particular attention should be paid to the structures' foundations and piers, so that the structures would be of a more permanent nature.*[2]
>
> *While Wilson was working on his Keanae-Nahiku extension, the MLFC authorized additional bridges for construction. ...In 1913, concrete structures were built in Papahawahawa, and in 1914 at Olowai [sic] and Ula'ino.*[3]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[4] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[5] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 145.

2 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 29.

3 Ibid., 33.

4 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

5 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The place name *Ulaino* is defined as, "Beach, Hana, Maui. Small pebble beach on an otherwise rocky shore. Site of Piilani Heiau, the largest shrine in the Hawaiian Islands. *Lit.,* stormy red."[6] The Ulaino Stream Bridge spans Ulaino Stream, which runs through Ulaino Ahupuaa.[7]

In ancient times, the shoreline along the Nahiku region was covered in a *hala* forest that extended from Ulaino to Hana.[8] The region above Nahiku was traditionally forested with native trees such as *koa, ohia lehua*, sandalwood, and many plants that were used for native medicine also grew there.[9]

In this traditional story of Aikanaka, Hina's children's excrement had to be carried to the north side of the water hole at Ulaino. Hina soon wearied of the task and the *tapu* involved in the disposition of the excrement. To escape this duty, Hina leapt to the moon from a place called Wanaikulani on the night of Hoku (Full moon). As her husband leapt to catch her, Hina's leg broke off in his hand. Thereafter she is called Lonomuku, and she hangs in the moon to this day.[10]

During the battle between the brothers Lono a Piilani and Kiha a Piilani, fighting commenced at:

> *Ulaino, at Makaolehua, and in Akiala at Laahana, at Kawaikau, at Nenewepue, at Kamehaikanas kukui tree and all the way along to Honokalani and Wakiu, into the pandanus grove of Kahalaoweke [Kahalaowaka], down to Pihehe, to the flats of Kalani and the spring of Punahoa.*[11]

Finally, the Hawaii warriors were able to gain the advantage when they invaded Kauiki at night. The army of Umi a Liloa pursued the escaping Hoolae makua across Koolau, where he was caught directly back of Nahiku at a place called Kapipiwai. He was killed. Kiha a Piilani then turned toward Wailuku, where Lono a Piilani ruled Maui. When Lono a Piilani learned of the death of Hoolae makua, he died of fear: that he would be the next one tortured by the forces of Umi a Liloa and Kiha a Piilani.[12]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.4, for the story of Aikanaka; Section 3.1.3.3.1.7, or the story of Kiha a Piilani; Section 3.1.2.8,for the broader regional background of the Nahiku area; and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[13]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Ulaino Stream Bridge.

6 John R. K. Clark, *Hawai'i Place Names: Shores, Beaches and Surf Sites* (Honolulu: University of Hawaii Press, 2002).

7 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

8 Robert Wenkam, *Maui: The Last Hawaiian Place* (San Francisco: Friends of the Earth, 1970).

9 E. S. Craighill Handy, Elizabeth Green Handy, and Mary Kawena Pukui, *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bernice P. Bishop Museum Bulletin 233, rev. ed. (Honolulu: Bishop Museum Press, 1991, 1995, 1972).

10 Thomas G. Thrum, *More Hawaiian Folk Tales: A Collection of Native Legends and Traditions* (Chicago: A.C. McClung, 1923).

11 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

12 Ibid.

13 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.43
Condition	Functionally Obsolete

Civil & Traffic

Ulaino Stream Bridge is located at mile point 27.92 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition on both approaches to the bridge. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are overhead telephone lines located on the upstream side of the bridge. They cross Hana Highway (upstream to downstream) just east of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 3, 2014. The overall condition rating of the bridge at the time of inspection varied between poor and fair.[14] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 38 inches and 36 inches respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

According to the SI&A sheet, load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.43.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

14 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Ulaino Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 3, 2014, record drawings,[15], [16] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Ulaino Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Ulaino Stream Bridge is currently being utilized at times as a two-lane bridge although NBI documents state this as a one-lane. It is recommended that the bridge be utilized as a one-lane bridge; therefore, no widening is needed. Thickness of the fill on the bridge, between the deck and the asphalt overlay, shall be limited as shown on current drawings for this bridge so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information).

15 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

16 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

CRM Approach Walls

This bridge has a CRM approach wall of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance. Approach walls of similar quality are shown in the following bridges and may be used for reference: current existing approach walls to this bridge, #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, and #40 Mokulehua Stream Bridge. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Exemplary upstream Hana CRM approach wall
Courtesy of NOEI

Exemplary downstream Hana CRM approach wall
Courtesy of NOEI

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a reconstructed CRM rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To achieve the reconstructed rock façades appearances, the existing CRM façades are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM approach walls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM approach walls are to be placed in front of the new reinforced concrete approach walls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. The downstream Kahului approach and upstream Hana corners have adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The upstream Kahului and downstream Hana approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall. The upstream Hana approach corner can be curved slightly into the adjacent private property bordering the bridge.

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the

Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM abutments are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments.

The CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete pier and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete pier wall is a good intact example of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier wall, it is recommended to be replaced in-kind with a reinforced concrete structure with the exterior façades detailed and finished to match existing conditions. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and concrete pier wall, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

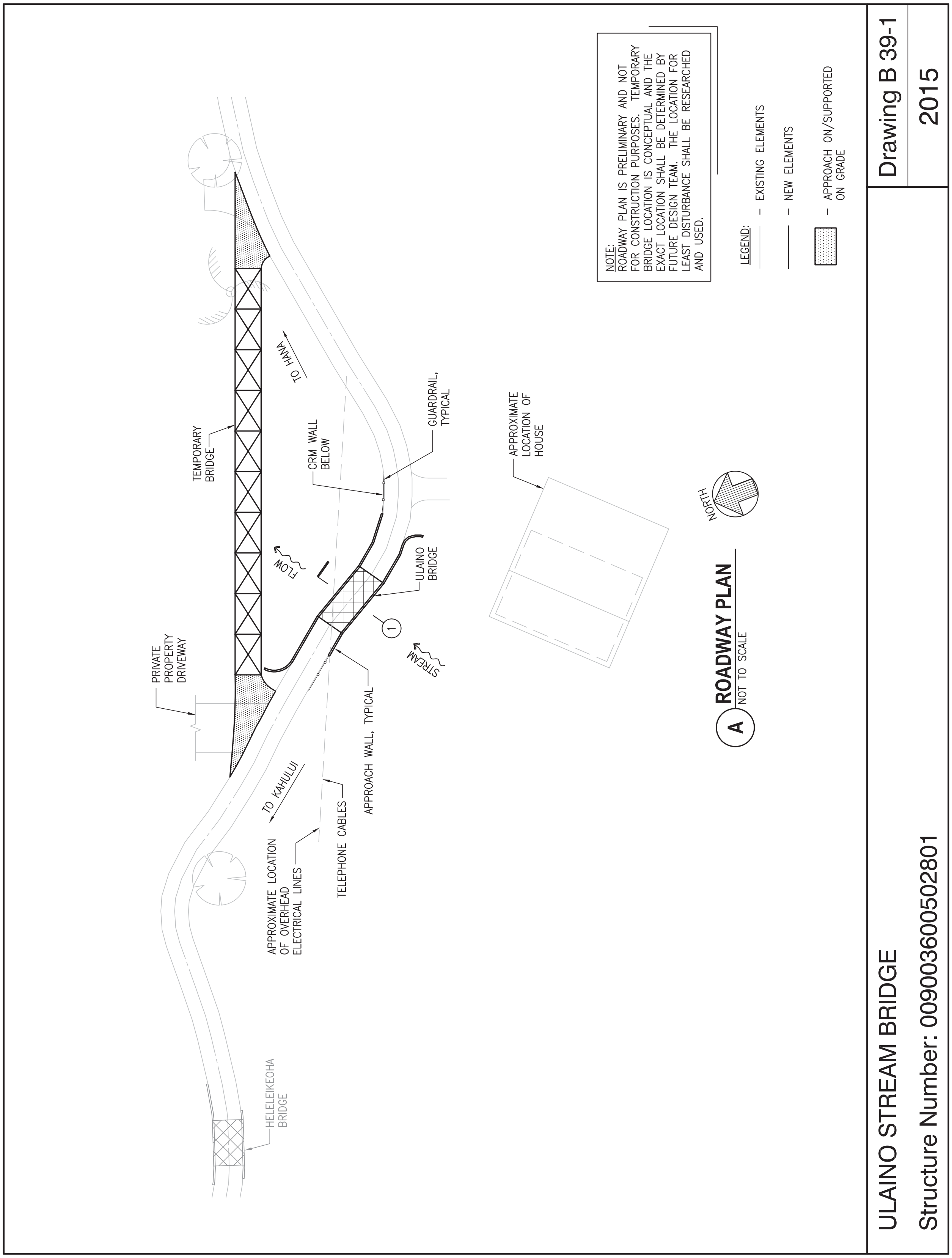
Civic, Traffic, & Signage

In regard to oncoming traffic visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book.

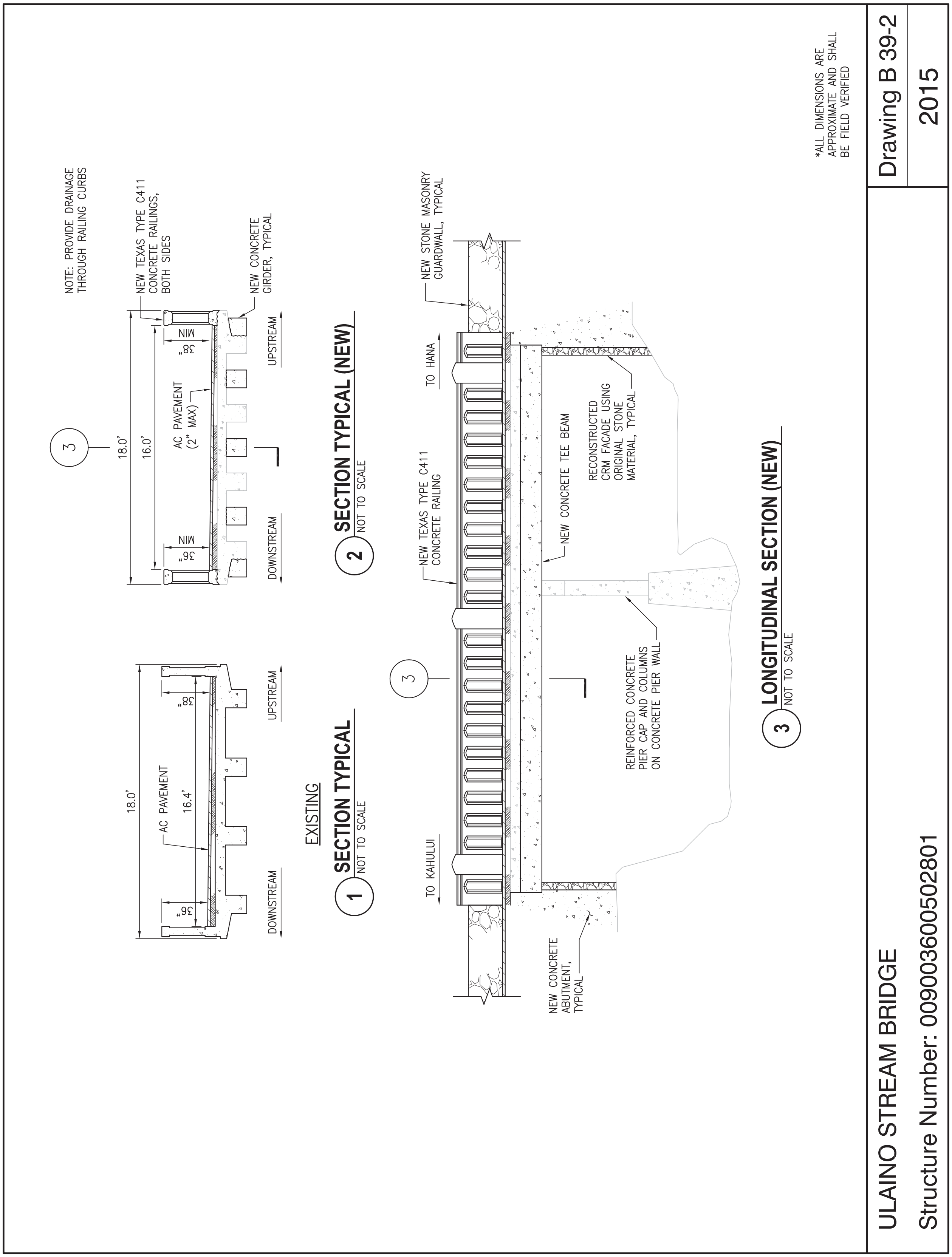
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Telephone lines are over the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI

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Mokulehua Stream Bridge

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MOKULEHUA STREAM BRIDGE

Bridge Number	009003600502835			**Island**	Maui		
Date of Construction	1908			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI

Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 47m 47s
Longitude	156d 03m 25s
Mile Point	28.25
Location	3.06 miles west of Alalele Place (road to Hana Airport)
Feature Crossed	Mokulehua Gulch

Bridge Features

Bridge Type	Concrete Slab
Total Length	47.90 feet
Number of Spans	3
Maximum Span	14.1 feet
Deck Width	• Curb-to-Curb = 13.78 feet • Out-to-Out = 15.10 feet
Abutment Material	• CRM Abutments • Concrete Pier Walls with rounded cutwater profile
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Solid
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 35 inches • Downstream Railing Height = 35 inches
Parapet / Railing Profile	• Parapet Thickness = ±8 inches
Parapet Inscription	None

Bridge Features

Mokulehua Stream Bridge is a triple-span reinforced concrete slab bridge built in 1908. The superstructure consists of a concrete deck slab with AC pavement overlay. The substructure consists of CRM abutments, two concrete pier walls, and CRM wingwalls. The abutments and piers bear directly on natural rock formations.

Setting of Mokulehua Stream Bridge
Courtesy of NOEI

Mokulehua Stream Bridge upstream elevation
Courtesy of NOEI

Hana approach to Mokulehua Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach Mokulehua Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Concrete piers with rounded cutwater profile
Courtesy of NOEI

Mokulehua Stream Bridge piers downstream elevation
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

CRM abutment set on natural rock and CRM wingwall, Hana side
Courtesy of NOEI

Significance & Context

Ahupuaa	Ulaino and Makapuu
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Exceptional Bridge: Oldest Concrete Bridge on Maui
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Oldest bridge on Hana Belt Road according to DOT records (1908) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Good intact examples of solid concrete pier walls on Hana Highway • Good intact example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural residential • Waterfall below bridge • Open, wide terraced stream
Character Defining Features	• Concrete Slab Bridge • CRM Abutments • CRM Wingwalls • Concrete Pier Walls with rounded cutwater profile • Concrete Solid Parapets
Detracting Features	• Damaged parapet ends with exposed rebar • Damaged approach wall corners • Overgrown flora/fauna on bridge

Significance & Context

Bridge Site History

This is the first reinforced concrete bridge built on the Hana Highway. It replaced a wooden bridge and was constructed on top of the older bridge piers.[1] The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he Mokulehua Bridge is the oldest bridge on Maui and the third oldest in the state, after Mamalahoa Highway bridge (1904) in Hawaii and the Waipahu Street bridge (1905) on Oahu."[2]

Archaeological / Cultural Significance

The Hawaiian phrase *moku lehua* translates as, "Solemn feast after the cutting (moku) of an *ohia* log for a temple image; cluster of lehua trees."[3] The Mokulehua Stream Bridge spans Mokulehua Gulch, which forms the boundary between Ulaino Ahupuaa and Makapuu Ahupuaa.[4]

The Hana region was under the jurisdiction of the Maui King Kamehamehanui in the mid-1700s. Around the year A.D. 1759, Kalaniopuu gathered an army at Kohala on the island of Hawaii and invaded Hana, taking the fort at Kauiki Hill overlooking the harbor of Hana, as well as the district of Kipahulu. But Kamehamehanui, although taken by surprise, soon made careful plans to retake his lost territory. Several battles were fought at Hana in which the Maui forces prevailed, primarily at Makaolehua [Mokulehua] and Akiala. However, the fortress at Kauiki withstood all attempts to retake it, and after a prolonged siege, Kamehamehanui withdrew his forces and left Hana in possession of Kalaniopuu.[5]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.5, for the story of Kamehamehanui, and to Section G, Appendix 1, Figure 12 for nearby archaeological study areas.[6]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Mokulehua Stream Bridge.

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1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 191.

2 Ibid.

3 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

4 Hugh Howell, "Map of the Nahiku Coffee Lands: Being a Subdivision of a Portion of the Districts of Koolau and Hana Maui, H.I.," registered map no. 2649 (1897).

5 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

6 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Obstructed by roadside brush
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.42
Condition	Functionally Obsolete

Civil & Traffic

Mokulehua Stream Bridge is located at mile point 28.25 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 15.10 feet that has no bicycle or pedestrian access routes. In regard to visibility, the westbound approach to the bridge is currently obstructed by roadside brush causing poor visibility of oncoming traffic. The eastbound approach to the bridge is currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

The Mokulehua Bridge has been known to have a history of ponding and flooding. Since the parapet railing design does not have any openings or scuppers along its length, runoff is forced to accumulate at the center of the bridge (local low point) which leads to ponding and flooding.

Electrical

Primary, telephone, and other unidentified communication type overhead lines are located on the downstream side of the bridge. They cross Hana Highway just east of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 3, 2014. The overall condition rating of the bridge at the time of inspection was fair.[7] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete parapets were in fair condition. The upstream and downstream parapets had a height of 35 inches. Although the heights of the upstream and downstream parapets are adequate for a TL-2 rating, neither parapet has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and the operating rating is 0.42.

The current curb-to-curb dimension is 13.78 feet, which for a one-lane bridge does not meet the design criteria minimum of 16 feet.

7 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Mokulehua Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 3, 2014, record drawings,[8, 9] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Mokulehua Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

In order to improve the existing drainage conditions, a more detailed drainage study (with the aid of a topographic survey) should be conducted by the design engineer to analyze the magnitude of potential flooding. Drainage solutions may consist of multiple spillways or a drain inlet system that empties back into the stream under the appropriate and current water quality standards.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. It may be more cost effective for the HDOT to purchase the temporary bridge components rather than rent them from a distributor if the HDOT plans to space out the rehabilitation projects. However, HDOT should consider the cost, space, and ease of storing the bridge components when not in use, or if not all of the components are used at each bridge location when the bypass bridge is shorter than the maximum length the parts are able to accommodate. Additionally, proper maintenance would be required to keep the bridge components in good condition.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

8 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

9 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

Recommendations have been identified per bridge component, as follows:

Deck

The Mokulehua Stream Bridge currently does not meet the minimum standard width of 16 feet for a one-lane bridge; therefore, at least 2.22 feet of widening is needed. Rehabilitation to the bridge deck is recommended to increase the load carrying capacity of the bridge and to support the new concrete railings. Refer to the "Railings/ Parapets" and "Load Rating" sections for more information.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

An historic characteristic of Mokulehua Stream Bridge is that it has the original concrete rounded cutwaters on the upstream faces of both piers. It is preferred to widen the bridge on the downstream side because of this historic characteristic, but there is a private property owner at the downstream Kahului corner of this bridge. If HDOT cannot utilize the 40' foot ROW, in order for the downstream widening to occur, HDOT will need to acquire a portion of the property for the Kahului approach to the bridge and the bridge's widening. The future design team shall perform their due diligence to explore this option prior to continuing with this report's presented option of widening on the upstream side. If land acquisition is unsuccessful and it was decided that a downstream widening is not feasible, then the widened deck portion along the upstream face shall span between the abutments and shall not damage the concrete cutwaters.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

CRM Approach Walls

This bridge has a CRM approach wall of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance. Approach walls of similar quality are shown in the following bridges and may be used for reference: current existing approach walls to this bridge, #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, and #39 Ulaino Stream Bridge. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM walls are recommended to be replaced with a reinforced concrete wall with a reconstructed CRM rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To achieve this, the existing façades of the CRM approach walls are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM approach walls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM approach walls are to be placed in front of the new reinforced concrete approach walls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation.

The upstream and downstream Kahului and upstream Hana of the approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The downstream Hana approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the bridge parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between bridge parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to preserve the downstream parapet by constructing a crash-tested railing in front it. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the bridge (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical concrete barrier rail (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The existing deck is not adequate enough to support these new crash-tested railings, so it is recommended to provide additional support by thickening the deck. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash tested railing design height can be changed to match existing conditions and have a straight exterior surface.

Foundations, Piers, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete pier walls and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. Although the concrete pier walls are good intact examples of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier walls, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. Wherever possible, the natural rock formation shall be maintained and preserved during investigation and bridge rehabilitation work.

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments, CRM wingwalls, and concrete pier walls, which show evidence of historic craftsmanship, is recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to thicken the existing slab.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

East Bridge Approach

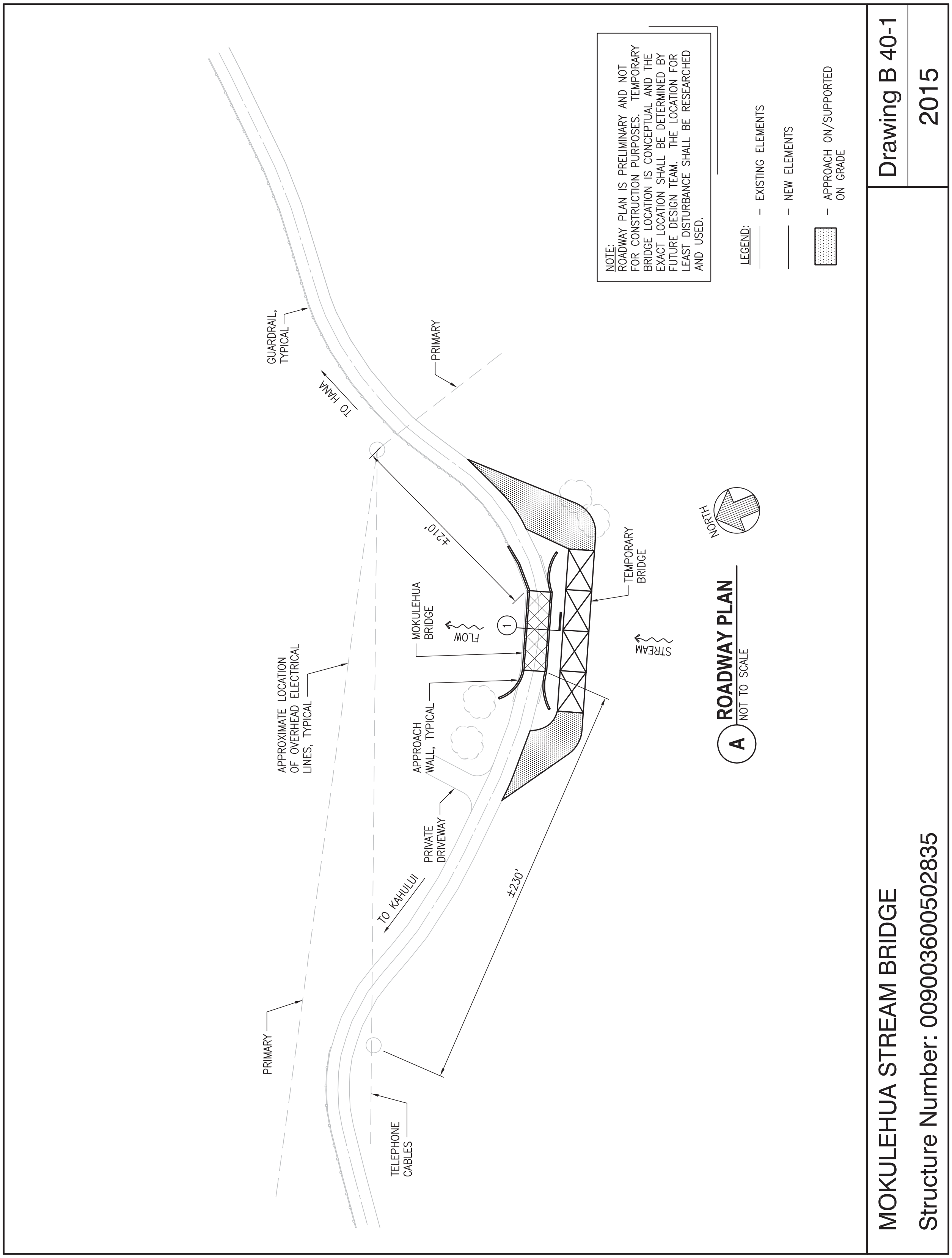
- Prune roadside brush and trees

RECOMMENDATIONS

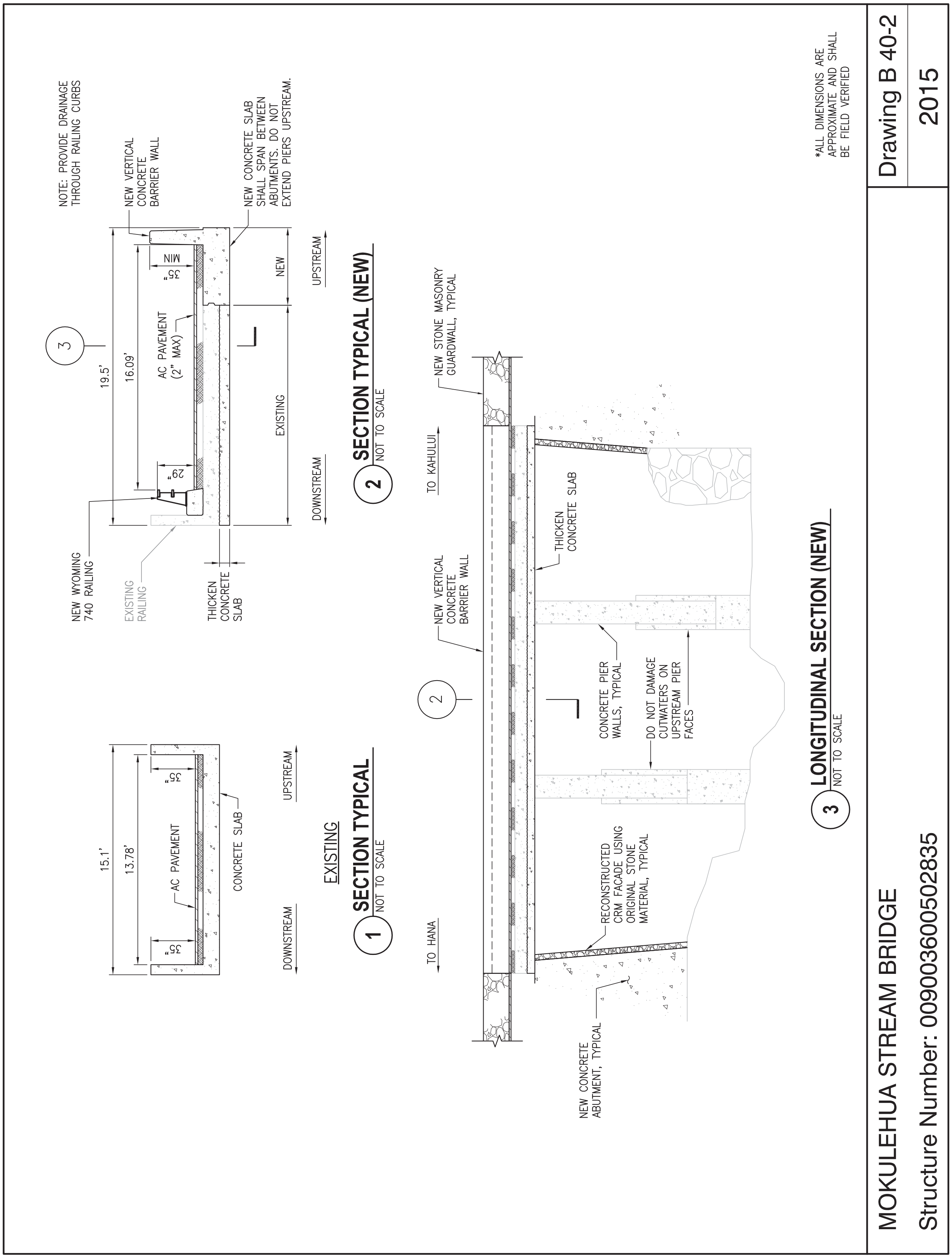
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed.



Courtesy of NOEI



Courtesy of NOEI

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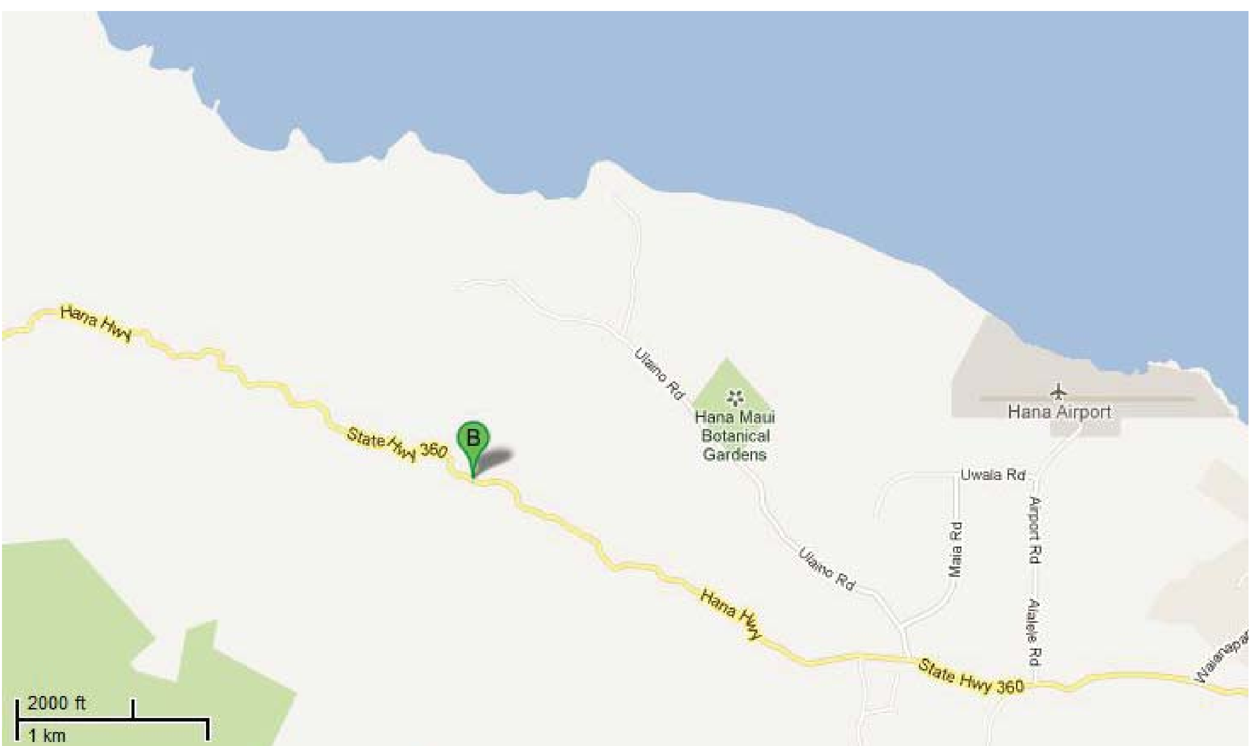
41 Oilowai Stream Bridge

41 OILOWAI STREAM BRIDGE

Bridge Number	009003600502922			**Island**	Maui		
Date of Construction	1914			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

Location

Latitude	20d 47m 31s
Longitude	156d 02m 46s
Mile Point	29.12
Location	2.19 miles west of Alalele Place (road to Hana Airport)
Feature Crossed	Oilowai Gulch

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	21.98 feet
Number of Spans	1
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	CRM Abutments
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 29 inches • Downstream Railing Height = 34 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Oilowai Stream Bridge is a single-span reinforced concrete tee beam bridge built in 1914. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams. The substructure consists of CRM abutments and wingwalls. The abutments bear directly on natural rock formations.

Oilowai Stream Bridge downstream elevation
Courtesy of NOEI

Waterfall near Oilowai Stream Bridge
Courtesy of FAI

Kahului approach to Oilowai Stream Bridge toward Hana
Courtesy of NOEI

Hana approach to Oilowai Stream Bridge toward Kahului
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of FAI

Downstream CRM wingwall, Kahului side
Courtesy of NOEI

Adjacent rock formations and upstream CRM wingwall, Kahului side
Courtesy of NOEI

CRM abutment set upon natural rock, Hana side
Courtesy of NOEI

CRM abutment set upon natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	West Honomaele
Designer / Builder	Wilson & McCandless (Contractor)
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Bridge: Open Picket Railing
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Bridge spans deep gully with upstream waterfall; trees and heavy vegetation • Mature trees upstream side • Driveways nearby
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Upstream and downstream railings are connected to approach walls • Excessive asphalt on upstream side • Downstream waterline

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he present concrete bridge was probably constructed by the contractors Wilson and McCandless in 1914 as part of Belt Road construction from Hana towards Keanae. The contractors replaced an inexpensive culvert bridge built in 1906."[1]

> *Howell's communications to the Maui County Board of Supervisors indicated that early wood structures along the Hana Coast were built using truss systems. Howell's program from 1906 to circa 1909 was to replace these failing structures with bridges built on concrete or rock piers, which eliminated the need for high-maintenance trusses. In constructing wood bridges with concrete foundations, Howell was following the advice of SPW C. S. Holloway, who strongly recommended that concrete or wood bridges, rather than steel, be built wherever possible. Holloway further emphasized that particular attention should be paid to the structures' foundations and piers, so that the structures would be of a more permanent nature.*[2]
>
> *While Wilson was working on his Keanae-Nahiku extension, the MLFC authorized additional bridges for construction. ...In 1913, concrete structures were built in Papahawahawa, and in 1914 at Olowai [sic] and Ula'ino.*[3]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[4] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[5] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 147.

2 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 29.

3 Ibid., 33.

4 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

5 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The Hawaiian word *oilo* translates as, "Seedling; to germinate, sprout,"[6] and the word *wai* means "water."[7] The Oilowai Stream Bridge spans Oilowai Gulch, which lies within West Honomaele Ahupuaa.[8, 9]

According to Native Hawaiian traditions, around the year A.D. 1570 a high chief from the western side of Maui named Kiha-a-Piilani conquered the formerly independent chiefdoms of the Hana region, uniting the entire island into one *moku*, or polity. At the time of his conquest, Kiha-a-Piilani may have dedicated the massive heiau of Piilanihale, which looms above the wind-swept cliffs of Honomaele.[10]

In Native Hawaiian legends, the battles of Kapalipilo describe the assault by the combined forces of Maui, Molokai, and Lanai on the fort at Kauiki that were meant to dislodge the Hawaii forces.[11] According to Kamakau, the field of battle started with the massing of the Maui armies from Heleleikeoha to Nahiku. Wananalua soon became the battlefield. At a signal from the islet of Mokuhano, the fortified walls of Kauiki were attacked. Soon, the battlefield shifted to the districts of Akiala and Keawaikau. The fighting soon came down to a challenge between Kaohele, a chief from Molokai, and Kamakaukii, a famous fighter from Hawaii. After a time, Kaohele gained the advantage, and Kamakaukii attempted to escape the battlefield, but the Molokai chief chased the Hawaii fighter through the *ahupuaa* of Honomaele to Kawaipapa. Kaohele overtook Kamakaukii at Waialanahu near Pihehe and thrust him through the scrotum with a spear. Despite the victory by Kaohele, the fort did not surrender, Kamehamehanui retired, leaving Hana in the hands of the warriors of Hawaii.[12]

Refer to Section G, Appendix 1, Section 3.1.3.1, for the background history of Honomaele; Section 3.1.3.3.1.6, and Section 3.1.3.3.1.10, for the battle at Kauiki; and to Section G, Appendix 1, Figure 14 for nearby archaeological study areas.[13]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Oilowai Stream Bridge.

6 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

7 Ibid.

8 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

9 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

10 Patrick V. Kirch, *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory* (Honolulu: University of Hawaii Press, 1985).

11 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co., Ludgate Hill, 1880).

12 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

13 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Obstructed by roadside brush • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line
Civil Utilities	• Sewer: None • Water: Downstream side (not attached to the bridge)
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.33 • Operating Rating = 0.43
Condition	Functionally Obsolete

Civil & Traffic

Oilowai Stream Bridge is located at mile point 29.12 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound approach to the bridge is currently obstructed by brush and trees causing poor visibility of oncoming traffic. The westbound approach to the bridge is currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

The Oilowai Stream has been known to overtop in high intensity storms.

Electrical

Telephone and other unidentified communication type overhead lines are located on the far downstream side of the bridge. They cross Hana Highway just west of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 4, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[14] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at the Kahului approaches to the bridge. Adjacent to the Kahului CRM walls and at the Hana approaches to the bridge are concrete walls with guardrail transitions connected to them.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 29 inches and 34 inches respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.33 and operating rating is 0.43.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

14 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Oilowai Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 4, 2014 and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Oilowai Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A detailed drainage analysis is recommended for the vicinity of this bridge in order to assess measures to prevent or mitigate runoff from overtopping the bridge.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Oilowai Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

Special attention should be paid to removing excessive asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum. Thickness of the fill on the bridge, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the CRM approach wall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

Although the CRM abutments and CRM wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of original historic craftsmanship along Hana Highway. Prior to removal, future design team shall document the existing appearance and condition of CRM abutments and CRM wingwalls.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

Until future rehabilitation work at this bridge is determined, retention of the existing appearance of the CRM abutments and CRM wingwalls, which show evidence of historic craftsmanship, is recommended.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civic, Traffic, & Signage

In regards to the oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. The signage including striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

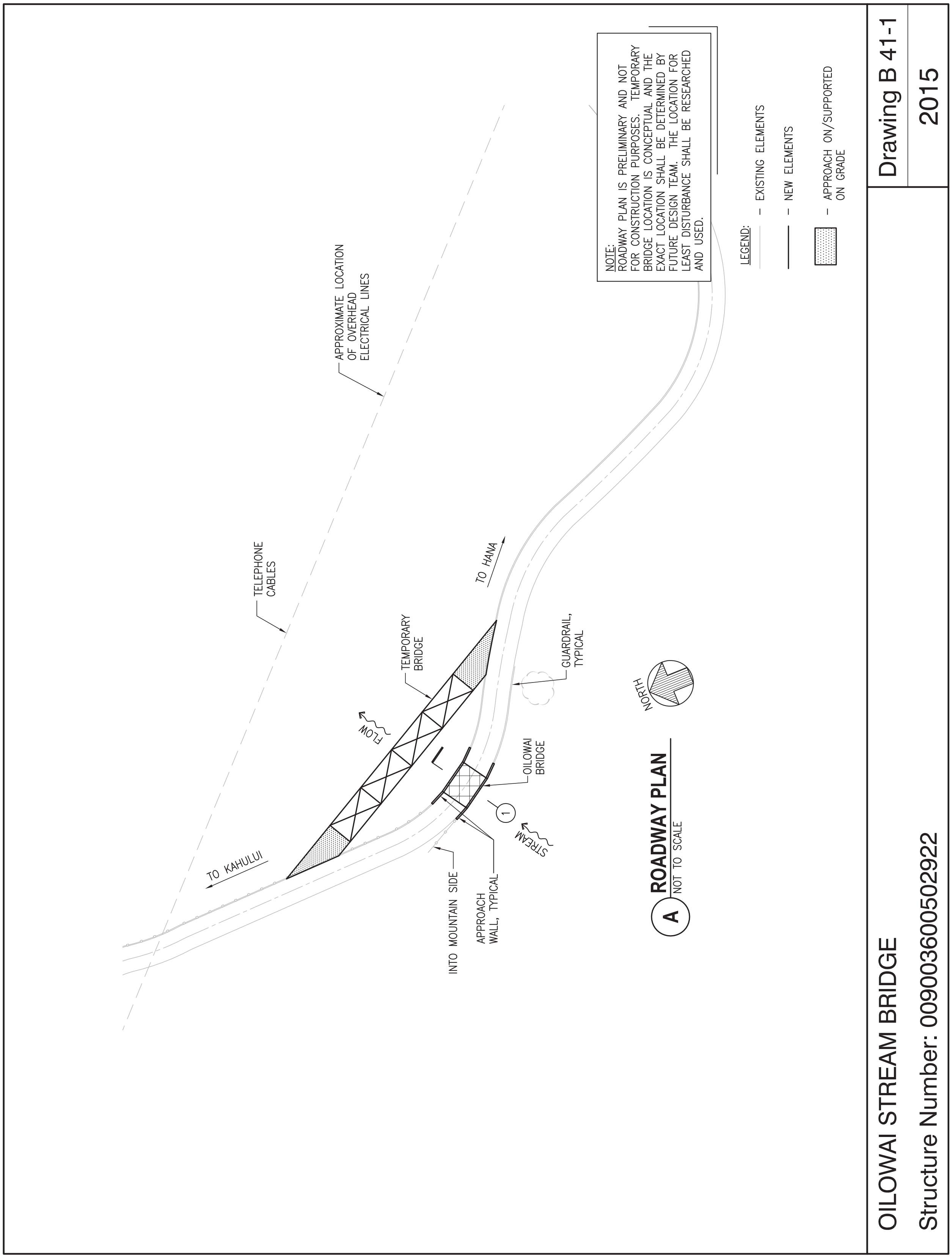
East Bridge Approach

- Add Object Marker Type 3 - Left and Right (OM3-L, OM3-R)

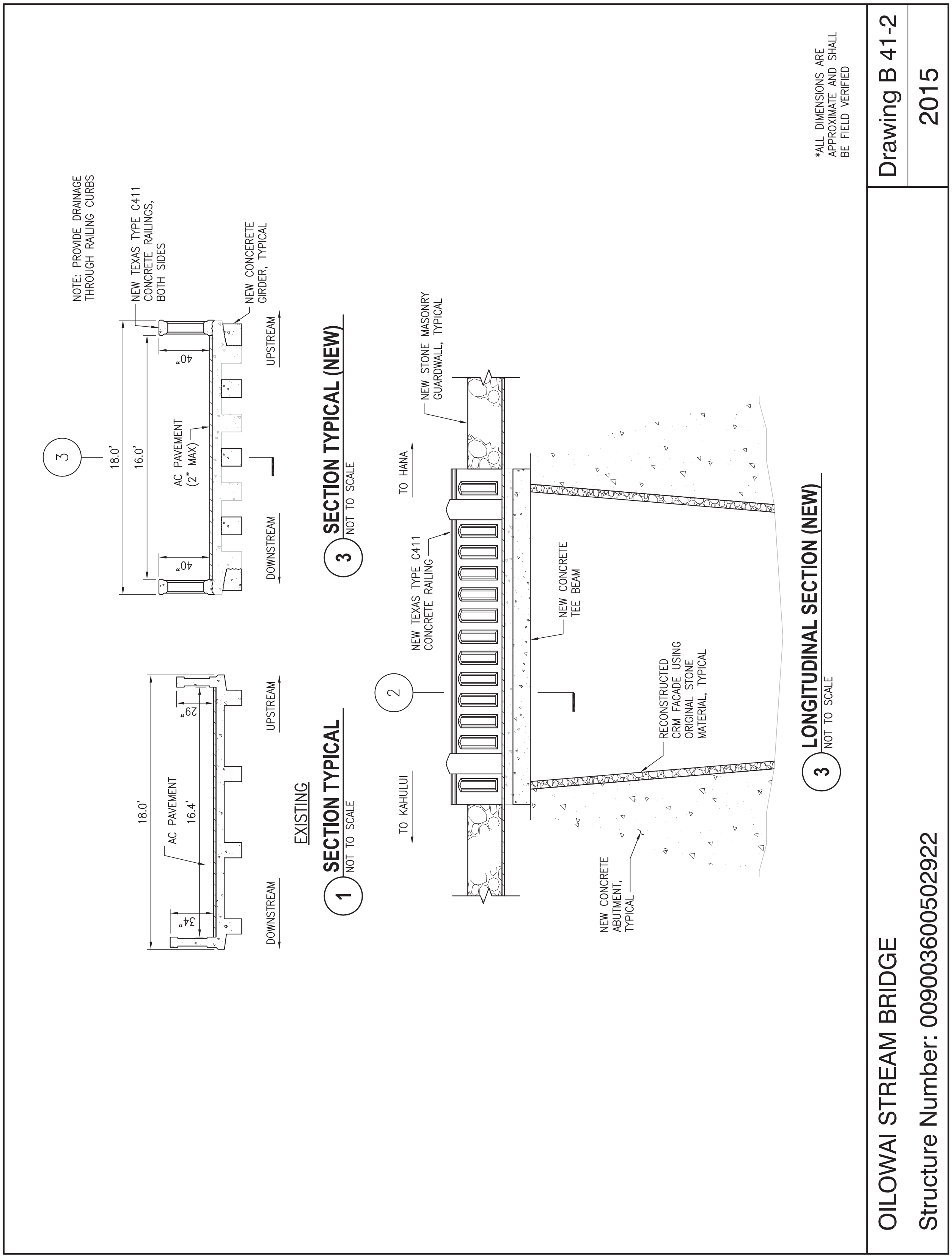
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Oilowai Stream Bridge at this time. No structural recommendations are being proposed that will impact existing electrical utilities.



Courtesy of NOEI



Courtesy of NOEI

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42

Honomaele Stream Bridge

42 HONOMAELE STREAM BRIDGE

Bridge Number	009003600502958			**Island**	Maui		
Date of Construction	1924			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI

Courtesy of Google Maps

Location

Latitude	20d 47m 24s
Longitude	156d 02m 31s
Mile Point	29.47
Location	1.83 miles west of Alalele Place (road to Hana Airport)
Feature Crossed	Honomaele Gulch

Bridge Features

Bridge Type	Concrete Tee Beam
Total Length	38.06 feet
Number of Spans	2
Maximum Span	20.0 feet
Deck Width	• Curb-to-Curb = 16.40 feet • Out-to-Out = 18.04 feet
Abutment Material	• CRM Abutments • Concrete Pier Wall
Wingwall Material	CRM Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 32 inches • Downstream Railing Height = 34 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 18 inches on-center • End posts = 10 inches x 10 inches
Parapet / Railing Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Bridge Features

Honomaele Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1924. The superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams, which are spaced approximately 5 feet on-center. The substructure consists of CRM abutments, concrete pier wall, and CRM wingwalls. The abutments and pier bear directly on natural rock formations.

Honomaele Stream Bridge upstream elevation
Courtesy of NOEI

Setting of Honomaele Stream Bridge
Courtesy of FAI

Hana approach to Honomaele Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Honomaele Stream Bridge toward Hana
Courtesy of NOEI

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Downstream approach wall attached to approach guard rail, Hana side
Courtesy of NOEI

Concrete pier
Courtesy of NOEI

CRM abutment set on natural rock, Hana side
Courtesy of NOEI

CRM abutment set on natural rock, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	West Honomaele and East Honomaele
Designer / Builder	County Engineer's Office - A. P. Low, Designer
Historic Drawings	September 1924
Alterations	None
Replacement	None
Preservation Priority	Exceptional Bridge: Distinctive Piers
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Oldest solid concrete pier wall on Hana Highway, State Route 360 • Good intact example of CRM abutments on Hana Highway • Good intact example of CRM wingwalls on Hana Highway • Exemplary example of natural rock formations on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Rural setting with pastoral fields on upstream side of road • Tree-lined, medium-wide stream with waterfall on downstream side
Character Defining Features	• Concrete Tee Beam Bridge • CRM Abutments • CRM Wingwalls • Concrete Pier Wall • Concrete Open Vertical Railings
Detracting Features	• Upstream and downstream railings connected to approach walls • Existing waterline at downstream elevation and Hana abutment

Significance & Context

Bridge Site History

The *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai* (1990) notes, "[t]he original Honomaele Bridge was a 19th century, 40-foot long wooden truss bridge. This was rebuilt in 1906 when the County constructed a central concrete pier to support a new timber deck. The present concrete bridge deck was built in 1924 by County Engineer A. P. Low's office as the County extended a macadam Belt Road from Kailua to Hana. The 1906 concrete pier still supports the current concrete deck and railings"[1]

The early 20th century was a period that saw significant development of early belt road construction across Hawaii and the creation of an organized Territorial government that could receive and disburse Federal monies for infrastructure developments, including newly paved roads along the present day Road to Hana route. However, initial construction of a road to Hana was severely limited by the challenging topography of the area and sporadic business development for sugar plantations, leading to several stop-start attempts over a couple decades before a continuous road was finally established in the late 1920s.[2]

Initially, a very rough road was established to reach the areas of Nahiku and Keanae. A 1905 report published by the SPW stated that "very rough country is encountered in these districts. On account of the great expenses of road construction, the road has been made as narrow as possible in order to construct, with the money available, the *maximum* [emphasis added] length of road."[3]

At this time, the early DPW began to establish the preferred standard use of concrete for bridge and culvert construction wherever possible, "and where the span was too great so as to make the cost excessive, timber bridges (treated with creosote) have been designed preferably to the steel structures which we have found … to be the most expensive to maintain and keep in repair."[4]

The Office of County Engineer was established in 1915, with the Maui Board of Supervisors naming Hugh Howell as the inaugural appointee to oversee bridge construction throughout Maui County.[5] By 1927, the local newspaper *Maui News* observed that "very few wooden structures are left on Maui… concrete bridges have been put in all over the County,"[6] thus marking the final shift towards replacement of original timber bridges in favor of concrete.

1 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 149.

2 Ibid, 5.

3 Public Works, *Report to the Governor, Territory of Hawaii by the Superintendent of Public Works for the Year Ending June 30, 1905,* Territory of Hawaii (Honolulu: 1905).

4 Ibid.

5 Hawaii Heritage Center, *Historic Bridge Inventory and Evaluation, Islands of Maui and Molokai*, prepared for the State of Hawaii Department of Transportation Highways Division (September 1990), 5.

6 "Roads and Bridges of County Weather Heavy Rain Storms," *Maui News*, April 6, 1927.

Archaeological / Cultural Significance

The place name *Honomaele* is defined as, "Land division, Hana qd., Maui. *Lit.,* numb bay."[7] The Honomaele Stream Bridge spans Honomaele Gulch, which divides West Honomaele Ahupuaa and East Honomaele Ahupuaa.[8, 9]

According to Native Hawaiian traditions, around the year A.D. 1570 a high chief from the western side of Maui named Kiha-a-Piilani conquered the formerly independent chiefdoms of the Hana region, uniting the entire island into one moku, or polity. At the time of his conquest, Kiha-a-Piilani may have dedicated the massive heiau of Piilanihale, which looms above the wind-swept cliffs of Honomaele.[10]

In Native Hawaiian legends, the battles of Kapalipilo describe the assault by the combined forces of Maui, Molokai, and Lanai on the fort at Kauiki that were meant to dislodge the Hawaii forces.[11] According to Kamakau, the field of battle started with the massing of the Maui armies from Heleleikeoha to Nahiku. Wananalua soon became the battlefield. At a signal from the islet of Mokuhano, the fortified walls of Kauiki were attacked. Soon, the battlefield shifted to the districts of Akiala and Keawaikau. The fighting soon came down to a challenge between Kaohele, a chief from Molokai, and Kamakaukii, a famous fighter from Hawaii. After a time, Kaohele gained the advantage, and Kamakaukii attempted to escape the battlefield, but the Molokai chief chased the Hawaii fighter through the *ahupuaa* of Honomaele to Kawaipapa. Kaohele overtook Kamakaukii at Waialanahu near Pihehe and thrust him through the scrotum with a spear. Despite the victory by Kaohele, the fort did not surrender, Kamehamehanui retired, leaving Hana in the hands of the warriors of Hawaii.[12]

Refer to Section G, Appendix 1, Section 3.1.3.1, for the background history of Honomaele; Section 3.1.3.3.1.6 and Section 3.1.3.3.1.10, for the battle at Kauiki; and to Section G, Appendix 1, Figure 14 for nearby archaeological study areas.[13]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Honomaele Stream Bridge.

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7 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

8 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

9 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

10 Patrick V. Kirch, *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory* (Honolulu: University of Hawaii Press, 1985).

11 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

12 S.M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

13 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line
Civil Utilities	• Sewer: None • Water: Existing waterline at downstream elevation
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Existing overhead electrical lines
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.44 • Operating Rating = 0.57
Condition	Functionally Obsolete

Civil & Traffic

Honomaele Stream Bridge is located at mile point 29.47 along Hana Highway and its existing conditions are as follows. This bridge is a one-lane bridge with an out-to-out width of 18.04 feet that has no bicycle or pedestrian access routes. . In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition. Currently, there is no apron at either entrance to the bridge and no utilities in the vicinity. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

Telephone and other unidentified communication type overhead lines are located on the downstream side of the bridge. They cross Hana Highway just east of the bridge.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 3, 2014. The overall condition rating of the bridge at the time of inspection was fair.[14] This one-lane bridge is *functionally obsolete* due to a rating of 2 for *deck geometry* and 3 for *approach alignment*. CRM walls are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 32 inches and 34 inches respectively. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.44 and the operating rating is 0.57.

The current curb-to-curb dimension is 16.40 feet, which for a one-lane bridge is adequate for this project's design criteria of 16 feet.

14 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Honomaele Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 3, 2014, record drawings,[15], [16], [17] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Honomaele Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck

The Honomaele Stream Bridge currently meets the standard width of a one-lane bridge; therefore, no widening is needed. There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay

15 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Bridges – Overburden Removal, Project No. 360AB-01-77 (October 1976).

16 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans of Repair Bridges – Various Locations, Island of Maui, Project No. HWY M-01-74 (November 1973).

17 County Engineer's Office, "East Honomaele Bridge," Hana, Historic Drawings, September 1924.

and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the bridge do not meet the TL-2 crash requirements and cannot act as the bridge's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The downstream Kahului and upstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The remaining two approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge railings do not meet TL-2 crash requirements. It is recommended to replace the railings on the upstream and downstream sides with a similarly designed reinforced concrete open vertical railing. For this purpose, it is recommended to use a Texas Type C411 concrete railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge. Since the existing deck cantilevers off of the existing exterior girders, this feature shall be retained and therefore, the new exterior girders shall not be constructed flush with the deck's edge. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new railing heights as measured from the deck shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved crash tested railing design height can be changed to match existing conditions.

Foundations, Wingwalls, & Abutments

The CRM abutments and CRM wingwalls are recommended to be replaced with reinforced concrete structures with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information).

It is recommended to investigate the current material composition of the concrete pier and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have concrete core samples extracted. A chloride concentration analysis is recommended to be conducted on the concrete core samples. Based on the results of the chloride concentration analysis, cathodic protection should be considered as a method to prolong the bridge's lifespan. Although the concrete pier walls are exemplary examples of this component along the Hana Highway, Route 360, if it is determined necessary to rehabilitate the concrete pier walls, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. The natural rock foundations of this bridge are unique in the bridge's construction and contribute to the overall setting of the bridge. Therefore, all efforts should be made to preserve the appearance of the natural rock during bridge rehabilitation work. Documentation of the existing foundations is strongly recommended if it is not feasible to retain the natural rock foundations in future projects.

The existing pier wall is an exemplary example of this bridge component; therefore, retention of the existing appearance of the pier wall, CRM abutments, and CRM wingwalls, which show evidence of excellent historic craftsmanship, is strongly recommended through preservation and routine maintenance.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the bridge superstructure to support a load carrying capacity of 40-tons. One method would be to add new reinforced concrete interior girders between the existing girders. The height of the new girders should not exceed that of the existing girders. Also, the load rating is governed by the substructure rating.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to oncoming traffic visibility at each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. It is recommended that object markers (OM3-L & OM3-R) are added to the bridge end treatments at the west bridge approach. The signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Add Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

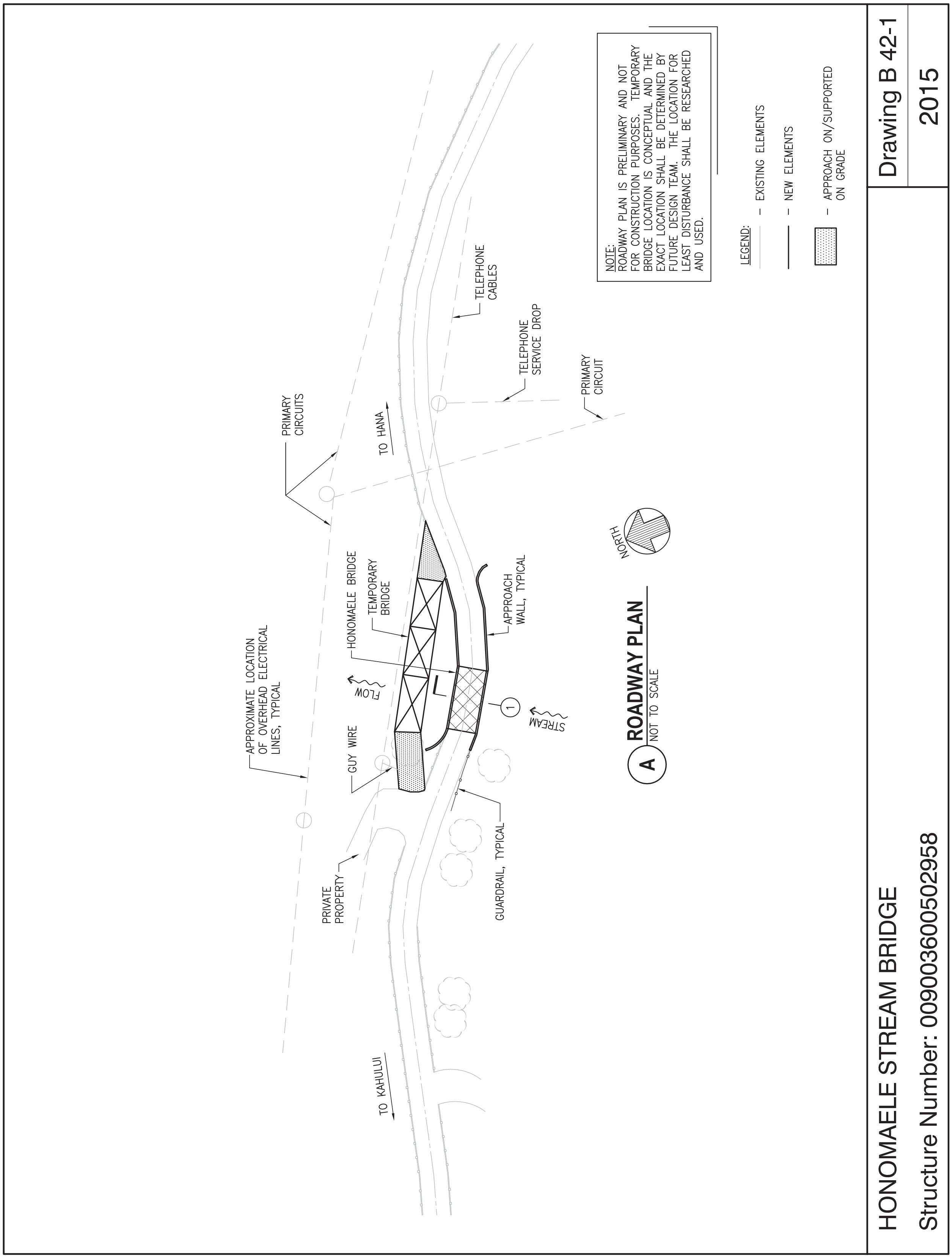
East Bridge Approach

- Add Object Marker Type 3 – Left and Right (OM3-L, OM3-R)

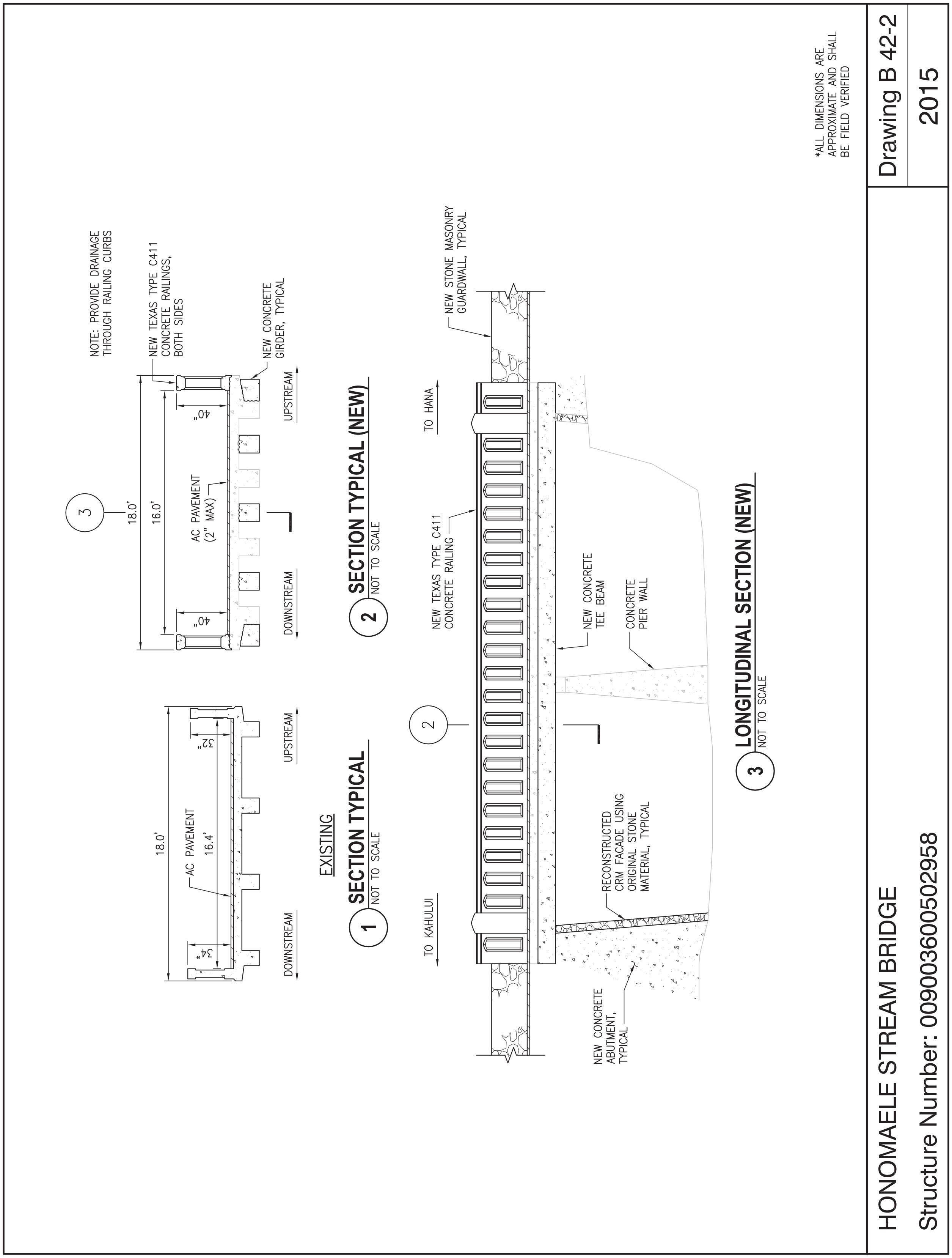
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Telephone lines are over the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



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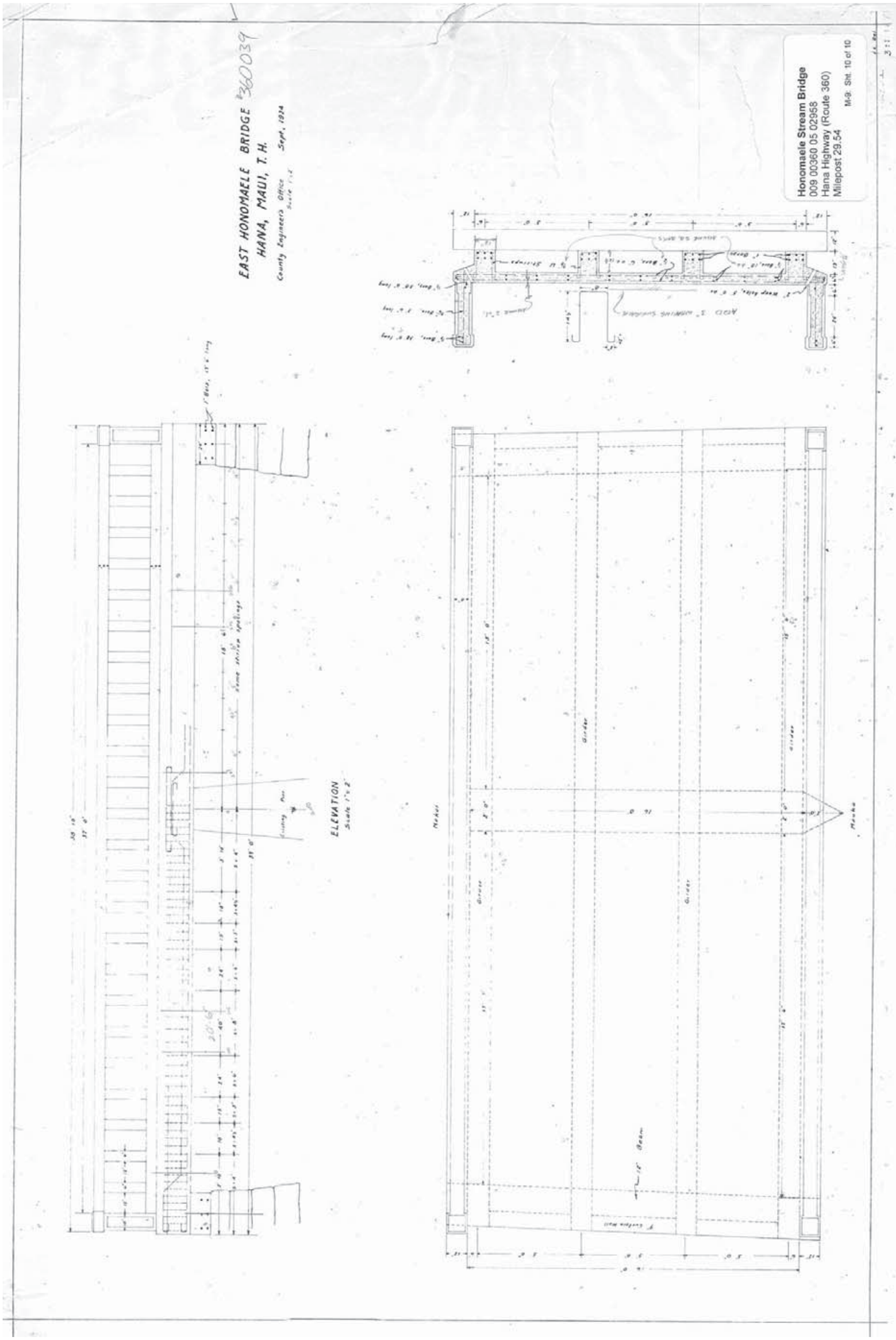


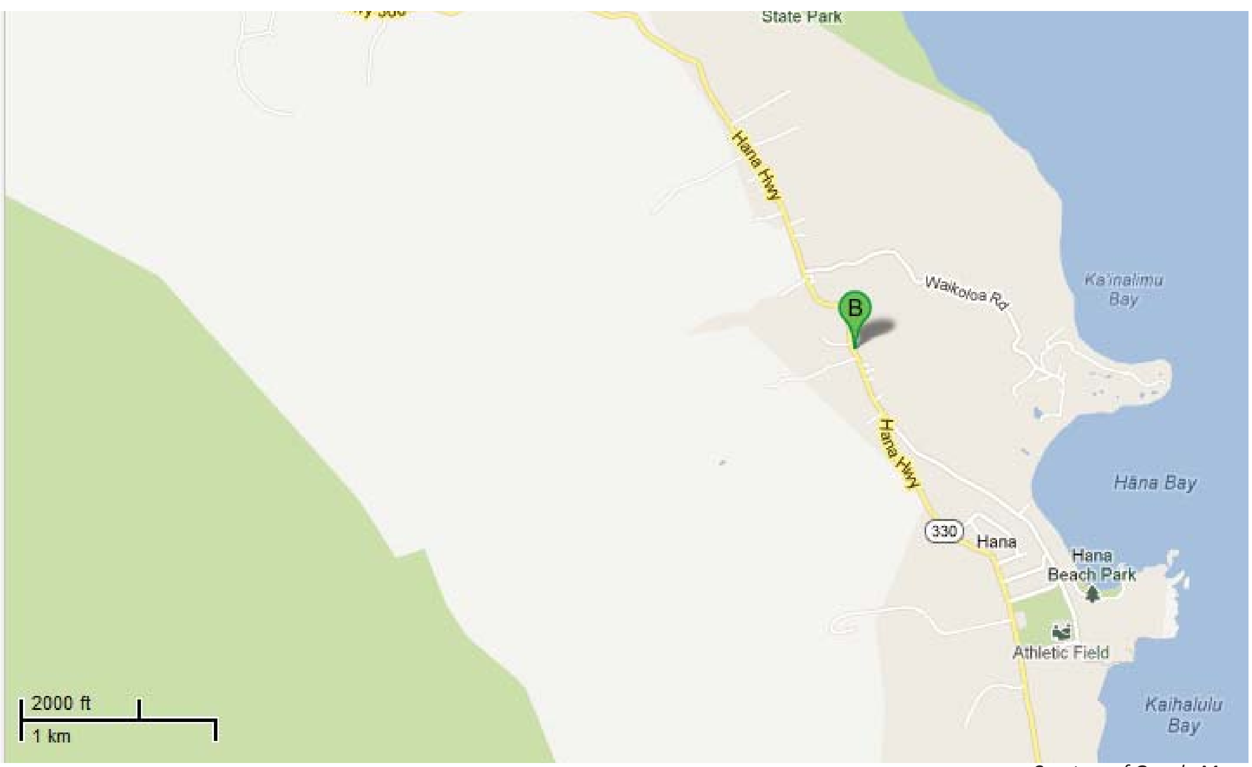
Courtesy of State of Hawaii Department of Transportation

43 Kawaipapa Stream Bridge

43 KAWAIPAPA STREAM BRIDGE

Bridge Number	009003600503347			**Island**	Maui		
Date of Construction	1947			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement

Courtesy of NOEI



Courtesy of Google Maps

BRIDGE INFORMATION

Location

Latitude	20d 45m 58s
Longitude	155d 59m 43s
Mile Point	33.37
Location	2.06 miles east of Alalele Place (road to Hana Airport)
Feature Crossed	Kawaipapa Gulch

Bridge Features

Bridge Type	Concrete Tee Beam and Reinforced Concrete Slab (culvert)
Total Length	79.07 feet
Number of Spans	2
Maximum Span	33.1 feet
Deck Width	• Curb-to-Curb = 26.50 feet (narrowest) • Out-to-Out = 31.50 feet
Abutment Material	• Concrete Abutments • Reinforced Concrete Pier Wall • Double-cell Reinforced Concrete Culvert
Wingwall Material	Concrete Wingwalls
Floor / Decking Material	Concrete Deck with AC Overlay
Parapet / Railing Type	Concrete Open Horizontal
Parapet / Railing Segments	• Culvert: 4 (upstream and downstream) • Bridge: 5 (upstream and downstream)
Parapet / Railing Height	• Upstream Railing Height = 32 inches • Downstream Railing Height = 32 inches
Baluster Dimensions	• Posts = 12 inches x 14 inches • Top Rail = 12 inches x 14 inches • Railing Span = 10 feet 4 inches (upstream), 10 feet (downstream)
Parapet / Railing Profile	Rectangular Cap

Bridge Features

The original Kawaipapa Stream Bridge is a double-span reinforced concrete tee beam bridge built in 1947. As part of a bridge improvement a double-cell culvert was added adjacent to the 1947 bridge in 1991. The original 1947 superstructure consists of a concrete deck slab with AC pavement overlay supported on four concrete tee beams in each span, which are spaced approximately 8.5 feet on-center. The substructure consists of concrete abutments, a pier wall, and wingwalls. The abutments and pier bear directly on natural rock formations.

The 1991 bridge improvement added 20 feet 7 inches x 10.86 feet to the 11.80-foot double-cell culvert at the Kahului end of the original bridge.

Kawaipapa Stream Bridge bridge (left) and culvert (right)
Courtesy of NOEI

Setting of Kawaipapa Stream Bridge
Courtesy of FAI

Hana approach to Kawaipapa Stream Bridge toward Kahului
Courtesy of NOEI

Kahului approach to Kawaipapa Stream Bridge toward Hana
Courtesy of NOEI

BRIDGE INFORMATION

Concrete open horizontal railing, upstream side
Courtesy of NOEI

Concrete open horizontal railing, downstream side
Courtesy of NOEI

Railing inscription, Hana side
Courtesy of NOEI

Concrete pier of bridge
Courtesy of NOEI

Concrete abutment of bridge, Kahului side
Courtesy of NOEI

Double-cell concrete culvert
Courtesy of NOEI

Significance & Context

Ahupuaa	Kawaipapa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	1991 - Double-cell culvert added at Kahului end of bridge
Replacement	None
Preservation Priority	Exceptional Bridge: Post WWII Type*
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of bridge engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • Good intact example of concrete abutments and concrete wingwalls on Hana Highway, Route 360 • Only example of 1940s bridge type in the Hana Highway Historic District • Good intact example of concrete abutments on Hana Highway • Good intact example of concrete wingwalls on Hana Highway • Good intact examples of pier walls on Hana Highway
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• SIHP -6549 is located within 200 m west-northwest • SIHP -6550 is located within 200 m west-northwest
Geographical Features / Setting	• In Hana town, adjacent to the Hana Health Center • Adjacent to a generator facility • Dry and rocky open area • A few shallow pools of water in the downstream area, with overhanging trees in the distance
Character Defining Features	• Concrete Tee Beam and Double-cell Concrete Culvert Bridge • Reinforced Concrete Pier Walls • Double-cell Reinforced Concrete Culvert • Concrete Open Horizontal Railings • Bridge name inscribed on railing end post
Detracting Features	• Graffiti • Guardrail attached across bridge name

*See Recommendations regarding NR designation as non-contributing, Chapter 7: *Hana Belt Road Historic District: State Bridges*

Significance & Context

Archaeological / Cultural Significance

The place name *Kawaipapa* is defined as, "the shallow water. Land section, Hana, Maui,"[1] or as, "Land section and gulch near Hana, Maui, where the chief Kiha-a-Piilani built a path paved with stones… *Lit.,* the stratum stream."[2] The Kawaipapa Stream Bridge spans Kawaipapa Gulch, which lies within Kawaipapa Ahupuaa.[3, 4]

Kamakau describes Kawaipapa in his book *Ruling Chiefs of Hawaii* as a place:

> *….where taro, sweet potatoespotatoes, bananas, sugar cane and wild fruits grew in abundance, and there was always much food to be had. Kawaipapa was rich in fish from the ponds and from the sea.*[5]

Kawaipapa is the region of Hana where Kiha a Piilani met his wife Koleamoku. The two of them surfed together at Waipunaalae and fell in love. They were married and soon had a son, named Kauhiokalani. It was then that Kiha a Piilani asked Koleamoku to ask of her father for some additional farm lands at Honomaele, Kaeleku, Kawaipapa, and the two Wananalua. Koleamoku's father, Hoolae makua, told her that the taking of those lands would pit Kiha a Piilani against Kiha a Piilani's brother, the king of Maui, Lono a Piilani, and that he would not agree to the award of these lands for farming, for his allegiance was with Lono a Piilani.[6] Kamakau relates the story of Kiha a Piilani and his wife, Koleamoku:

> *Kiha a Piilani asked his wife to appeal to her father for additional farmland. In response, Kiha a Piilani and Koleamoku were refused ownership in the following ahupuaa- the lands of Honomaele and Kaeleku that supplied the ohia wood and ieie vines for Kealakona to build ladders for the fortress of Kauiki, the ahupuaa of Kawaipapa, which supplied the stones of kanawao that were used in battle, and the Wananalua lands, where the fortress Kauiki was located. Koali contained the fortress of Kue. The father of Koleamoku recognized that Kiha a Piilani was planning a rebellion against his brother, Lono a Piilani, by attempting to gain control of these lands. He did not consent to the request for additional farmland, because he supported the rule of Lono a Piilani.*[7]

Kiha a Piilani appealed to the Hawaii chief Umi a Liloa for help in defeating his brother in battle. One year was spent building canoes for this war on the island of Hawaii. The armies of Umi a Liloa sailed from the island of Hawaii in great numbers, but, owing to the courageous fighting of the Maui hero Hoolae makua at Punahoa, the invading canoes were forced to land at Waikaahiki. The battle shifted between Kihahale and Waikoloa, in front of Kawaipapa, where

1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

3 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

4 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

5 S.M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

6 Ibid.

7 Ibid.

they fought with slings:

> *Stones were slung at the canoes. Hoolae kept close to a rock that is now called Hoolae Rock. It was so named because he kept close to it in battle and was victorious over the warriors of Hawaii. The next morning the Hawaii war canoes pressed shoreward from Nalualele to Kaihalulu to Lehuaula. Hoolaemakua fought with those who slung the solid ala stones of Kawaipapa, the skilled throwers of smooth pebbles of Waiaahiki, the expert stone tossers of Waikiu and Honokalani and the quick-slinging lads of Kaeleku. These men used their skill with stones and the Hawaii warriors were sent helter-skelter. Some of the canoes were broken and some were seized by Hoolae makua.*[8]

Kiha a Piilani conceived a new plan. He called for the fleet of canoes to land instead at Wailua Iki and for the warriors to travel overland to engage the forces of Lono a Piilani on land instead of at the seashore, where they would be more evenly matched. In time, the fortress of Kauiki was taken by the Hawaii invaders. When this news was received at Wailuku by Lono a Piilani, he died. The victor, Kiha a Piilani, divided the lands of Maui among his chiefs, and Umi a Liloa returned to Kailua, on the island of Hawaii.[9]

Kawaipapa is also the *ahupuaa* where Kiha a Piilani began to build his famous road paved with stones from the sea, a road that would, one day, encircle the entire island. According to Kamakau, Kiha a Piilani paved the roads of Maui with rocks and attempted to straighten the existing roads out, when that was possible.[10]

In Native Hawaiian legends, the battles of Kapalipilo describe the assault by the combined forces of Maui, Molokai, and Lanai on the fort at Kauiki that were meant to dislodge the Hawaii forces.[11] According to Kamakau, the field of battle started with the massing of the Maui armies from Heleleikeoha to Nahiku. Wananalua soon became the battlefield. At a signal from the islet of Mokuhano, the fortified walls of Kauiki were attacked. Soon, the battlefield shifted to the districts of Akiala and Keawaikau. The fighting soon came down to a challenge between Kaohele, a chief from Molokai, and Kamakaukii, a famous fighter from Hawaii. After a time, Kaohele gained the advantage, and Kamakaukii attempted to escape the battlefield, but the Molokai chief chased the Hawaii fighter and thrust him through the scrotum with a spear. Despite the victory by Kaohele, the fort did not surrender. Kamehamehanui retired, leaving Hana in the hands of the warriors of Hawaii.[12]

By the close of the year A.D. 1785 or the beginning of A.D. 1786, Kamehameha had defeated a number of Hawaii chiefs for supremacy of the island of Hawaii. Kamehameha then set his sights on Hana, and assembled an expedition to retake the districts of Hana and Kipahulu, knowing that the governor of Maui, Kahekili, was currently at war on Oahu. According to Kamakau, Kamehameha's fleet landed at the shore from Hamoa to Kawaipapa.[13] The eldest son of Kahekili, Kalanikupule was sent to rout the invaders from Hamakualoa. Led by the warrior Kamohomoho, the battle commenced at a small hill called Puukoae, situated on the *makai* side of Puumaile in Hanawana at Hoalua, where

8 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

9 Ibid.

10 Ibid.

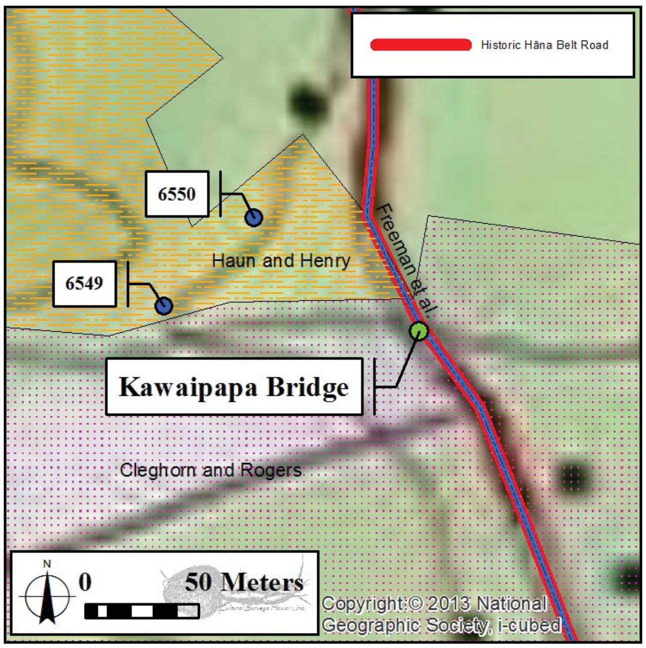
11 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

12 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

13 Ibid.

the Maui forces were victorious. This caused Kamehameha to beach his forces at Halehaku and force an additional attack alongside of a main road. Kamehameha routed the Maui forces and confronted them with the canon Lopaka. With men to haul the canon and operate it accurately, Kamehameha consolidated his victories and drove the Maui forces to the west.

Refer to Section G, Appendix 1, Section 3.1.1.1.1, for the story of Kamehameha's victory; Section 3.1.3.3, for the regional background in the vicinity of Kawaipapa; and to Section G, Appendix 1, Figure 17 for nearby archaeological study areas (refer to figure below).[14, 15, 16]



A 72.81 acre parcel (TMK 1-3-004:001) was recently surveyed just *mauka* of the highway in Kawaipapa Ahupuaa for the proposed development of an affordable housing subdivision.[17] A total of 26 sites were documented during the archaeological inventory survey (SIHP -4964, and -6527 through -6551), consisting of agricultural pits, walls, terraces, modified outcrops, mounds, enclosures, surface scatters, platforms, pavements, and historic ranching features including troughs, a basin, a foundation, a railroad grade, and a road.[18] Prehistoric habitation and agricultural sites accounted for the majority of the sites documented during the survey, however, the remains of sugar cane plantation infrastructure were also evident.[19] SIHP -6549 and -6550 are located approximately 110 meters east and 88 meters northeast of Kawaipapa Bridge, respectively (refer to figure above). Site -6549 is a permanent habitation complex consisting of a partially collapsed enclosure and associated pavement, while Site -6550 is a small isolated agricultural terrace.[20] Refer to Section G, Appendix 1, Table 2: Previous archaeological studies conducted along Hana Highway, Route 360.

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of the Kawaipapa Stream Bridge.

14 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

15 Paul L. Cleghorn and Kathie Rogers, *Preliminary Historical and Archaeological Investigations of Hāna Ranch Lands, Maui Hawaiian Islands*, prepared for EDAW, Inc.(Honolulu: Department of Anthropology, Bernice Pauahi Bishop Museum, 1987).

16 Alan E. Haun and David Henry, "Archaeological Inventory Survey TMK: (2) 1-3-04:001, Kawaipapa Ahupuaʻa, Hana District, Island of Maui," inventory survey, Haun & Associates (Kailua-Kona: 2014).

17 Ibid.

18 Ibid.

19 Ibid.

20 Ibid.

Civil & Traffic

Number of Lanes	One Lane (currently striped as Two Lanes)
Bicycle / Pedestrian Access	None
Visibility / Approach	• East Bound: Clear • West Bound: Clear
Signage (as of September 2014)	West Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (Worn out, OM3-L, OM3-R)
	East Bridge Approach • Yield Sign w/ To Oncoming Traffic Sign (R1-2, R1-2a) • Yield Line • Left and Right Object Markers (Worn out, OM3-L, OM3-R)
Civil Utilities	• Sewer: None • Water: Existing waterline
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	Electrical lines (primary and telephone) located nearby
Load Rating	• Method of Load Rating Calculations = Load and Resistance Factor Rating (LRFR) • Inventory Rating = 0.81 • Operating Rating = 1.05
Condition	Bridge is not Functionally Obsolete or Structurally Deficient

Civil & Traffic

Kawaipapa Stream Bridge is located at mile point 33.37 along Hana Highway and its existing conditions are as follows. This bridge is an observed two-lane bridge with an out-to-out width of 31.50 feet that has no bicycle or pedestrian access routes. In regard to visibility, the eastbound and the westbound approaches to the bridge are currently clear of any obstructions providing a clear view of oncoming traffic. The signs in this area are in relatively good condition except the Type 3 Object Markers (Left and Right) on both approaches to the bridge are worn. Currently, there is no apron at either entrance to the bridge. There are also no sewer utilities in the vicinity but there is an existing 6-inch waterline that runs along the upstream side of the bridge. During the research phase of this project, the team was not able to locate any HDOT Right-of-Way maps or any easements in this area.

Electrical

There are electrical lines (primary and telephone) that are close to the potential area of work.

Structural

The bridge was last inspected as part of the routine bridge inspection for Maui DOT on February 3, 2014. The overall condition rating of the bridge at the time of inspection varied between fair and good.[21] This two-lane bridge is not *functionally obsolete* or *structurally deficient*. Metal guardrails and guardrail transitions are located at each corner of the approaches to the bridge.

At the time of inspection, the concrete railings were in fair condition. The upstream and downstream railings had a height of 32 inches. Although the heights of the upstream and downstream railings are adequate for a TL-2 rating, neither railing has been crash-tested for a TL-2.

Load rating for this structure was calculated using LRFR and the inventory rating is 0.81 and the operating rating is 1.05.

The current curb-to-curb dimension is 26.50 feet (over the bridge) and 28.50 feet (over the culvert), which for a two-lane bridge is adequate for this project's design criteria of 24 feet.

21 See Glossary for more information for condition ratings.

Recommendation

It is recommended that the existing bridge structure of Kawaipapa Stream Bridge be rehabilitated. Any rehabilitation work to this bridge will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on the information provided by the routine bridge inspection report dated February 3, 2014, record drawings,[22], [23] and site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Kawaipapa Stream Bridge is to be rehabilitated, any rehabilitation work to this bridge will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for bridge rehabilitation, as this bridge contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A temporary bypass bridge is recommended during repair and/or rehabilitation for all bridges in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this bridge shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per bridge component, as follows:

Deck & Culvert

The Kawaipapa Stream Bridge currently meets the standard width of a two-lane bridge; therefore, no widening is needed. Rehabilitation to the bridge deck and culvert is recommended to increase the load carrying capacity of the bridge and to support the new concrete railings. Refer to "Railings/Parapets" and "Load Rating" sections for more information.

There are also no recommendations for adding a pedestrian or bicycle access route due to the limited width of the existing bridge.

22 Territory of Hawaii, Territorial Highway Department, *Plans of Kawaipapa Bridge on Hana Belt Road*, Federal Aid Project No. F. 58(1), March 1946.

23 State of Hawaii, Department of Transportation, Highways Division, "As-Built" Plans for Hana Highway Improvements at Kawaipapa Bridge, Project No. 360B-01-89 (May 1990).

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

Kawaipapa Stream Bridge currently does not have approach CRM walls like the other historic bridges along Hana Highway. Therefore, it is recommended to install reinforced concrete walls with new natural rock façades at each of the bridge approach corners. The new reinforced concrete walls shall be designed to meet TL-2 crash requirements. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the bridge after the stone masonry guardwall. New approach walls shall be designed to be independent of the bridge railings; a small space is recommended between railings and approach walls.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). Guardrail attachment to the bridge post with the name of the bridge should be carefully removed to expose existing bridge name. The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete bridge parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). This railing is attached to the deck of the bridge and culvert, which does not have sufficient capacity to support the design loads of the railings. Additional support for the railing will be required, for instance in the form of a new girder under the bridge and the thickening of the top slab of the culvert. Refer to current drawings for this bridge. Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Piers, Wingwalls, Abutments, & Culvert

According to record drawings, the abutments are constructed of CRM material. During site visits to the bridge, no CRM stones were visible, and the façades of the abutments appeared to be concrete. Therefore, the existing structural make-up of the abutments cannot be verified by visual inspection.

Although the concrete wingwalls are a good intact example of this component along the Hana Highway, Route 360, additional constraints may affect reconstruction of the existing appearance of these typical features. Therefore, the concrete wingwalls are recommended to be replaced in-kind with reinforced concrete structures. Prior to removal, future design team shall document the existing appearance and condition of concrete wingwalls.

It is recommended to investigate the current material composition of the concrete abutments, pier, culvert, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. Bridges with and without record drawings should be scanned for reinforcing and have core samples extracted. If the core samples show that the abutments are concrete structures, then a condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the bridge's lifespan. If investigations of the material and strength of the abutments yield no substantial results, then it is recommended to replace the substructure completely with a reinforced concrete structure. If it is determined necessary to rehabilitate the abutments and pier walls, they are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. If it is determined that the abutments are constructed of CRM material, prior to removal, the future design team shall document the existing appearance, condition, and CRM sublayer.

Following investigation of the abutments and pier walls, if it is determined necessary that these components are to be replaced, the abutments and pier walls are recommended to be replaced in-kind with reinforced concrete structures with the exterior façades detailed and finished to match existing conditions. If it is determined that the abutments are constructed of CRM material, prior to removal, the future design team shall document the existing appearance, condition, and CRM sublayer.

Load Rating

Load rating for this bridge was updated with LRFR and the recommended bridge load posting matched the current 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). It is recommended to strengthen the culvert superstructure to support a load carrying capacity of 40-tons. One method would be to thicken the existing top slab. Also, the load rating is governed by the substructure rating of the culvert.

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Should the bridge be widened on the downstream side, the existing waterline must be relocated and comply with current Maui County Department of Water Supply Standards. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways,* 2009 edition by the FHWA or the most current edition/revision of this book. Signage, traffic, and visibility recommendations include the following:

West Bridge Approach

- Replace Object Markers Type 3 - Left & Right (OM3-L, OM3-R)

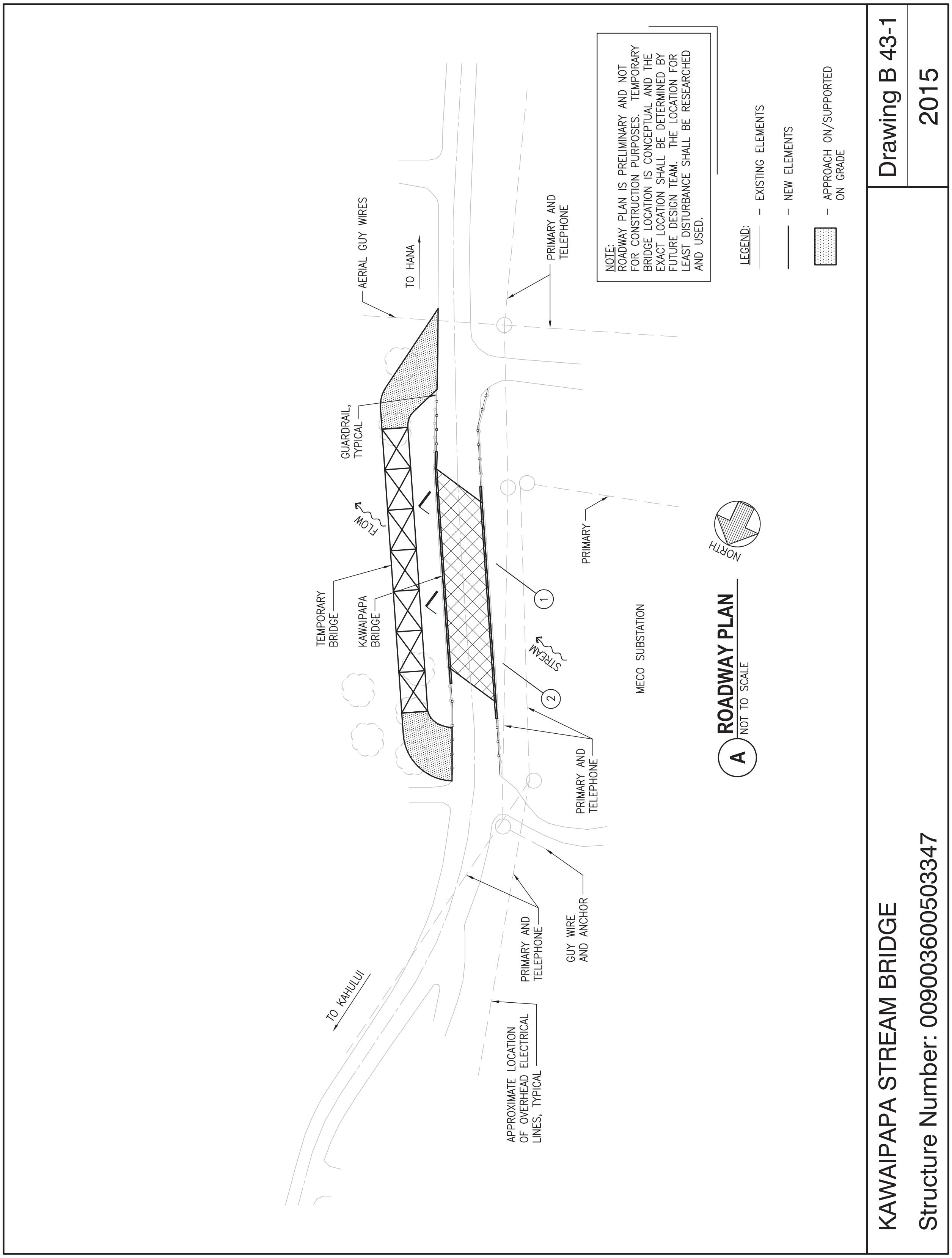
East Bridge Approach

- Replace Object Markers Type 3 - Left & Right (OM3-L, OM3-R)

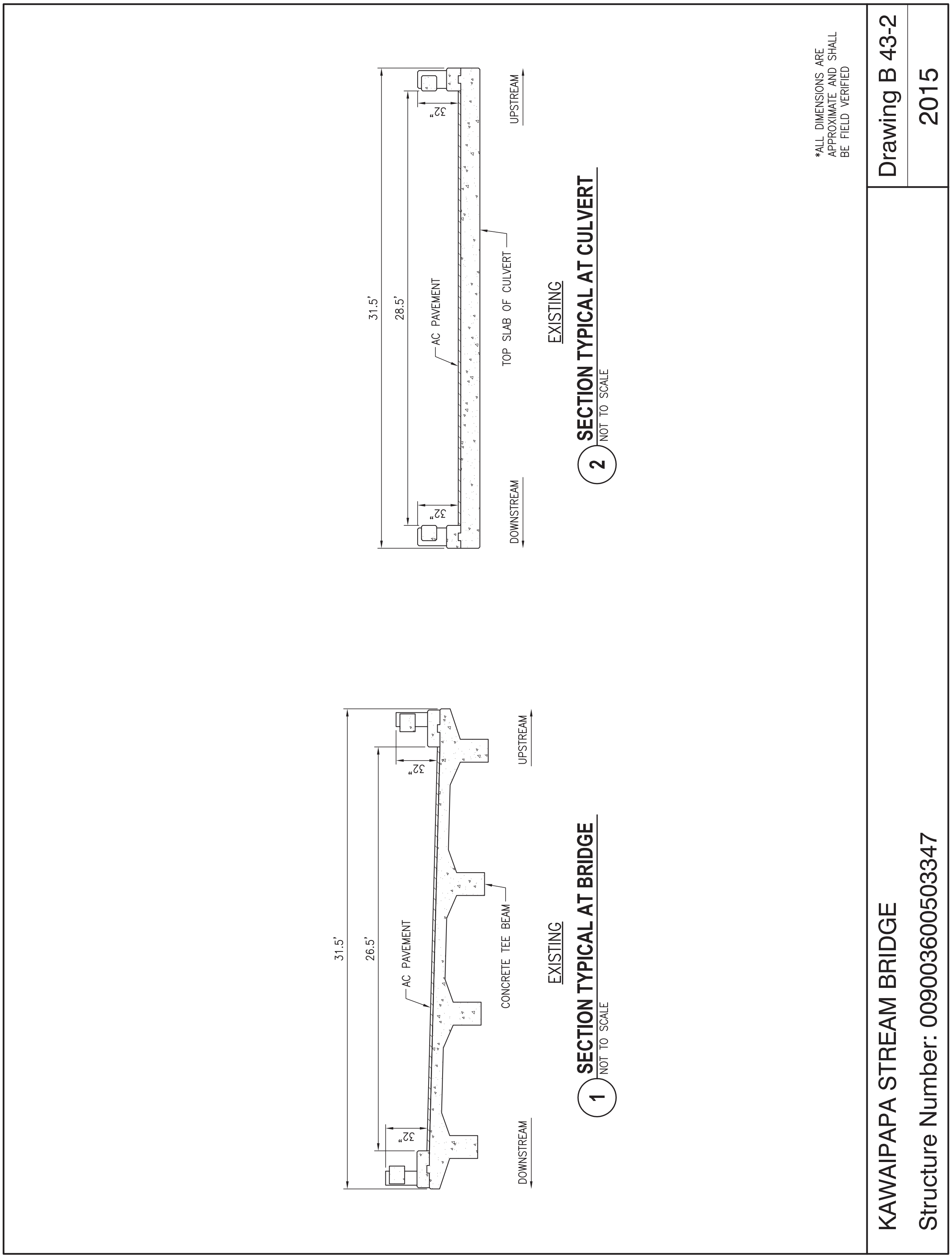
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Primary and telephone lines are close to the area of work. The contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



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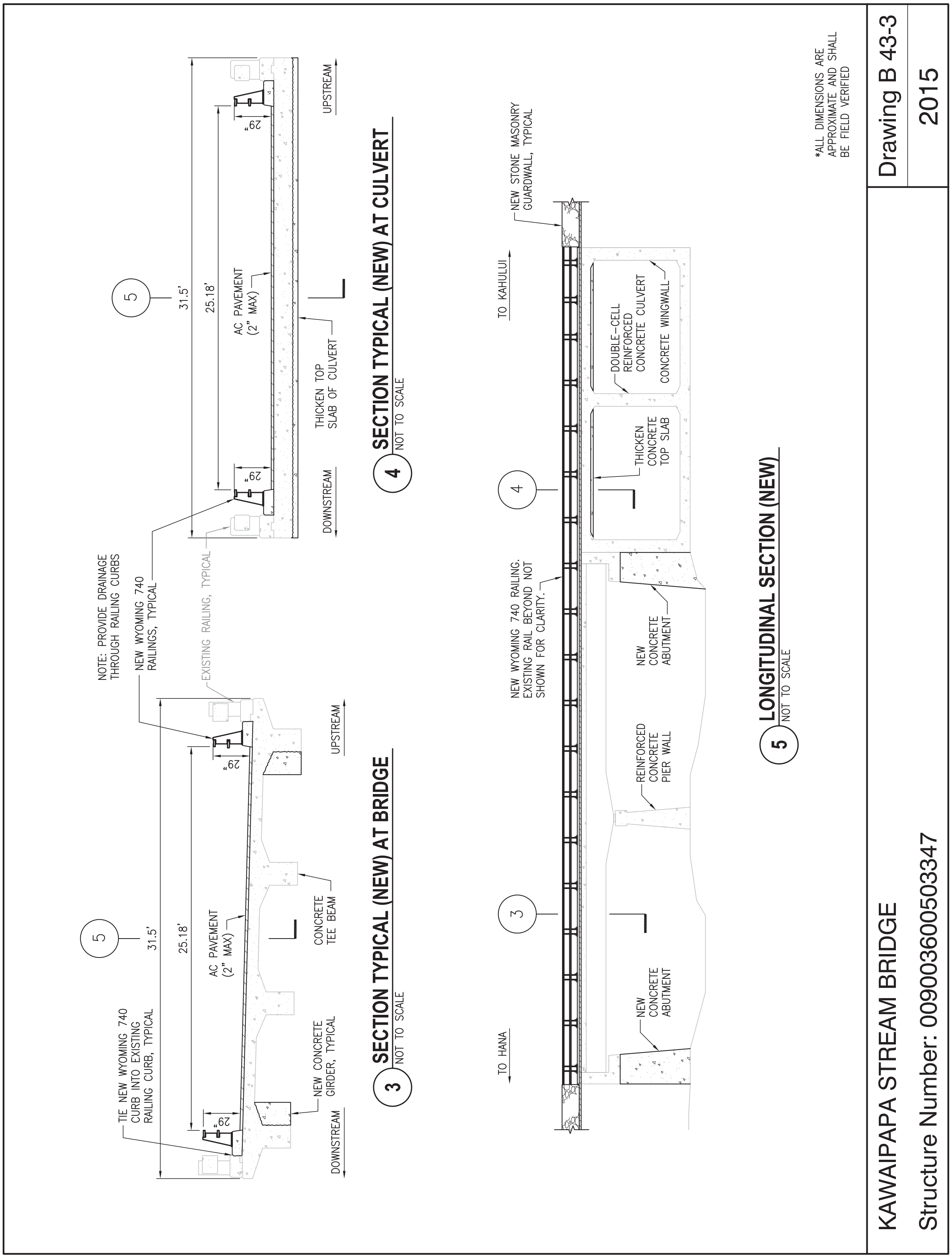

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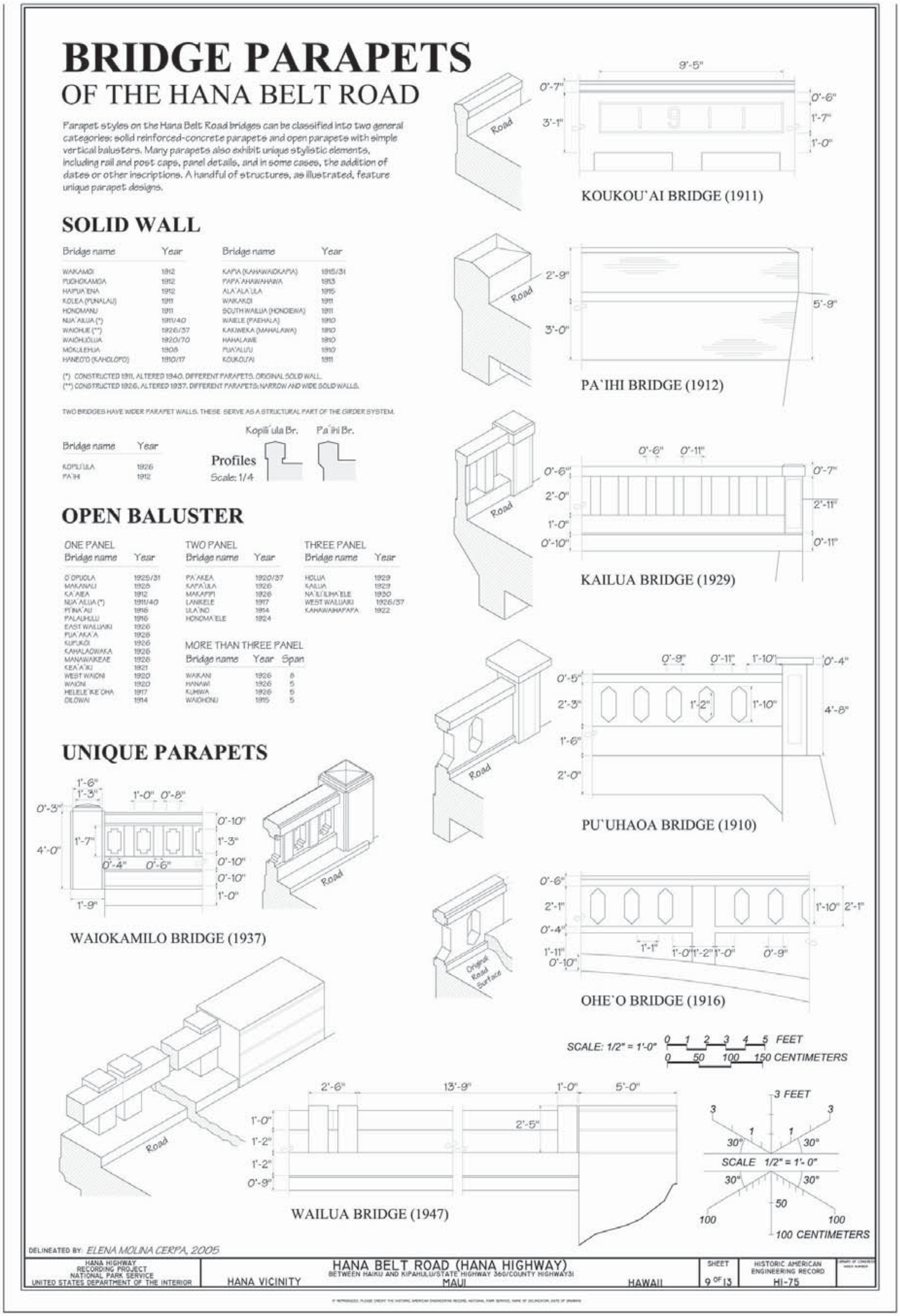


Courtesy of HAER HI-75

SECTION C

CULVERTS

HAER CULVERTS OVERVIEW

The 12 individual chapters presented in this section have been adapted with specific information for each particular HAER-identified culvert, with relevant cultural, historical, and technical information, as well as detailed treatment recommendations for each historic culvert.

Culvert inventory sheets contain the following information:

- Photographs and maps,
- Location information,
- Documentation of existing conditions,
- Structural conditions, such as load rating and overall condition,
- Pertinent considerations adjacent to culvert locations, such as private property, utilities, and signage,
- Archaeological sites identified within vicinity of the culvert,
- Statement of historic/cultural significance and historic references, and
- Character-defining features of each culvert.

Detailed written pages also address:

- References to current civil, electrical, and structural conditions, and identified issues,
- Historic and cultural site context pertinent to each historic culvert location, and
- Site-specific recommendations by the team tailored to the individual conditions at each culvert.

Lastly, current drawings indicate existing conditions and present conceptual treatment recommendations with preferred railing type for each culvert. Historic drawings are not available for individual culverts.

Culvert Matrix

Hana Highway, Route 360

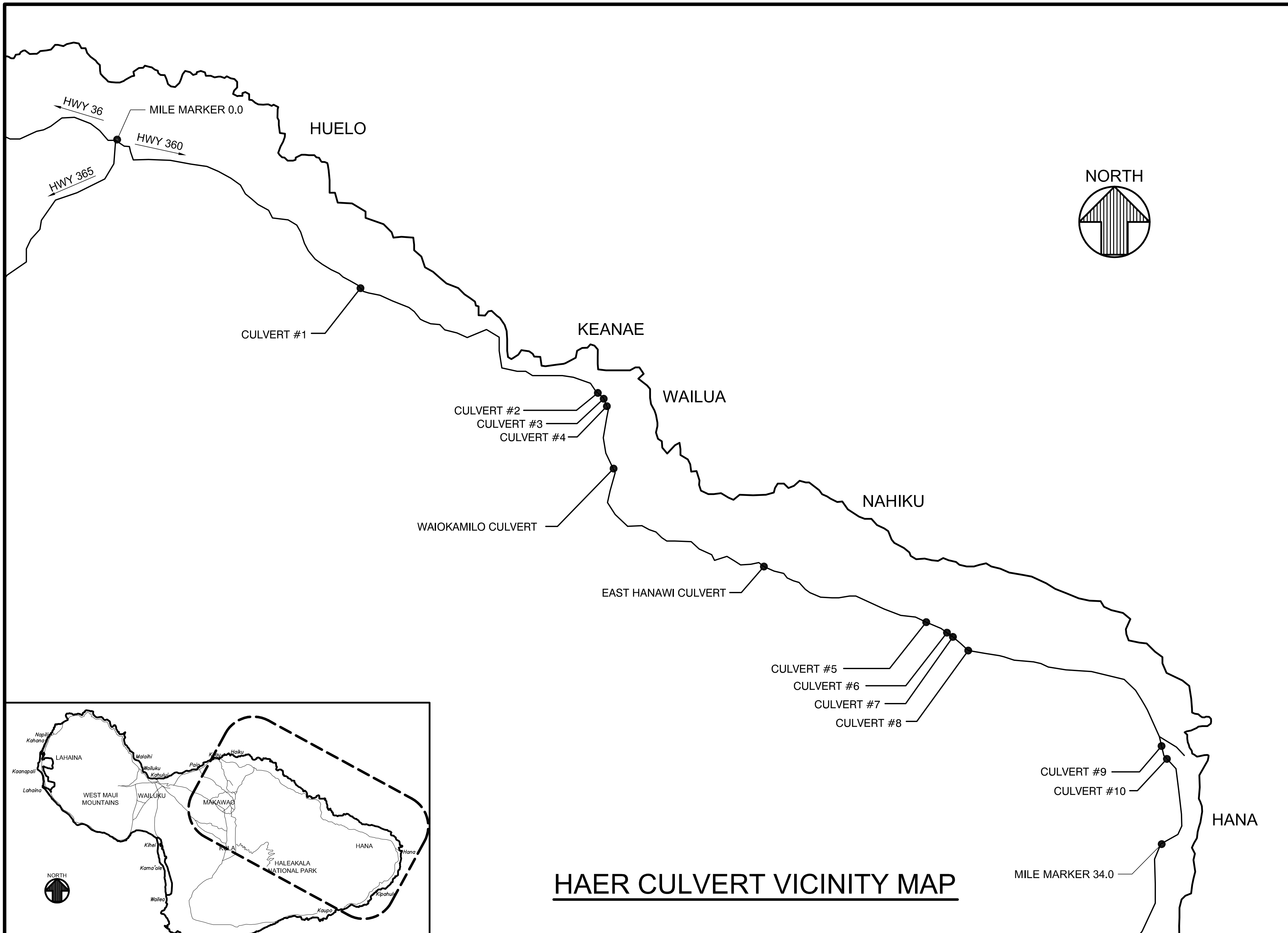
	Bridge Name	Mile Point	Details	Length (ft)	Year Reconstructed	Structure Type	No. Spans	Latitude	Longitude
1C	Culvert	6.57	24" RCP						
2C	Culvert #1	7.03	8' x 9.5' Box	9		Concrete Slab	1	20d 52m 56s	156d 12m 08s
3C	Culvert	9.13	24" RCP						
4C	Kolea Culvert	9.24	5' x 10' Box						
5C	Culvert	10.18	8' x 8' Box						
6C	Culvert	10.48	3' x 3' Box						
7C	Culvert	11.82	24" RCP						
8C	Culvert	12.12	2' x 1' Rock Box						
9C	Culvert	12.65	24" RCP						
10C	Culvert	14.63	8' x 4" Box						
11C	Culvert	14.91	? Filled. As-builts: 48" SSP & 4' x 4' Box						
12C	Culvert	15.4	24" RCP						
13C	Culvert	16.06	12' x 5' Box						
14C	Culvert	17.03	24" RCP						
15C	Culvert	17.19	24" RCP						
16C	Culvert	17.27	(3) 42" RCP & (1) 24" RCP						
17C	Culvert	17.31	36" RCP & 24" RCP						
18C	Culvert	17.36	? Size. 24" RCP?						
19C	Culvert #2 (Bridge)	17.46	Clr Ht: 6' (u/s) & 13' (d/s) and Clr Wth: 7' (u/s) & 10' (d/s)	10	circa 1937-1940	Concrete Slab	1	20d 51m 04s	156d 08m 33s
20C	Culvert #3 (Bridge)	17.48	Clr Ht: 4' (u/s) & 8' (d/s) and Clr Wth: 10' (u/s) & 14' (d/s)	15	circa 1937-1940	Concrete Slab	1	20d 51m 04s	156d 08m 31s
21C	Culvert #4 (Bridge)	17.49	Clr Ht: 7' (u/s) & 10'-6" (d/s) and Clr Wth: 8' (u/s) & 11' (d/s)	13	circa 1937-1940	Concrete Slab	1	20d 51m 03s	156d 08m 31s
22C	Culvert	17.51	Clr Ht: 5'-4" (u/s) & 9'-2" (d/s) and Clr Wth: 11'-9"						
23C	Culvert	17.55	24" RCP						
24C	Culvert	17.65	24" RCP						
25C	Waiokamilo Culvert	18.08	Clr Ht: 6' and Clr Wth: 13'-8"	24		Concrete Slab	1	20d 50m 55s	156d 08m 10s
26C	Culvert	20.01	30" CMP						
27C	Culvert	20.03	36" CMP						
28C	Culvert	20.05	48" CMP						
29C	Culvert	21	6' x 8' Box						
30C	Culvert	21.11	9' x 8' Box						

Culvert Matrix

Hana Highway, Route 360

	Bridge Name	Mile Point	Details	Length (ft)	Year Reconstructed	Structure Type	No. Spans	Latitude	Longitude
31C	Culvert	21.29	18" RCP (inlet) & 2' x 1' Rock (outlet)						
32C	Culvert	21.92	(2) 24" RCP						
33C	Culvert	22.1	4' x 4' Box						
34C	Culvert	22.52	4' x 4' Rock Box						
35C	Culvert	22.54	18" RCP						
36C	Culvert	22.79	3' x 8' Box						
37C	Culvert	22.9	24" RCP						
38C	Culvert	23.04	48" CMP						
39C	Culvert	23.21	6' x 4' Box						
40C	Culvert	23.26	6' x 8' Box						
41C	Culvert	23.7	48" RCP						
42C	East Hanawi Culvert	24.2	Int. Ht: 7'-6" & Int. Wth: 12'-0"	11'-8"		Concrete Slab	1	20d 48m 36s	156d 06m 26s
43C	Culvert	24.38	24" RCP						
44C	Culvert	24.71	2' x 2' Rock Box						
45C	Culvert	24.9	3' x 3' Box						
46C	Culvert	26.13	4' x 4' Box						
47C	Culvert	26.33	2' x 1' Rock Box						
48C	Culvert	27.26	3' x 7' Box						
49C	Culvert	27.41	24" CMP						
50C	Culvert	27.6	2.5' x 2.5' Rock Box						
51C	Culvert	27.7	1' x 2.5' Rock Box						
52C	Culvert #5	29.78	Clr Ht: 10'-6" and Clr Wth: 14'-6"	18		Concrete Slab	1	20d 47m 16s	156d 02m 17s
53C	Culvert #6	30.02	Clr Ht: 7' and Clr Wth: 11'-7"	12		Concrete Slab	1	20d 47m 13s	156d 02m 06s
54C	Culvert #7	30.13	Clr Ht: 5'-6" and Clr Wth: 5'-4"	6		Concrete Slab	1	20d 47m 11s	156d 02m 00s
55C	Culvert #8	30.44	Clr Ht: 8'-8" and Clr Wth: 11'-6"	13		Concrete Slab	1	20d 47m 02s	156d 01m 47s
56C	Culvert #9	33.65	Clr width: 14'-0" and Length: 14'-1" (original) / Clr width: 14'-0" to 23'-0" and Length: 13'-11" (widen)	15		Concrete Slab	1	20d 45m 44s	155d 59m 38s
57C	Culvert #10	34	12.5' x 17' Box	14		Concrete Slab	1	20d 45m 38s	155d 59m 33s

HAER Culverts



HAER CULVERT VICINITY MAP

OVERALL PLAN

Culvert #1

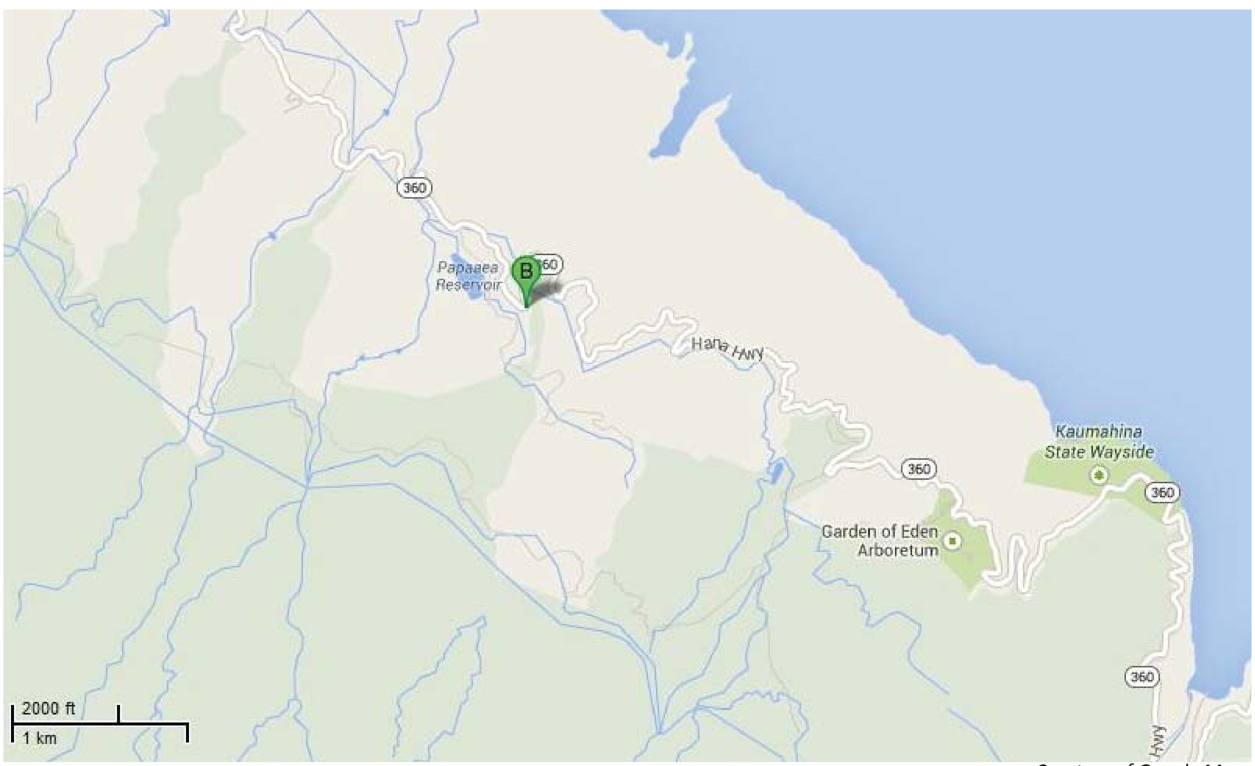
2C

2C

CULVERT #1

Culvert Number		**Island**	Maui
Date of Construction	Unknown	**Route**	Hana Highway

Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 52m 56s
Longitude	156d 12m 08s
Mile Point	7.03

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 19.75 feet
Number of Spans	1
Clear Span	8.00 feet
Clear Height	10 feet (approx)
Deck Width	Curb-to-Curb = 17.75 feet
Abutment Material	• CRM Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Solid Parapets
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 24 inches • Downstream Railing Height = 24 inches
Parapet Profile	• No Cap • Flat Parapet
Parapet Inscription	None

Culvert Features

Culvert #1 is located at mile point 7.03 and has a clear opening of approximately 8.00 feet wide by 10 feet high. The culvert is 17.75 feet long. The top slab is concrete with CRM abutment walls, and the bottom is an unlined channel.

Setting of Culvert #1
Courtesy of FAI

Kahului approach to Culvert #1 toward Hana
Courtesy of NOEI

Significance & Context

Ahupuaa	West Makaiwa
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Heavy vegetation
Character Defining Features	• Box Culvert • CRM Abutment Walls • CRM Wingwalls • Concrete Solid Parapets
Detracting Features	• Excessive asphalt

Significance & Context

Archaeological / Cultural Significance

Culvert #1 is located within West Makaiwa Ahupuaa.[1, 2] The Hawaiian word *makaiwa* translates as, "Mother-of-pearl eyes, as in an image, especially of the god Lono."[3] No other specific cultural or archaeological information could be found for this particular location.

Refer to Section G, Appendix 1, Figure 8 for nearby archaeological study areas.[4]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of Culvert #1.

1 U.S. Geological Survey, ed., *Haiku Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

2 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

3 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

4 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	• Signs are in good condition • Missing Object Marker Type 3 - Left Eastbound
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic.

This culvert receives its runoff from an 88-acre (approximate) drainage area and has a terrain that consists of mostly forest type. The upstream and downstream ends of the culvert are highly vegetated and overgrown. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #1 is a one-lane reinforced concrete slab culvert. Metal guardrails with end treatments are located at the upstream Kahului and downstream Hana approaches. There is a CRM wall at the upstream Hana approach and no approach wall at the downstream Kahului approach. The upstream and downstream concrete parapets have a height of 24 inches. Neither parapet has been crash-tested for a TL-2.

The current curb-to-curb dimension is 17.75 feet, which for a one-lane culvert is adequate for this project's design criteria of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #1 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #1 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per culvert component, as follows:

Deck

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the new railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the culvert, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

CRM Approach Walls

The existing CRM walls at the approaches to the culvert do not meet the TL-2 crash requirements and cannot act as the culvert's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the culvert after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete culvert parapets do not meet TL-2 crash requirements. It is recommended to replace the parapets on the upstream and downstream sides with a similarly designed reinforced concrete parapet. For this purpose, it is recommended to use a vertical concrete barrier rail concrete parapet which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the deck is recommended (refer to "Deck" section). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions and have a straight exterior surface.

Foundations, Wingwalls, & Abutments

The CRM culvert walls and wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. If it is determined necessary to rehabilitate the concrete foundations, it is recommended they be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to “Deck” section). It is assumed that the culvert can support 10-tons at a minimum, per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver’s visibility should be trimmed or removed per an approved landscape plan. Signage shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

West Bridge Approach

- Add Object Marker Type 3 - Right (OM3-R) to East Bound

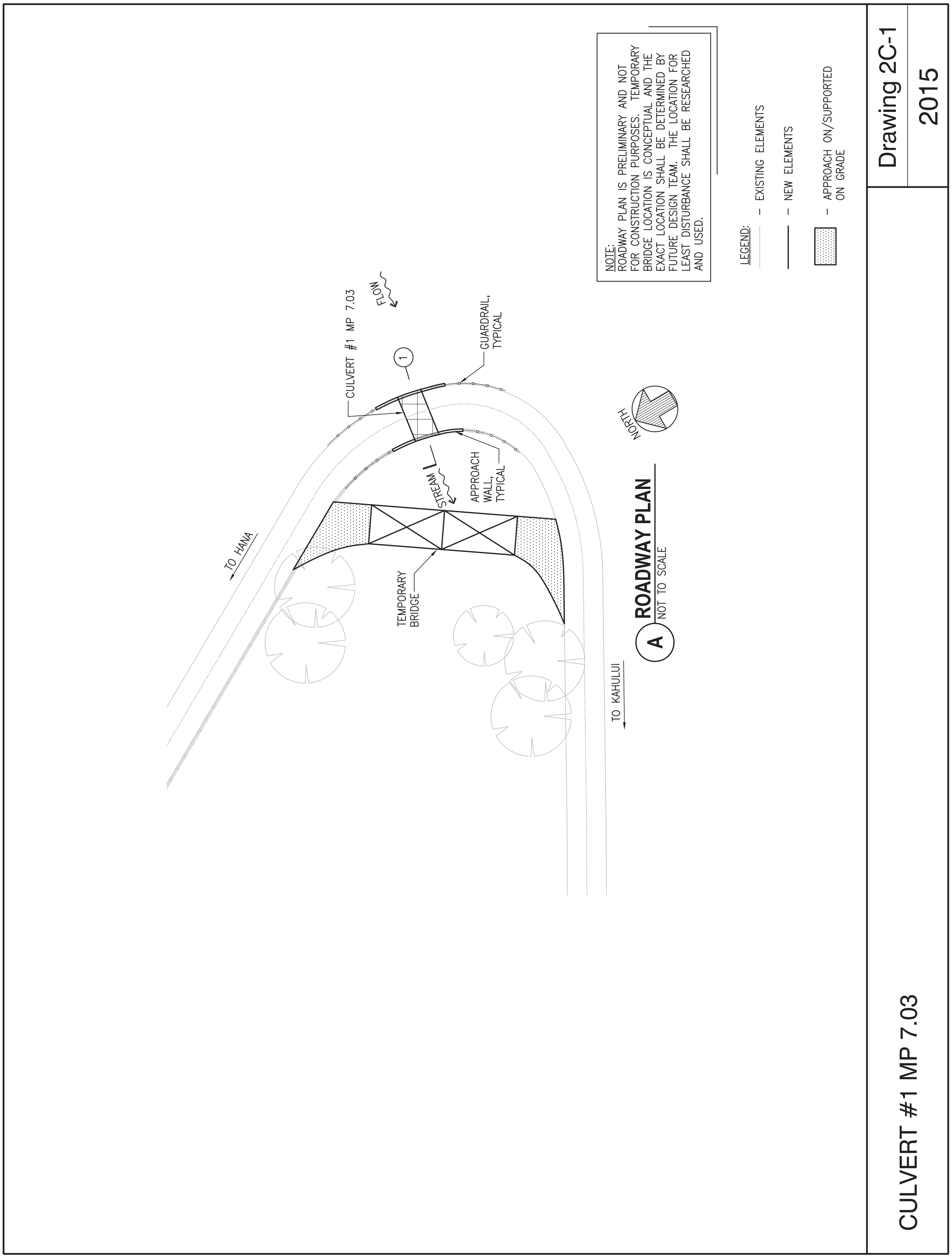
East Bridge Approach

- Add Yield sign (R1-2) and “To On Coming Traffic” plaque (R1-2a)
- Add Yield Line

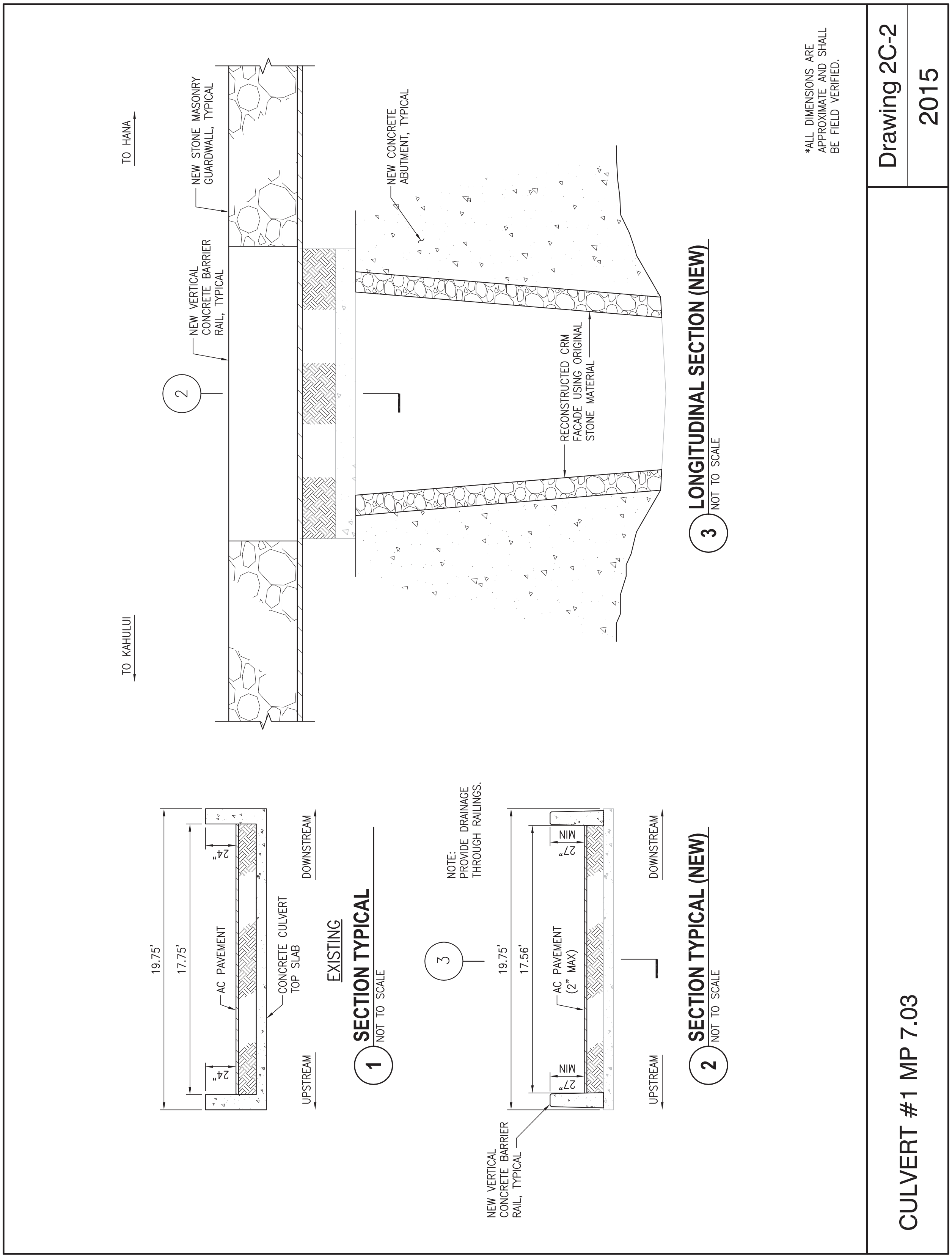
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #1 at this time.



Courtesy of NOEI



Courtesy of NOEI

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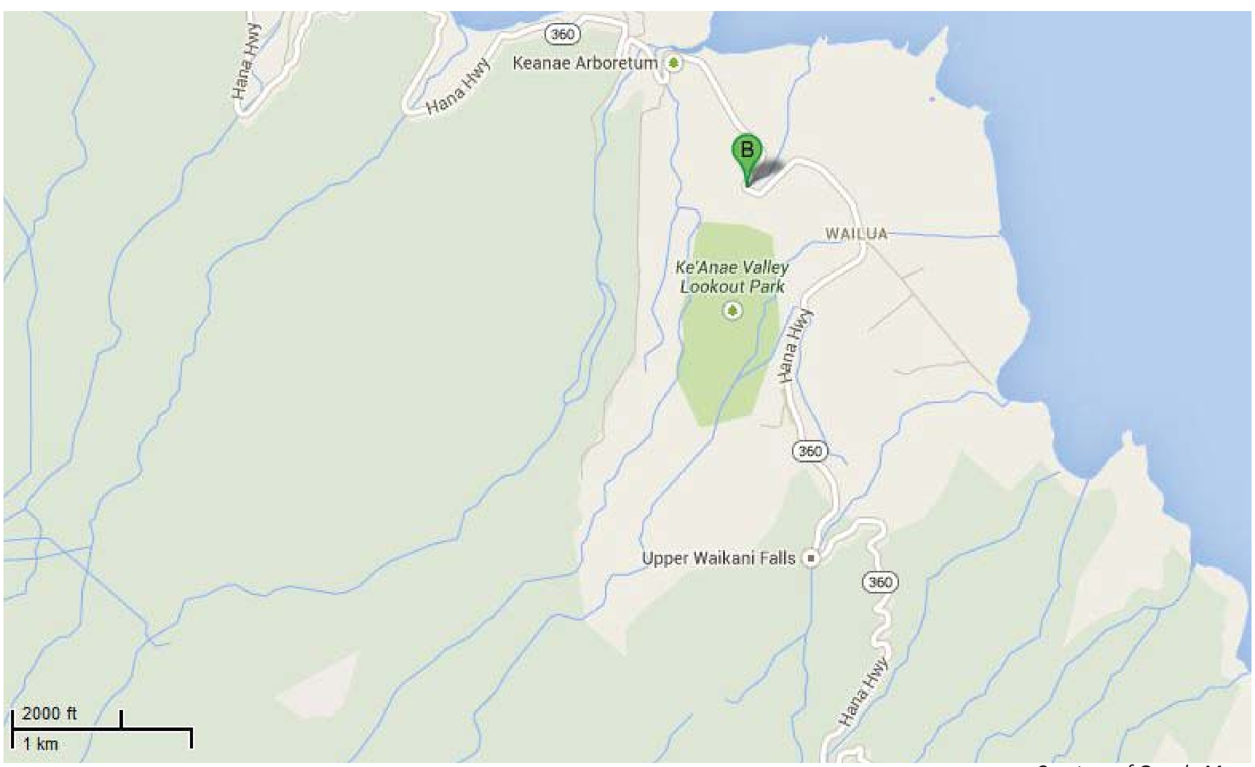
Culvert #2 19C

19C CULVERT #2

Culvert Number				**Island**	Maui		
Date of Construction	circa 1937-1940			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 51m 04s
Longitude	156d 08m 33s
Mile Point	17.46

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 23.00 feet
Number of Spans	1
Clear Span	15.00 feet
Clear Height	6 feet (upstream) & 13 feet (downstream) (approx)
Deck Width	Curb-to-Curb = 20.75 feet
Abutment Material	• CRM (upstream) & Concrete (downstream) Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	CRM (upstream) & Concrete Solid (downstream) Parapets
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 24 inches • Downstream Railing Height = 27 inches
Parapet Profile	• No Cap • Flat Parapet with Board-Formed Concrete Texture
Parapet Inscription	None

Culvert Features

Culvert #2 is located at mile point 17.46 and has a clear opening of approximately 15.00 feet wide by 6 feet high at the upstream end and 13 feet high at the downstream end. The culvert is approximately 23.00 feet long. According to the HAER report, the original date of construction is unknown, but the culvert was widened on the downstream side circa 1937-1940.[1] The top slab and walls are concrete with CRM and concrete abutment walls, and the bottom is an unlined channel.

Setting of Culvert #2
Courtesy of NOEI

Kahului approach to Culvert #2 toward Hana
Courtesy of NOEI

1 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005).

Significance & Context

Ahupuaa	Waianu
Designer / Builder	Unknown
Historic Drawings	None
Alterations	Circa 1937-1940
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Walker Site 94, the Heiau of Ohia, was once located approximately 115 meters southeast of historic Culvert #4. The *heiau* was documented by Walker as, “Stones removed to build pig pen, and outlines thus lost. Probably an agricultural *heiau* built by a chief named Kaimuki.”
Geographical Features / Setting	• Heavy vegetation • Taro farm located on downstream side
Character Defining Features	• Box Culvert • CRM (upstream) & Concrete (downstream) Abutment Walls • CRM Wingwalls • CRM (upstream) & Concrete Solid with Board-Formed Texture (downstream) Parapets
Detracting Features	• Excessive asphalt

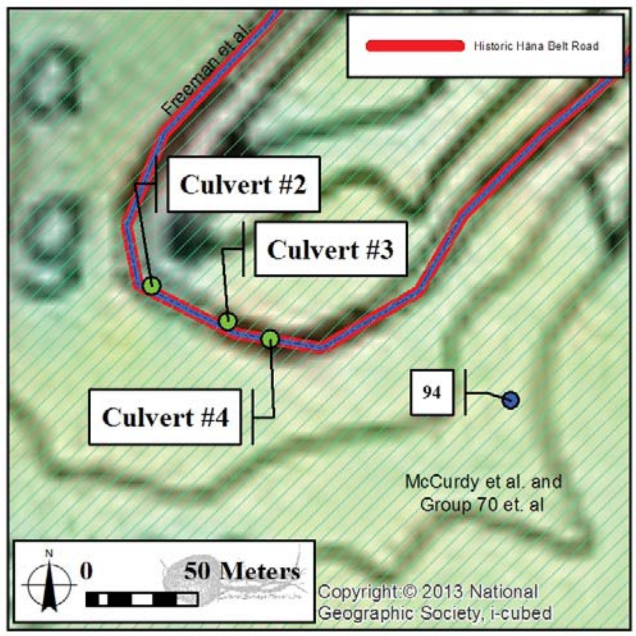
Significance & Context

Archaeological / Cultural Significance

Culvert #2 is located at the Ohia Stream crossing of Hana Highway, Route 360, within Waianu Ahupuaa. The Hawaiian word *ohia* is most commonly used to refer to a type of tree (*Metrosideros macropus*), but may also be used for a tomato, a native variety of sugar cane, a variety of taro, a red birthmark, and for the word "tabooed."[2]

The Keanae region is described as a unique wet-taro growing area developed by the early inhabitants for irrigated taro with a *loi* complex that covered the peninsula. The Native Hawaiian mythology states that the god Kane accompanied by Kanaloa, thrust his *kauila* staff into solid rock and water gushed forth. Additionally, Ashdown stated that the Lualailua fishponds were located at Keanae, and that they were considered sacred, or *wahi pana*.

The initial occupation of this portion of Maui first occurred along the coastal region about A. D. 1200. The accepted pre-contact settlement pattern for the region of Keanae/Wailuanui centers on the series of occupational episodes that utilized the Palauhulu Stream for taro (*Colocasia esculenta*) cultivation.



Refer to Section G, Appendix 1, Section 3.1.2.5 for the regional history of Keanae, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[3, 4, 5]

Adjacent Cultural Sites

Walker Site 94, the Heiau of Ohia, was once located approximately 170 meters southeast of historic Culvert #2. The *heiau* was documented by Walker as, "Stones removed to build pig pen, and outlines thus lost. Probably an agricultural *heiau* built by a chief named Kaimuki."[6] Walker was not able to relocate the site, and Soehren was unable to identify the site during his 1963 survey as well.[7] Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway, and to the adjacent figure for approximate location of previous *heiau* relative to Culvert #2.

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2 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

3 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

4 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

5 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

6 Winslow Walker, *Archaeology of Maui*, 1931, manuscripts on file, Bishop Museum Archives, Honolulu.

7 Lloyd J. Soehren, *An Archaeological Survey of Portions of East Maui, Hawaiʻi*, Bernice Pauahi Bishop Museum (Honolulu: 1963).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	• Signs are in good condition • Missing Object Marker Type 3 - Left Eastbound
Apron	None
Civil Utilities	• Water: Existing waterline, upstream side
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The invert of the culvert is approximately 13 feet below the roadway pavement. There is a 6-inch waterline that runs along the upstream end of the culvert.

The roadway above the culvert is striped for two lanes, allowing vehicles to travel across the span of the culvert without yielding to oncoming traffic.

Culvert #2 receives storm water runoff from a 51-acre drainage area (approximate) and consists of mostly forest type terrain. The downstream end of the culvert consists of an unnamed shallow stream that travels towards the ocean and has a constant flow caused by a continuous flowing natural spring. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #2 is a two-lane reinforced concrete slab culvert. CRM walls are located at each corner of the approaches to the culvert. The upstream CRM parapet and downstream concrete parapet have a height of 24 inches and 27 inches, respectively. Neither parapet has been crash-tested for a TL-2.

The current curb-to-curb dimension is 20.75 feet, which for a two-lane culvert does not meet the design criteria minimum of 24 feet.

Load rating for this culvert is unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #2 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #2 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question. Near the base of Culvert #2, Ohia Stream provides irrigation for agricultural fields located downstream of Hana Highway, Route 360. If Culvert #2 is to be rehabilitated, care shall be taken to ensure that construction activities do not interfere or contaminate the stream.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per culvert component, as follows:

Deck

There are no record drawings for this culvert. It is recommended to widen the deck on the downstream side, scan the deck for reinforcing, and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the new railings and a 40-ton load carrying capacity. The widened deck slab shall be designed to cantilever off the existing slab and abutments. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the culvert, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

The existing CRM walls at the approaches to the culvert do not meet the TL-2 crash requirements and cannot act as the culvert's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului and upstream and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. The downstream Kahului approach corner does not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at this corner after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The culvert parapets currently do not meet TL-2 crash requirements. The upstream CRM parapet is recommended to be replaced with a reinforced concrete wall with a new natural rock façade. Since the approach walls are similar to the upstream parapet, it is recommended to construct the upstream parapet monolithic with the approach walls. Therefore, the upstream parapet will be replaced with a stone masonry guardwall (refer to Section G, Appendix

5. *Proposed Crash-Tested Railing Options*). The downstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical concrete barrier rail (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the existing deck is recommended to determine whether it can support the design loads of the parapets (refer to “Deck” section). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions and have a straight exterior surface.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the CRM/concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The concrete portions of the culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert’s lifespan. If it is determined necessary to rehabilitate the CRM and concrete abutments, and foundations they are recommended to be replaced in-kind.

If it is determined necessary to rehabilitate the CRM/concrete abutments, it is recommended that the concrete portions be replaced in-kind and CRM portions be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed CRM façade portions shall closely match that of the original historic craftsmanship along Hana Highway.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to “Deck” section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

RECOMMENDATIONS

Civil, Traffic, & Signage

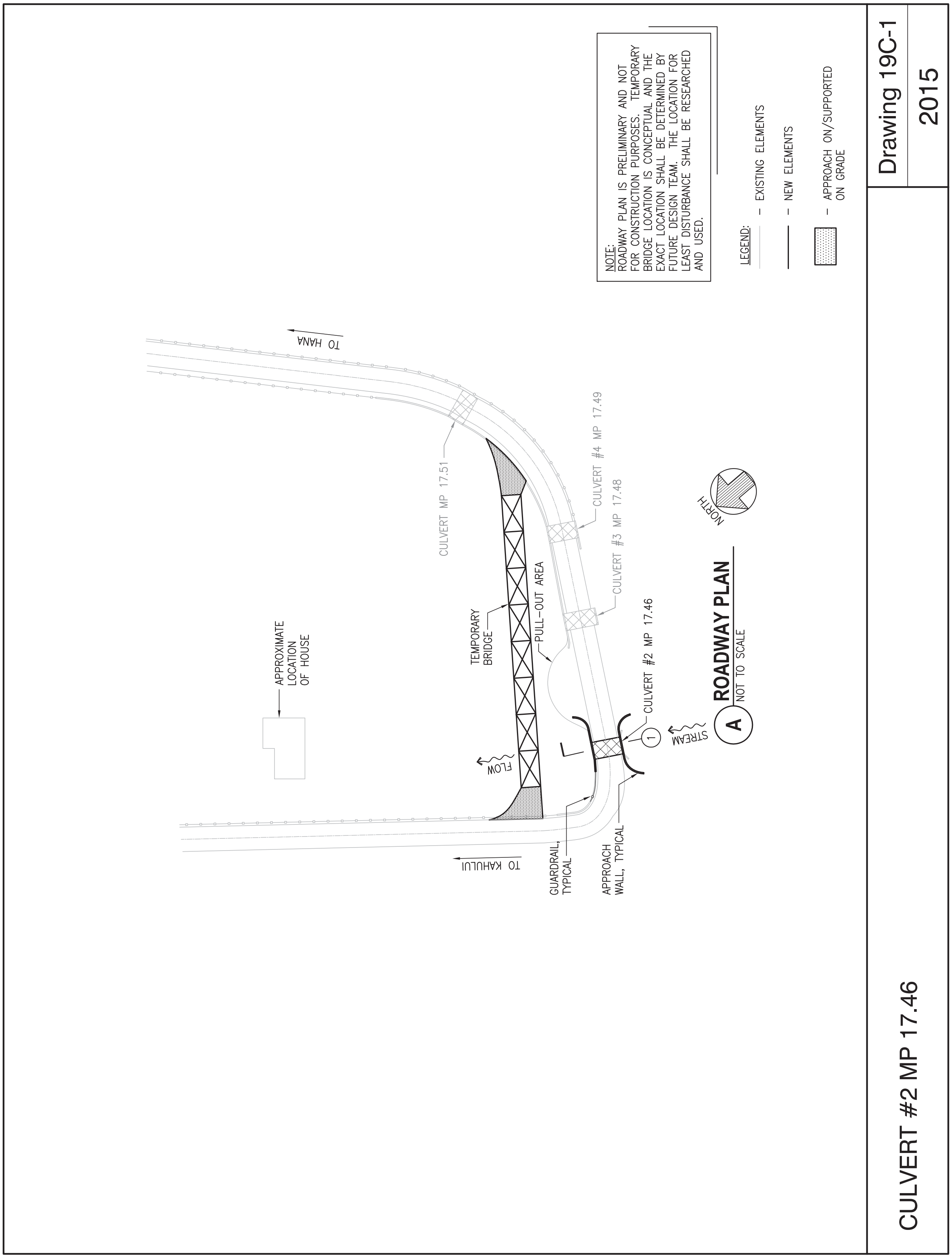
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Marker Type 3 - Right (OM3-R) to East Bound

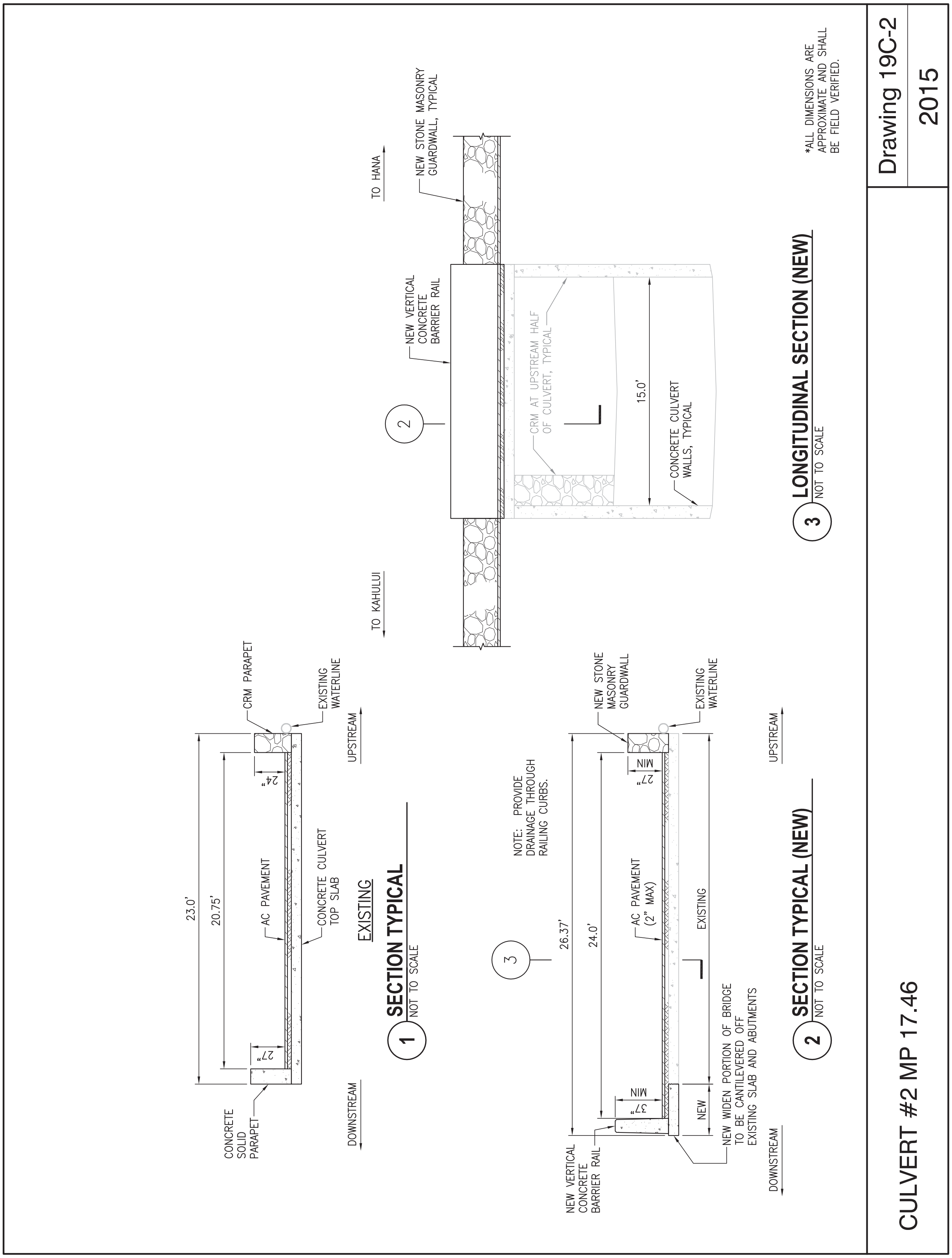
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #2 at this time.



Courtesy of NOEI



Courtesy of NOEI

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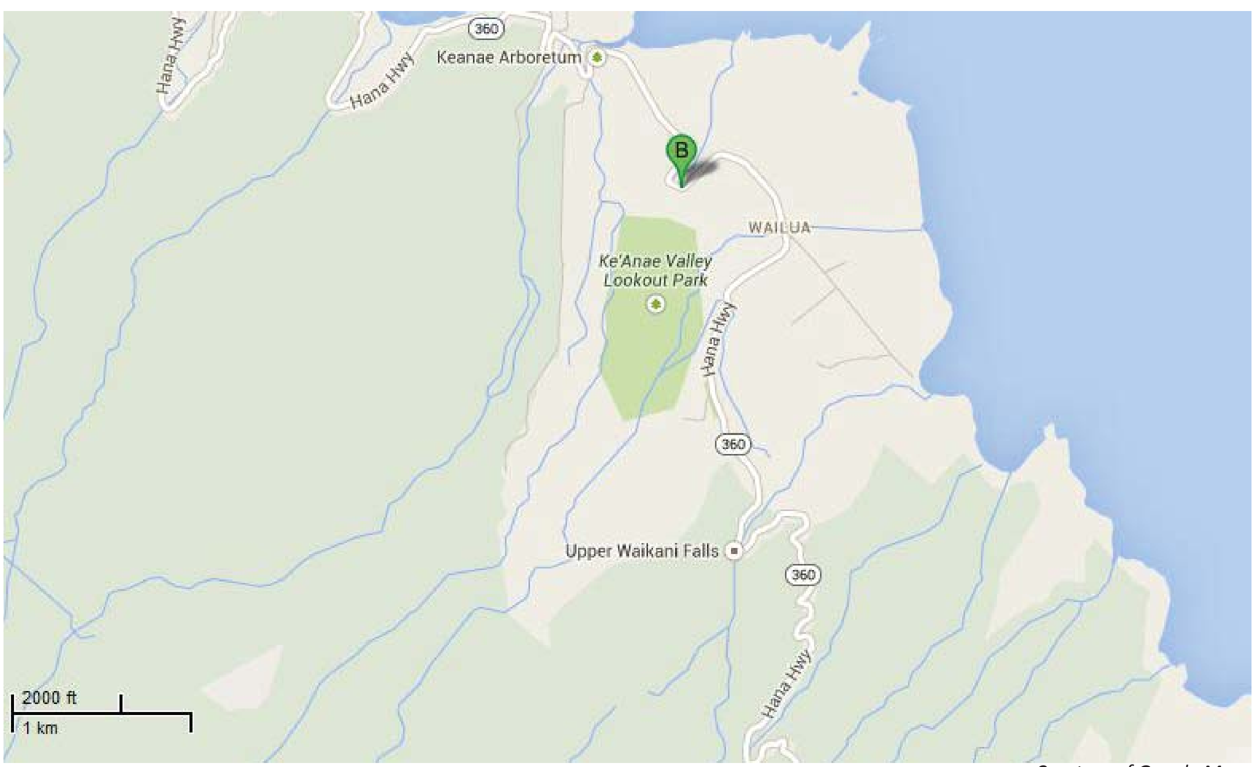
Culvert #3 20C

20C

CULVERT #3

Culvert Number				**Island**	Maui		
Date of Construction	circa 1937-1940			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 51m 04s
Longitude	156d 08m 31s
Mile Point	17.48

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 25.00 feet
Number of Spans	1
Clear Span	16 feet (upstream) & 20.50 feet (downstream)
Clear Height	4 feet (upstream) & 8 feet (downstream) (approx)
Deck Width	Curb-to-Curb = 22.16 feet
Abutment Material	• CRM (upstream) & Concrete (downstream) Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Solid Parapets
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 24 inches • Downstream Railing Height = 30 inches
Parapet Profile	• No Cap • Flat Parapet
Parapet Inscription	None

Culvert Features

Culvert #3 is located at mile point 17.48 and has a clear opening of approximately 16 feet wide by 4 feet high at the upstream end, and 20.50 feet wide by 8 feet high at the downstream end. The culvert is 25.00 feet long. According to the HAER report, the original date of construction is unknown, but the culvert was widened on the downstream side circa 1937-1940.[1] The top slab and walls are concrete with CRM and concrete abutment walls, and the bottom is an unlined channel.

Solid concrete parapet, downstream side
Courtesy of NOEI

Solid concrete parapet, upstream side
Courtesy of NOEI

Kahului approach to Culvert #3 toward Hana
Courtesy of NOEI

1 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005).

Significance & Context

Ahupuaa	Waianu
Designer / Builder	Unknown
Historic Drawings	None
Alterations	Circa 1937-1940
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Walker Site 94, the Heiau of Ohia, was once located approximately 115 meters southeast of historic Culvert #4. The *heiau* was documented by Walker as, “Stones removed to build pig pen, and outlines thus lost. Probably an agricultural *heiau* built by a chief named Kaimuki.”
Geographical Features / Setting	• Heavy vegetation • Taro farm located on downstream side
Character Defining Features	• Box Culvert • CRM (upstream) & Concrete (downstream) Abutment Walls • CRM Wingwalls • Concrete Solid Parapets
Detracting Features	• Excessive asphalt

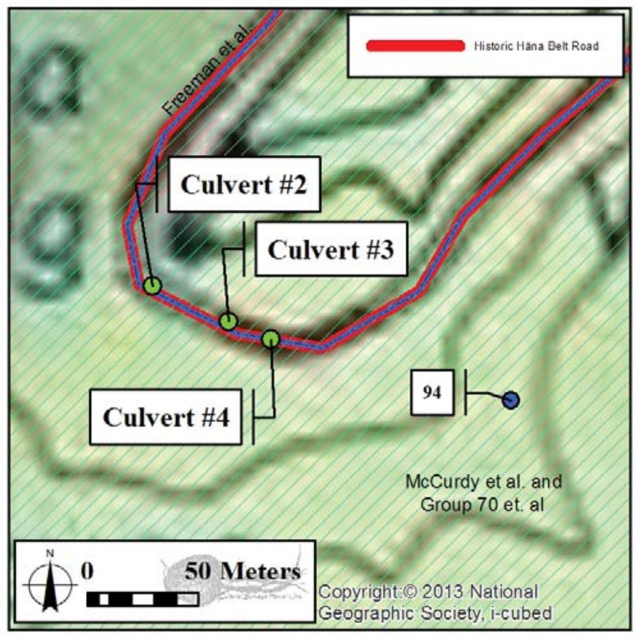
Significance & Context

Archaeological / Cultural Significance

Culvert #3 is located at the Ohia Stream crossing of Hana Highway, Route 360,[2] within Waianu Ahupuaa.[3] The Hawaiian word *ohia* is most commonly used to refer to a type of tree (*Metrosideros macropus*), but may also be used for a tomato, a native variety of sugar cane, a variety of taro, a red birthmark, and for the word "tabooed."[4]

The Keanae region is described as a unique wet-taro growing area developed by the early inhabitants for irrigated taro with a *loi* complex that covered the peninsula. The Native Hawaiian mythology states that the god Kane accompanied by Kanaloa, thrust his *kauila* staff into solid rock and water gushed forth. Additionally, Ashdown stated that the Lualailua fishponds were located at Keanae, and that they were considered sacred, or *wahi pana*.[5]

The initial occupation of this portion of Maui first occurred along the coastal region about A.D. 1200.[6] The accepted pre-contact settlement pattern for the region of Keanae/Wailuanui centers on the series of occupational episodes that utilized the Palauhulu Stream for *taro* (*Colocasia esculenta*) cultivation.



Refer to Section G, Appendix 1, Section 3.1.2.5 for the regional history of Keanae, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[7, 8, 9]

Adjacent Cultural Sites

Walker Site 94, the Heiau of Ohia, was once located approximately 135 meters southeast of historic Culvert #3. The *heiau* was documented by Walker as, "Stones removed to build pig pen, and outlines thus

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2 U.S. Geological Survey, ed., *Keanae Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 W. D. Alexander, "Map of the Koolau Coast Maui: From Wahinepee to Kekuapaawela," registered map no. 1065 (1879).

4 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

5 Inez MacPhee Ashdown, *Ke Alaloa O Maui – Authentic History and Legends of the Valley Isle* (Wailuku: Kamaʻaina Historians, Inc., 1971).

6 Alan E. Haun, David Henry, and Maria Orr, "Archaeological Inventory Survey, Waiʻānapanapa State Park, Lands of Honokalani, Wākiu and Kawaipapa, Hāna District, Island of Maui," Haun & Associates (Keaau: 2004).

7 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

8 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

9 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

lost. Probably an agricultural *heiau* built by a chief named Kaimuki."[10] Walker was not able to relocate the site, and Soehren was unable to identify the site during his 1963 survey as well.[11] Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway, and to the adjacent figure for approximate location of previous *heiau* relative to Culvert #3.

10 Winslow Walker, *Archaeology of Maui*, 1931, manuscripts on file, Bishop Museum Archives, Honolulu.

11 Lloyd J. Soehren, *An Archaeological Survey of Portions of East Maui, Hawai'i*, Bernice Pauahi Bishop Museum (Honolulu: 1963).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The invert of the culvert is approximately 9 feet below the roadway pavement. There is a 6-inch waterline that runs along the upstream end of the culvert.

The roadway above the culvert is striped for two lanes and includes, allowing vehicles to travel across the span of the culvert without yielding to oncoming traffic.

Culvert #3 receives storm water runoff from a 12-acre drainage area (approximate) and consists of mostly forest type of terrain. The downstream end of the culvert consists of an unnamed shallow stream that travels towards the ocean. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #3 is a two-lane reinforced concrete slab culvert. CRM walls are located at each corner of the approaches to the culvert. The upstream and downstream concrete parapets have a height of 24 inches and 30 inches, respectively. Neither parapet has been crash-tested for a TL-2.

The current curb-to-curb dimension is 22.16 feet, which for a two-lane culvert does not meet the design criteria minimum of 24 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #3 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #3 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per culvert component, as follows:

Deck

There are no record drawings for this culvert. It is recommended to widen the deck on the downstream side, scan the deck for reinforcing, and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the new railings and a 40-ton load carrying capacity. The widened deck slab shall be designed to cantilever off the existing slab and abutments. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the culvert, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

CRM Approach Walls

The existing CRM walls at the approaches to the culvert do not meet the TL-2 crash requirements and cannot act as the culvert's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream and downstream Kahului and upstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The culvert parapets currently do not meet TL-2 crash requirements. The upstream concrete parapet is recommended to be replaced with a reinforced concrete wall with a new natural rock façade. Since the approach walls are similar to the upstream parapet, it is recommended to construct the upstream parapet monolithic with the approach walls. Therefore, the upstream parapet will be replaced with a stone masonry guardwall (See Section G, Appendix 5 for more information). The downstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical concrete barrier rail (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the existing deck is recommended to determine whether it can support the design loads of the parapets (refer to "Deck" section). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions and have a straight exterior surface.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the CRM/concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The concrete portions of the culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert's lifespan. If it is determined necessary to rehabilitate the CRM and concrete abutments, and foundations they are recommended to be replaced in-kind.

If it is determined necessary to rehabilitate the CRM/concrete abutments, it is recommended that the concrete portions be replaced in-kind and CRM portions be replaced with a reinforced concrete structure with a new rock façade. The appearance of the reconstructed CRM façade portions shall closely match that of the original historic craftsmanship along Hana Highway.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

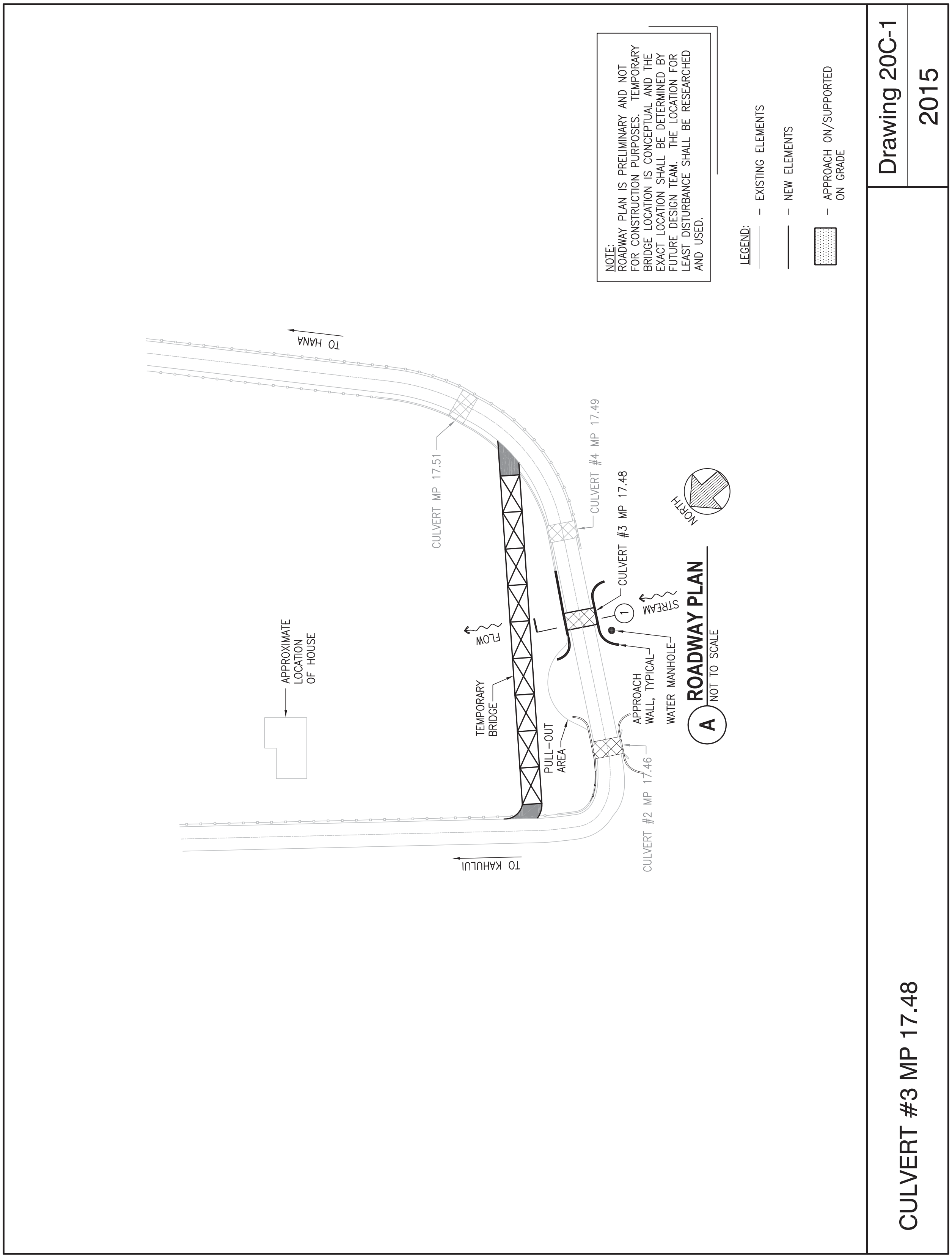
- Add Object Markers to approach walls

RECOMMENDATIONS

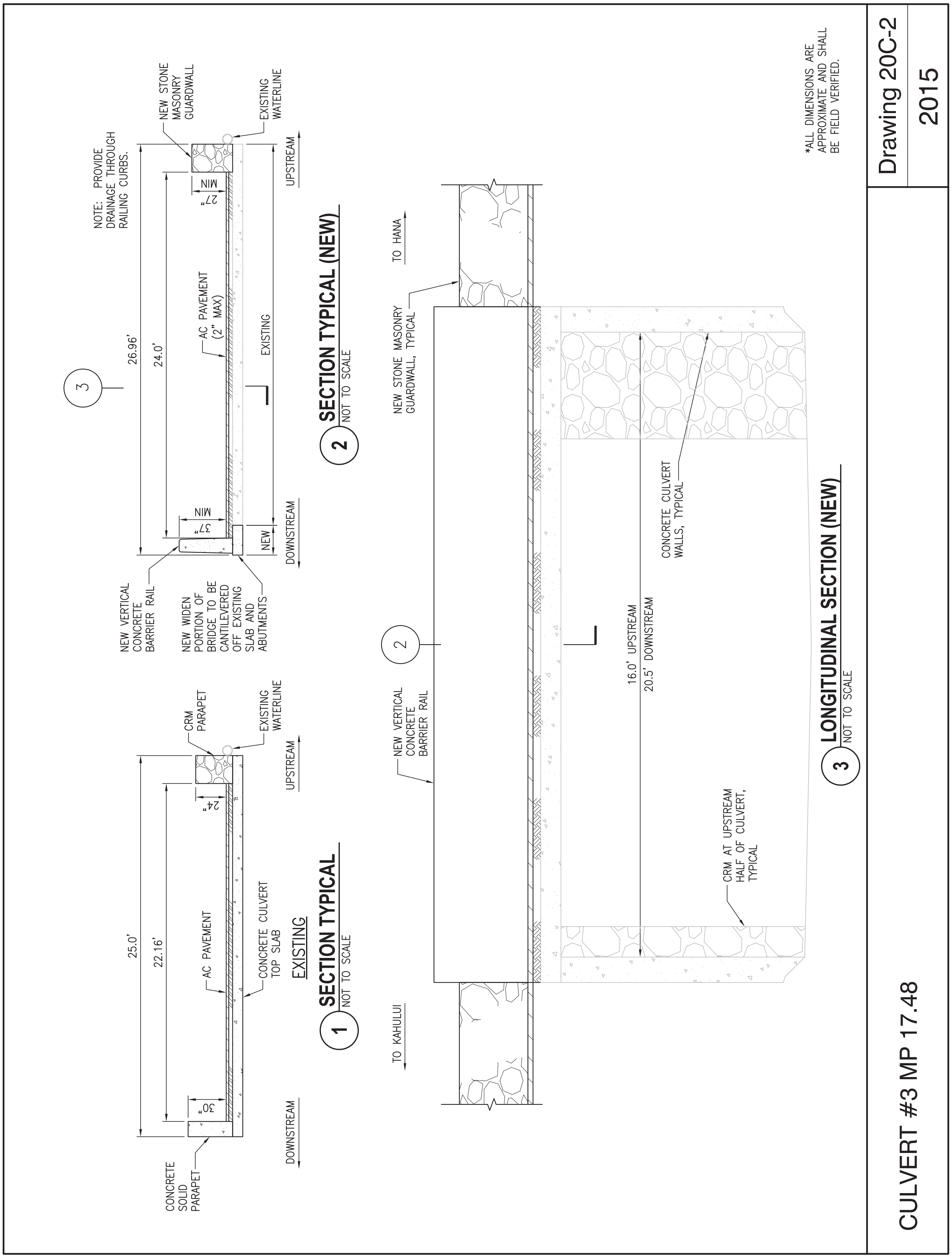
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #3 at this time.



Courtesy of NOEI



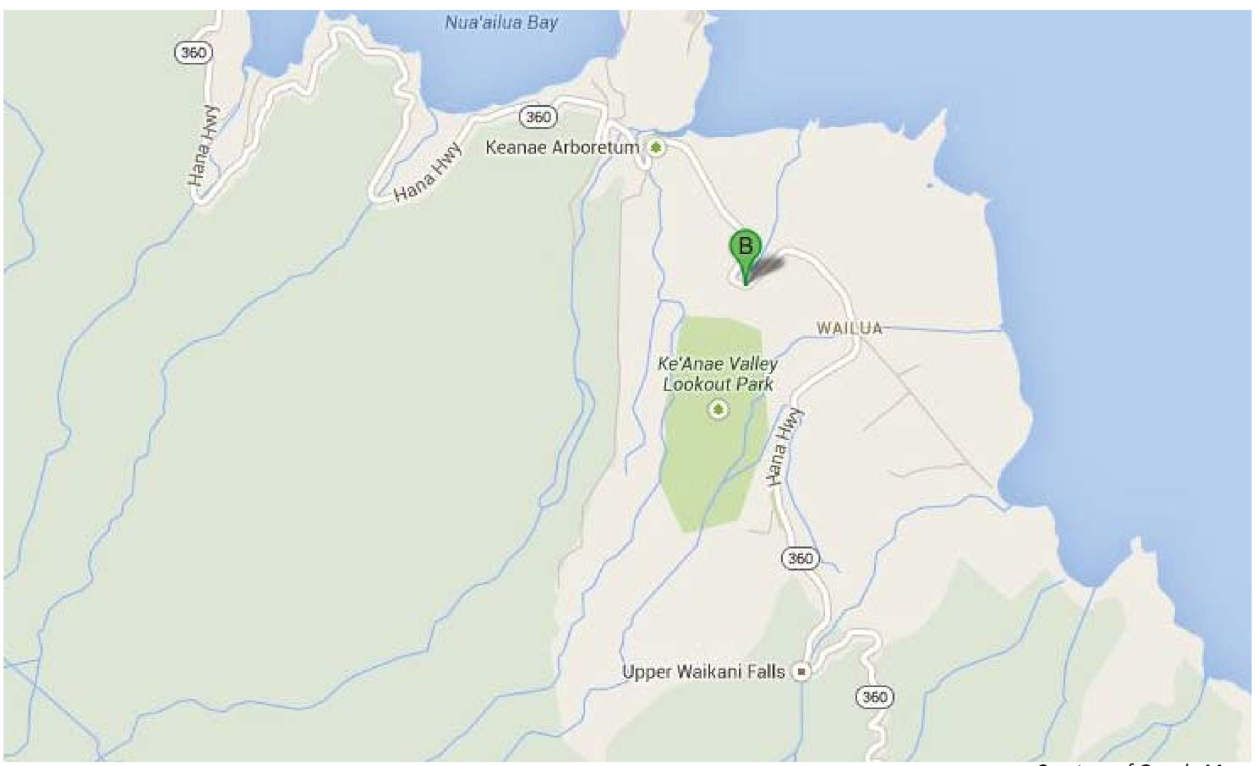
Courtesy of NOEI

Culvert #4 21C

21C

CULVERT #4

Culvert Number				**Island**	Maui		
Date of Construction	circa 1937-1940			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 51m 03s
Longitude	156d 08m 10s
Mile Point	17.49

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 22.50 feet
Number of Spans	1
Clear Span	12.67 feet (upstream) & 13.08 feet (downstream)
Clear Height	7 feet (upstream) & 10.5 feet (downstream) (approx)
Deck Width	Curb-to-Curb = 21.16 feet
Abutment Material	• CRM (upstream) & Concrete (downstream) Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Solid Parapets
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 24 inches • Downstream Railing Height = 28 inches
Parapet Profile	• No Cap • Flat Parapet
Parapet Inscription	None

Culvert Features

Culvert #4 is located at mile point 17.49 and has a clear opening of approximately 12.7 feet wide by 7 feet high at the upstream end and 13.1 feet wide by 10.5 feet high at the downstream end. The culvert is 22.50 feet long. According to the HAER report, the original date of construction is unknown, but the culvert was widened on the downstream side circa 1937-1940.[1] The top slab and walls are concrete and the bottom is an unlined channel.

Solid concrete parapet, downstream side
Courtesy of FAI

Solid concrete parapet, upstream side
Courtesy of FAI

CRM abutment, Kahului and Hana sides
Courtesy of FAI

Downstream approach wall, Kahului side
Courtesy of FAI

1 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005).

Significance & Context

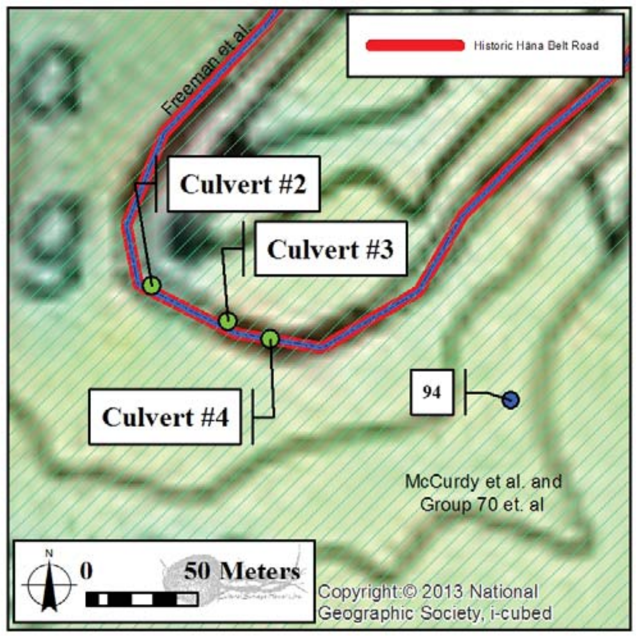
Ahupuaa	Waianu
Designer / Builder	Unknown
Historic Drawings	None
Alterations	Circa 1937-1940
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Walker Site 94, the Heiau of Ohia, was once located approximately 115 meters southeast of historic Culvert #4. The *heiau* was documented by Walker as, "Stones removed to build pig pen, and outlines thus lost. Probably an agricultural *heiau* built by a chief named Kaimuki."
Geographical Features / Setting	• Heavy vegetation, • Taro farm located on downstream side
Character Defining Features	• Box Culvert • CRM (upstream) & Concrete (downstream) Abutment Walls • CRM Wingwalls • Concrete Solid Parapets
Detracting Features	• Excessive asphalt • Non-historic cementitious materials on face of culvert walls and wingwalls

Significance & Context

Archaeological / Cultural Significance

Culvert #4 is located at the Ohia Stream crossing of Hana Highway, Route 360,[2] within Waianu Ahupuaa.[3] The Hawaiian word *ohia* is most commonly used to refer to a type of tree (*Metrosideros macropus*), but may also be used for a tomato, a native variety of sugar cane, a variety of taro, a red birthmark, and for the word "tabooed."[4]

The Keanae region is described as a unique wet-taro growing area developed by the early inhabitants for irrigated taro with a *loi* complex that covered the peninsula. The Native Hawaiian mythology states that the god Kane accompanied by Kanaloa, thrust his *kauila* staff into solid rock and water gushed forth. Additionally, Ashdown stated that the Lualailua fishponds were located at Keanae, and that they were considered sacred, or *wahi pana*.[5]



The initial occupation of this portion of Maui first occurred along the coastal region about A. D. 1200.[6] The accepted pre-contact settlement pattern for the region of Keanae/Wailuanui centers on the series of occupational episodes that utilized the Palauhulu Stream for taro (*Colocasia esculenta*) cultivation.

Refer to Section G, Appendix 1, Section 3.1.2.5 for the regional history of Keanae, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[7, 8, 9]

Adjacent Cultural Sites

Walker Site 94, the Heiau of Ohia, was once located approximately 115 meters southeast of historic Culvert #4. The *heiau* was documented by Walker as, "Stones removed to build pig pen, and outlines thus

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2 U.S. Geological Survey, ed., *Keanae Quadrangle, Hawaii, 7.5 Minute Series* (United States Department of the Interior, 1992).

3 W. D. Alexander, "Map of the Koolau Coast Maui: From Wahinepee to Kekuapaawela," registered map no. 1065 (1879).

4 Mary Kawena Pukui and Samuel H. Elbert, *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian*, rev. and enl. ed. (Honolulu: University of Hawaii Press, 1986).

5 Inez MacPhee Ashdown, *Ke Alaloa O Maui – Authentic History and Legends of the Valley Isle* (Wailuku: Kamaʻaina Historians, Inc., 1971).

6 Alan E. Haun, David Henry, and Maria Orr, "Archaeological Inventory Survey, Waiʻānapanapa State Park, Lands of Honokalani, Wākiu and Kawaipapa, Hāna District, Island of Maui," Haun & Associates (Keaau: 2004).

7 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

8 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

9 Todd D. McCurdy, Tanya L. Lee-Greig, and Hallett H. Hammatt, "Literature Review and Field Inspection for the Proposed Hana Highway Improvements Huelo to Hāna, Phase II Project, Makaīwa to Koʻolau Ahupuaʻa, Hāna District, Maui Island TMK: [2] 1-1-001:999; [2] 1-1-002:999; [2] 1-1-007:999; [2] 1-1-008:999; [2] 1-1-009:999 and [2] 1-2-001:999 (pors)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2014).

lost. Probably an agricultural *heiau* built by a chief named Kaimuki."[10] Walker was not able to relocate the site, and Soehren was unable to identify the site during his 1963 survey as well.[11] Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway, and to the adjacent figure for approximate location of previous *heiau* relative to Culvert #4.

10 Winslow Walker, *Archaeology of Maui,* 1931, manuscripts on file, Bishop Museum Archives, Honolulu.

11 Lloyd J. Soehren, *An Archaeological Survey of Portions of East Maui, Hawai'i*, Bernice Pauahi Bishop Museum (Honolulu: 1963).

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The invert of the culvert is approximately 12 feet below the roadway pavement. There is a 6-inch waterline that runs along the upstream end of the culvert.

The roadway above the culvert is striped for two lanes, allowing vehicles to travel along the span of the culvert without yielding to oncoming traffic.

Culvert #4 receives storm water runoff from a 19.7-acre (approximate) drainage area and consists of mostly forest type of terrain. The downstream end of the culvert consists of an unnamed shallow stream that travels towards the ocean. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #4 is a two-lane reinforced concrete slab culvert. CRM walls are located at three corners of the approaches to the culvert. There is no approach wall at the upstream Kahului approach. The upstream and downstream concrete parapets have a height of 24 inches and 28 inches, respectively. Neither parapet has been crash-tested for a TL-2.

The current curb-to-curb dimension is 21.16 feet, which for a two-lane culvert does not meet the design criteria minimum of 24 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #4 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic bridges is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #4 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per culvert component, as follows:

Deck

There are no record drawings for this culvert. It is recommended to widen the deck on the downstream side, scan the deck for reinforcing, and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the new railings and a 40-ton load carrying capacity. The widened deck slab shall be designed to cantilever off the existing slab and abutments. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the culvert, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information). As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

CRM Approach Walls

The existing CRM walls at the approaches to the culvert do not meet the TL-2 crash requirements and cannot act as the culvert's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Kahului approach corner has adequate room to curve the approach wall away from the roadway so as to eliminate the potential of a blunt end collision occurring. The upstream and downstream Hana approach corners do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall. Culvert #3 is in close proximity to this culvert; therefore, it is recommended to have the stone masonry guardwall be continuous between the downstream parapets.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

Of the three historic culverts along this stretch of Hana Highway, Culvert #4 is the only culvert with a reinforced concrete upstream and downstream parapet. The concrete parapets do not meet TL-2 crash requirements. To keep with the historic character of the adjacent culverts, it is recommended to replace the upstream parapet with a similar recommended design as Culverts #2 and #3. Therefore, the upstream parapet will be replaced with a stone masonry guardwall, which will be constructed monolithic with the approach walls (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The downstream parapet will be replaced with a similarly designed reinforced concrete parapet, such as the vertical concrete barrier rail (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the existing deck is recommended to determine whether it can support the design loads of the parapets (refer to "Deck" section above). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable. Also, new concrete railing heights, as measured from the deck, shall not be less than existing railings. As a design consideration, future design team shall consult with FHWA, HDOT, and SHPD whether the FHWA approved concrete crash-tested railing design height can be changed to match existing conditions and have a straight exterior surface.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the CRM and concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The concrete portions of the culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert's lifespan.

If it is determined necessary to rehabilitate the CRM/concrete abutments, it is recommended that the concrete portions be replaced in-kind and CRM portions be replaced with a reinforced concrete structure with a new rock façade. The appearance of the reconstructed CRM façade portions shall closely match that of the original historic craftsmanship along Hana Highway.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

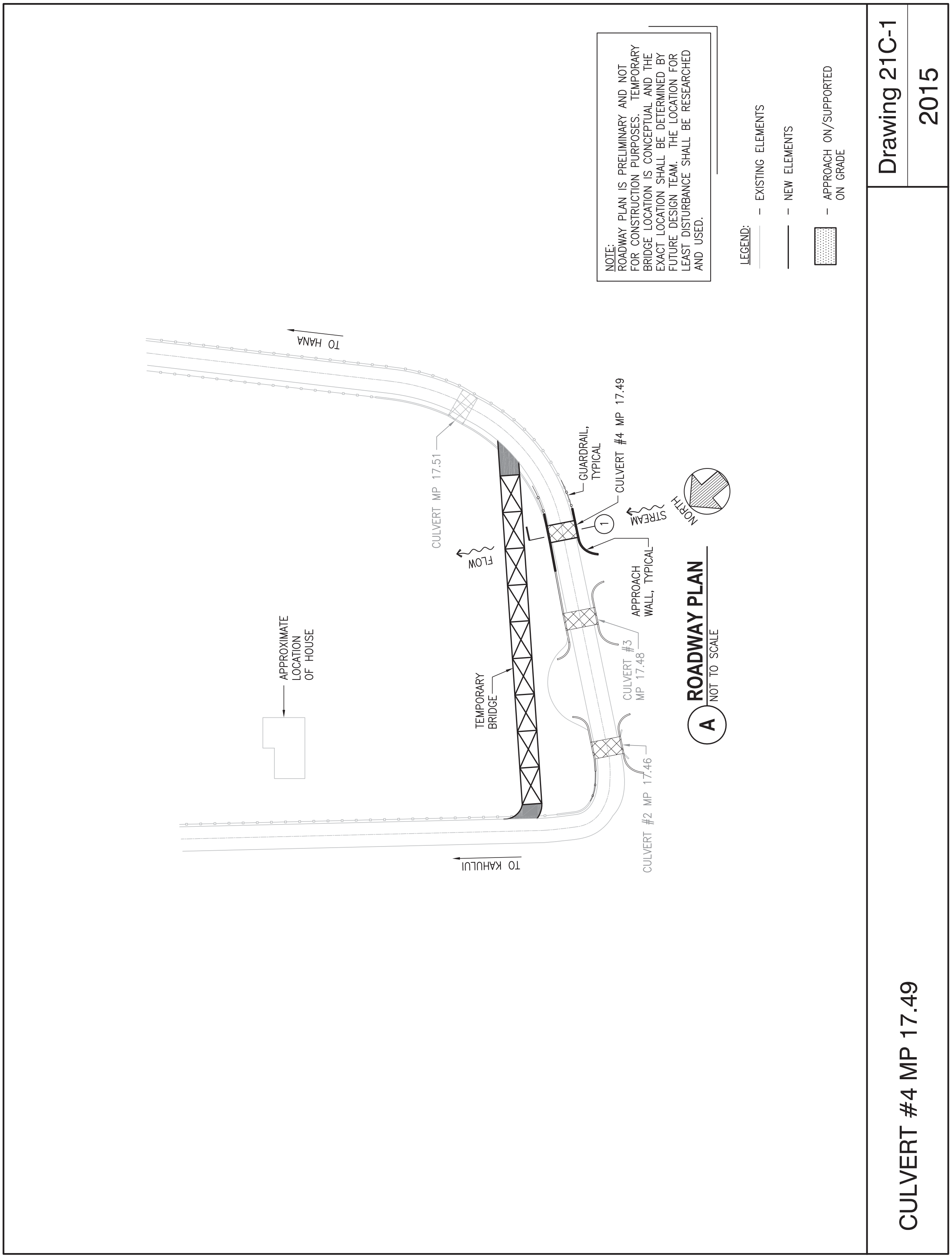
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

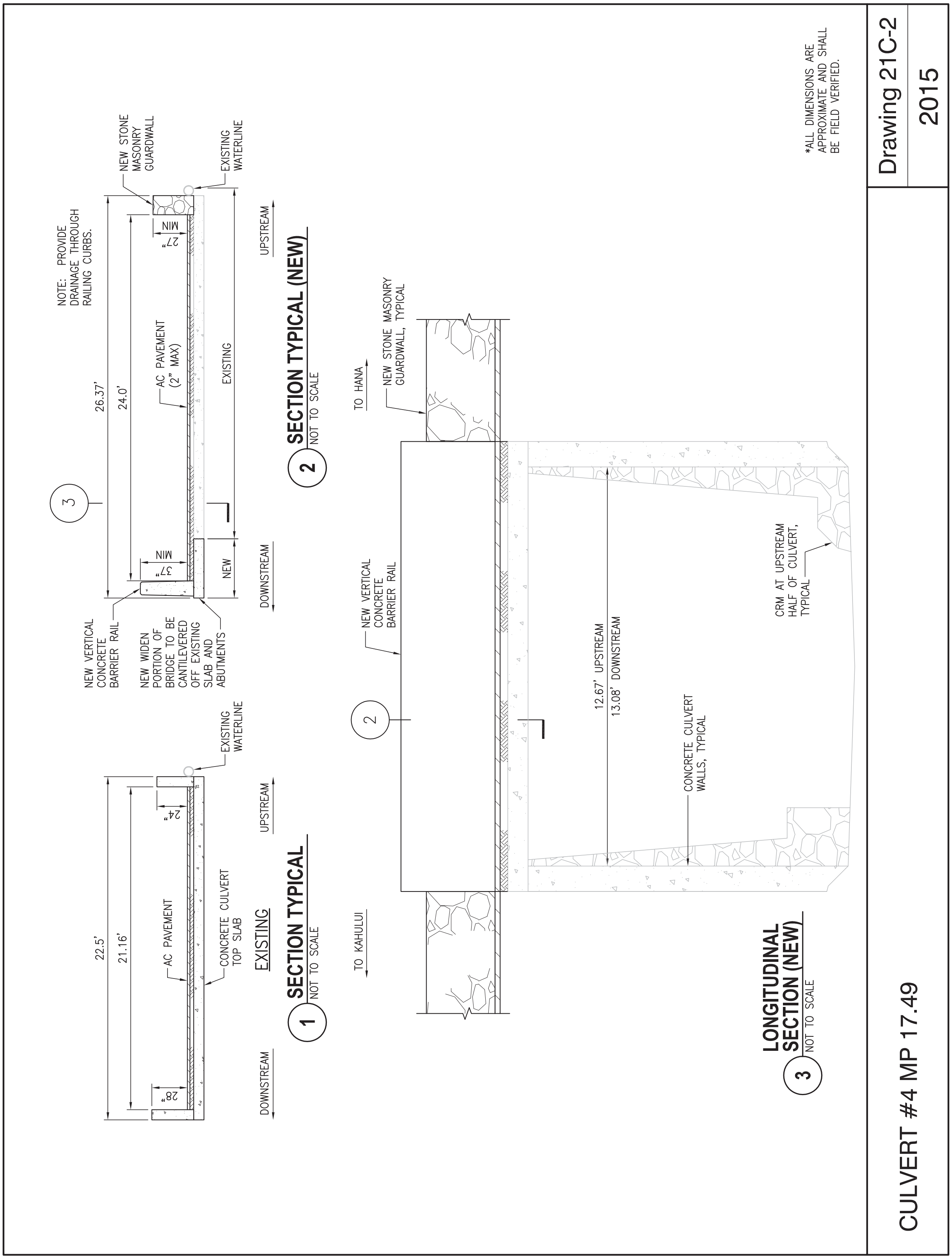
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #4 at this time.



Courtesy of NOEI



Courtesy of NOEI

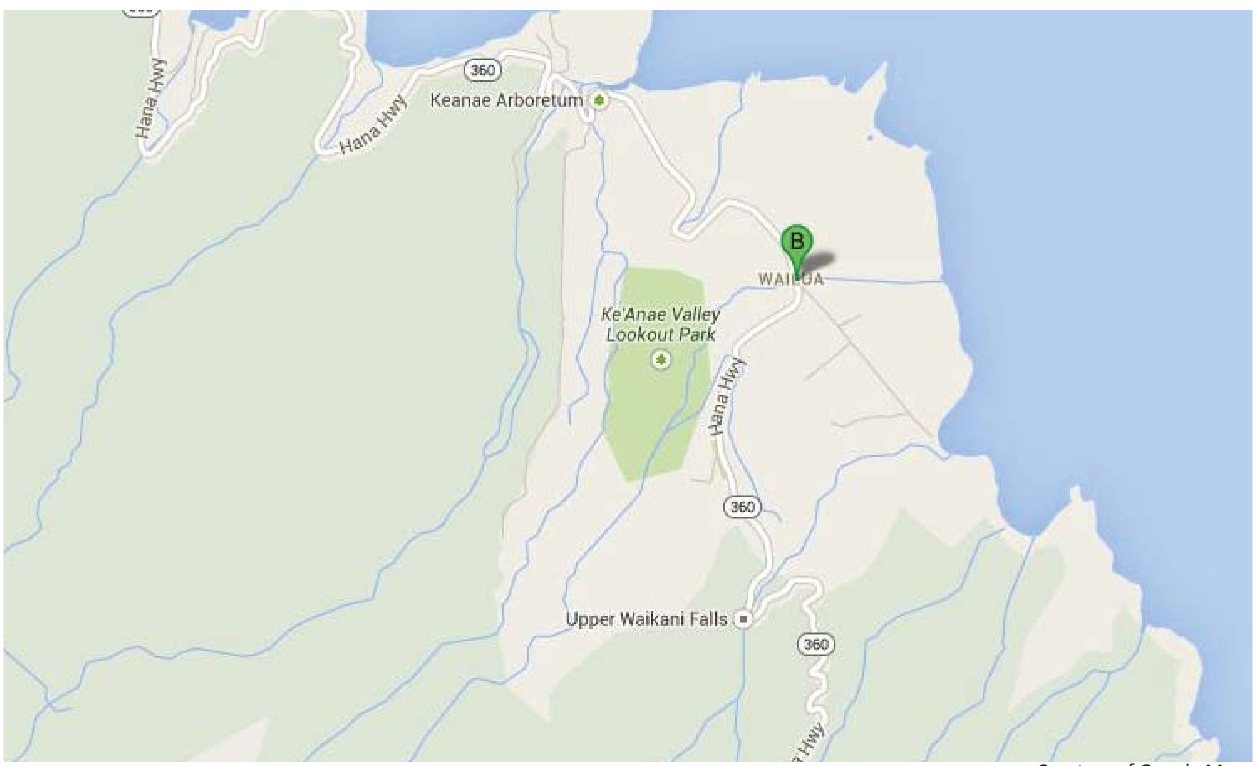
25C

Waiokamilo Culvert

25C

WAIOKAMILO CULVERT

Culvert Number				**Island**		Maui	
Date of Construction	1921			**Route**		Hana Highway	
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 50m 55s
Longitude	156d 0m 10s
Mile Point	18.08

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 44.5 feet (approx)
Number of Spans	1
Clear Span	13.67 feet
Clear Height	6 feet (approx)
Deck Width	Curb-to-Curb = 42.50 feet
Abutment Material	• Concrete Walls
Wingwall Material	• Concrete Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Open Greek Cross
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 33.5 inches with 52” headwall (includes girder height) • Downstream Railing Height = 33.5 inches 52” headwall (includes girder height)
Baluster Dimensions	• Posts = 6 inches x 6 inches • Decorative Panels = 1 foot 7 inches (h) x 1 foot (w) • Posts and Panels spaced approx. 1 foot 6 inches on-center • End posts = 1 foot 9 inches x 1 foot 9 inches
Parapet Cap Profile	• Stepped Cap • Railing cap = 6 inches x 12 inches

CULVERT INFORMATION

Culvert Features

Waiokamilo Culvert is located at mile point 18.08 and has a clear opening of approximately 13.7 feet wide by 6 feet high. The culvert is 44.5 feet long. The top slab and walls are concrete and the bottom is an unlined channel.

Setting of Waiokamilo Culvert
Courtesy of NOEI

Greek cross parapet, upstream side
Courtesy of NOEI

Greek cross parapet, downstream side
Courtesy of NOEI

Concrete abutment
Courtesy of NOEi

Significance & Context

Ahupuaa	Pauwalu and Wailuanui
Designer / Builder	County Engineer's Department - D. K. Kapohakimohewa, Designer Plans approved by Joseph Matson, Jr., County Engineer (1937 alteration plan)
Historic Drawings	November 1937
Alterations	Widened and installed new parapets in 1937
Replacement	None
Preservation Priority	Exceptional Culvert: Distinctive Parapets/Railings
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005) • One of two structures with open Greek cross parapets on Hana Highway, State Route 360
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Walker Site 88, the former Kamokukupeu Heiau, was documented as having been located approximately 78 meters southwest of Waiokamilo Culvert, but was recorded as destroyed by Walker.
Geographical Features / Setting	• Rural residential • Adjacent to snack shops • Open clearing with dense vegetation around stream • Adjacent to "Y" intersection with Lower Wailua Road
Character Defining Features	• Box Culvert • Concrete Culvert Walls • Concrete Wingwall • Concrete Open Greek Cross Railings (built as a set with Waiokamilo Stream Bridge) • Stepped railing cap
Detracting Features	• Attached guardrail on Kahului upstream side

Significance & Context

Archaeological / Cultural Significance

The place name Waiokamilo is defined as, "Kamilo's water. Stream. Koolau. Maui."[1] The Waiokamilo Culvert is located near the village of Wailua and is adjacent to Waiokamilo Stream Bridge, which spans the Waiokamilo Stream dividing Pauwalu Ahupuaa and Wailuanui Ahupuaa.[2, 3]

According to a State of Hawaii DLNR report for the Waiokamilo Stream, the stream enters the ocean in the region of the Village of Wailua.[4] The Waiokamilo Stream originates in a narrow watershed, with its stream water directed to taro patches (*loi*) in Wailua for over one hundred years.

A cultural landscape study recorded the intensive use of the Keanae and Wailuanui region for taro, identified three separate field systems, and noted the processes by which community cooperation led to the field system operation.[5] According to Maly, water from the Waiokamilo Stream enters the Lakini *auwai* system of taro *loi* that includes *loi* above the Hana Highway and some 339 *loi* west of Wailua Nui Stream.[6]

Evidence of a cohesive population is perhaps best described by the first Europeans to visit Keanae. From the journal of William Richards, a Protestant missionary, comes information that the region between Honomanu and Wailua was densely populated:

> *We went on board the canoe, and rowed a few miles, avoiding some difficult paries [steep cliffs]. After landing, we walked a few miles further, to Wailua, where we put up for the Sabbath. Very early the morning [of the Sabbath], the horns, summoning the people to the house of God, were heard in every direction; and we soon perceived that the call had not been heard with indifference. At the early hour, the house was thronged with attentive worshipers. [The next day] we examined the schools, which were large. About 10 oclock, A.M., the princess [Nahienaena] arrived, and addressed the people; after which, we proceeded on our way [to Hana].*[7]

According to *Kalo Kunu O Ka ʻAina a Cultural Landscape Study of KeʻAnae and Wailuanui, Island of Maui* (1995), over 490 Land Commission Awards (LCA) claimed taro patches of various sizes at Keanae and Wailuanui during the time

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1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 Hawaii Heritage Center, "Historic Culvert Inventory and Evaluation, Islands of Maui and Molokai" (Honolulu: 1990).

3 Joseph Iao, "Portion of Hamakualoa & Koolau Maui," registered map no. 2482, Hawaii Territory Survey (1909).

4 State of Hawaii, Division of Aquatic Resources, *Report on Waiokamilo Stream, Maui, Hawaii*, prepared for the State of Hawaii, Commission on Water Resource Management, Department of Land and Natural Resources (2008).

5 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., "Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui," prepared for the County of Maui Planning Department (1995).

6 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

7 William Richards, Lorrin Andrews, and Jonathan Green, "A Tour of Maui," *The Missionary Herald, containing Proceedings of The American Board of Commissioners for Foreign Missions with a View of Other Benevolent Operations for the year 1829* (Boston: Crocker and Brewster for A.B.C.F.M., 1829).

of the Great Mahele [beginning in 1848].[8] Several LCAs included claims for pools and fishponds. In addition, evidence of densely-grouped regional *heiau* and smaller shrines was the subject of specialized studies dating from the turn of the 20th century to more recent work by Maria E. Orr. [9,10]

Background research into the land use patterns of the surrounding vicinity indicated that the area was intensively used for pre-contact agricultural pursuits, permanent and temporary habitation and traditional ceremony, as well as historic-era agriculture represented by taro *loi*, sweet potato, rice, and other staple crop cultivation. Early settlement patterns for the area seem to have focused primarily on valley and gulch lands, from river mouths to *mauka* lands. In the river gulches, it is expected that the soils are rich and fertile and conducive to agriculture. In addition, the constant supply of fresh water would have supported fairly intense agricultural pursuits. Within these valleys intensive agriculture would have likely been taking place in association with habitation activities. Toward the river mouths, the widening gulches would have provided ample areas for small communities and access to marine resources, as well as additional *loi*.

Based on available archaeological evidence and interpretations, it is possible that historically significant subsurface cultural deposits representing both traditional and historic agriculture, as well as midden and other cultural material concentrations representing both traditional and historic habitation may occur within the area.

Refer to Section G, Appendix 1, Section 3.3.2 for the Settlement Pattern of the Koolau District in the Keanae and Wailuanui vicinity, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[11], [12], [13]

Adjacent Cultural Sites

Walker Site 88, the former Kamokukupeu Heiau, was documented as having been located approximately 78 meters southwest of Waiokamilo Culvert, but was recorded as destroyed by Walker.[14] Refer to Section G, Appendix 1, Table 1: Heiau sites identified by Walker (1931) along the historic portion of Hana Highway, and to figure below for approximate location in relation to Waiokamilo Culvert.

Haun and Henry conducted an archaeological inventory survey of approximately 4 acres at Pauwalu in Wailuanui Ahupuaa.[15] The inventory survey resulted in the identification of one historic property, SIHP -5237, consisting of an overhang (Feature A) and trail (Feature B) located approximately 120 meters southwest of Waiokamilo Culvert (refer

8 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., “Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui,” prepared for the County of Maui Planning Department (1995).

9 Maria E. Orr, “A Preliminary Report on the Heiau of Hana and Their Significance, Past and Present,” Department of Anthropology, University of Hawaii (Honolulu: 1990).

10 Thomas G. Thrum, “Heiaus and Heiau Sites Throughout the Hawaiian Islands; Omitting Koas, or Places of Offering to Kuula, the Deity of Fisher Folk,” The Hawaiian Annual (1908), 38-42.

11 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

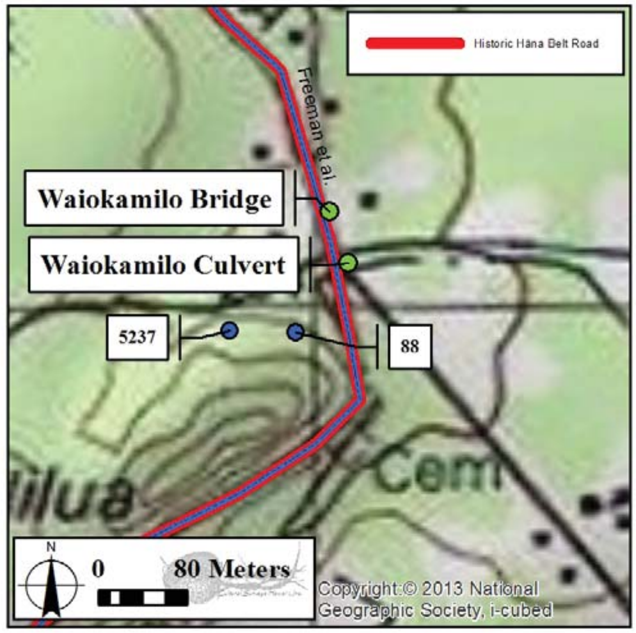
12 Group 70 International, Inc., Davianna McGregor, Ph.D., and Cultural Surveys Hawaii, Inc., “Kalo Kanu o ka ʻAina, A Cultural Landscape Study of Keʻanae and Wailuanui, Koʻolau District, Island of Maui,” prepared for the County of Maui Planning Department (1995).

13 Alan E. Haun and Jack D. Henry, “Archaeological Inventory Survey TMK: 1-1-008:015, 023, Land of Pauwalu, Hana District, Island of Maui,” inventory survey, Haun & Associates (Keaau: 2003).

14 Winslow Walker, *Archaeology of Maui*, 1931, manuscripts on file, Bishop Museum Archives, Honolulu.

15 Ibid.

to figure at right). The overhang was interpreted as a pre-contact temporary habitation shelter that was occupied between A. D. 1420-1650 and the trail as a transportation route. Refer to Section G, Appendix 1, Table 2: Previous archaeological studies conducted along Hana Highway, Route 360.



Civil & Traffic

Number of Lanes	Two-Lanes, adjacent part of the Y-intersection
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	None
Civil Utilities	Waterline upstream
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the Waiokamilo Culvert is striped for two-lane travel, allowing vehicles freely cross the culvert without yielding to oncoming traffic.

This culvert was observed to have constant, but relatively low constant flow traveling through the culvert. It receives such flow from the nearby Waiokamilo Stream and the absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Waiokamilo Culvert is a two-lane plus a part of the Y-intersection reinforced concrete slab culvert. The culvert is located near a Y-intersection and supports two lanes of traffic and part of the Y-intersection. A metal guardrail with an end treatment is located at the downstream Kahului approach. A metal guardrail with no end treatment is located at the upstream Kahului approach. No approach walls are located at the Hana approach. The upstream and downstream concrete parapets with decorative Greek cross panels have a height of 36 inches and 34 inches, respectively. The upstream and downstream parapets are not crash-tested for a TL-2.

The current curb-to-curb dimension is 42.50 feet, which for a two-lane culvert is adequate for this project’s design criteria of 24 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Waiokamilo Culvert be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Waiokamilo Culvert is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form). In addition, undocumented burial mounds have been reported to Maui SHPD assistant archaeologist Jenny Pickett by Dr. Melissa Kirkendall. Precise location information is unavailable at this time; however, the mounds are reported to be located along the upstream side of Hana Highway between TMK (2) 1-1-08:002 and 004, approximately 200-500 meters south to southwest of the culvert. These mounds were recommended for further investigation and recording during the Environmental Assessment phase for Waiokamilo Bridge and/or Culvert. Due to the sensitive nature of these site types, it is also recommended that confidentiality of the site location should be respected.

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

The name of this culvert shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. Hawaiian Place Names Research for further research and discussion.

Recommendations have been identified per culvert component, as follows:

Deck

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

It is recommended to investigate the current material composition of the concrete deck to determine whether the deck is capable of supporting the new railings and a 40-ton load carrying capacity. This culvert should be scanned for reinforcing and have concrete core samples extracted. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

CRM Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other culverts along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The upstream Hana approach corner has adequate room to curve the approach wall away from the roadway as to eliminate the potential of a blunt end collision occurring. The remaining three approaches do not have adequate room for this; therefore, it is recommended to install guardrails and an end treatment at these corners after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between culvert railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete culvert parapets do not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are available, additional investigation of the deck is recommended (refer to "Deck" section). Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert's lifespan.

Following investigation of concrete abutments and foundations, if it is determined necessary that this component is to be replaced, the abutments and foundations are recommended to be replaced in-kind with a reinforced concrete structure.

Load Rating

Load rating is recommended to be completed on this culvert (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

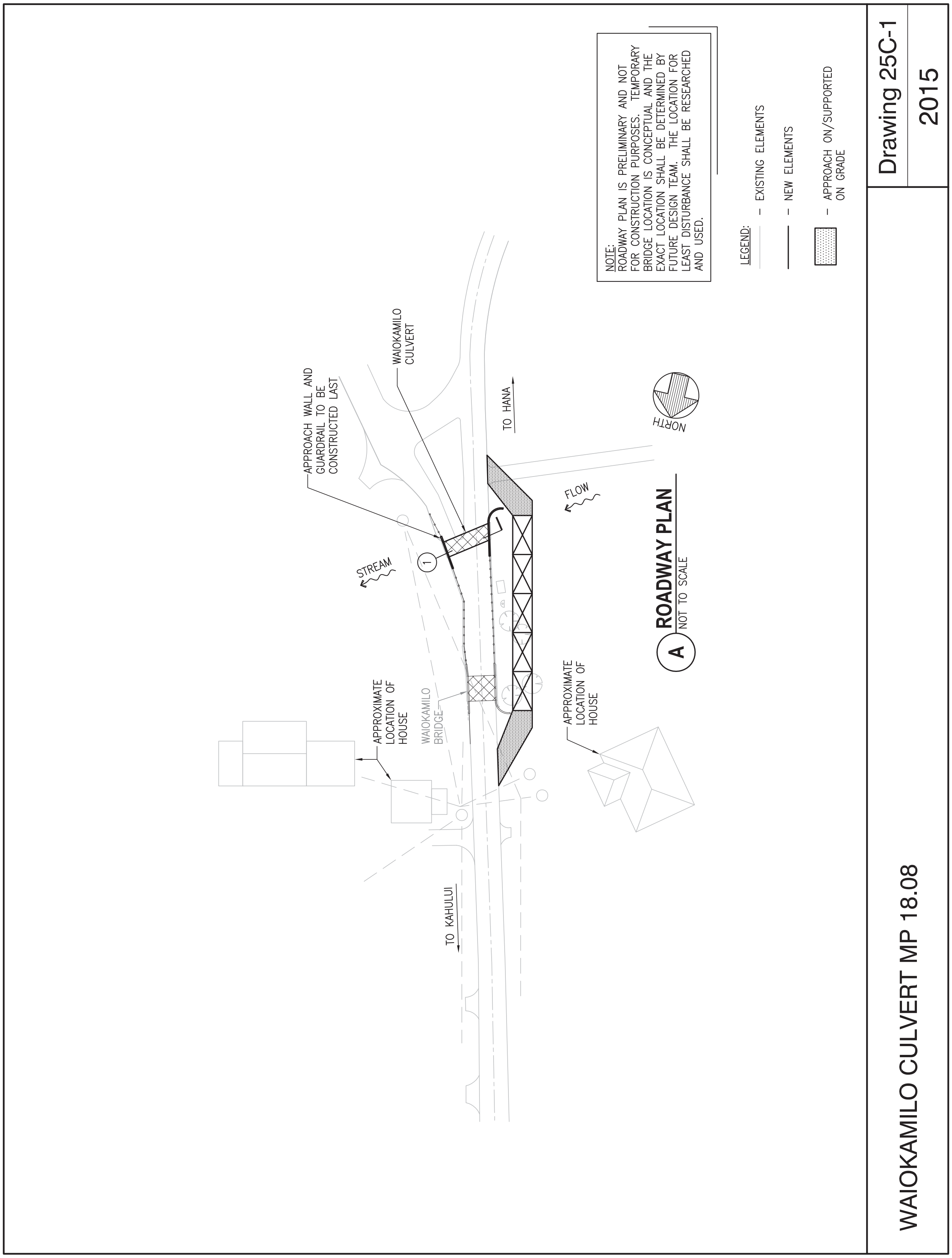
- Add Object Markers to approach walls

RECOMMENDATIONS

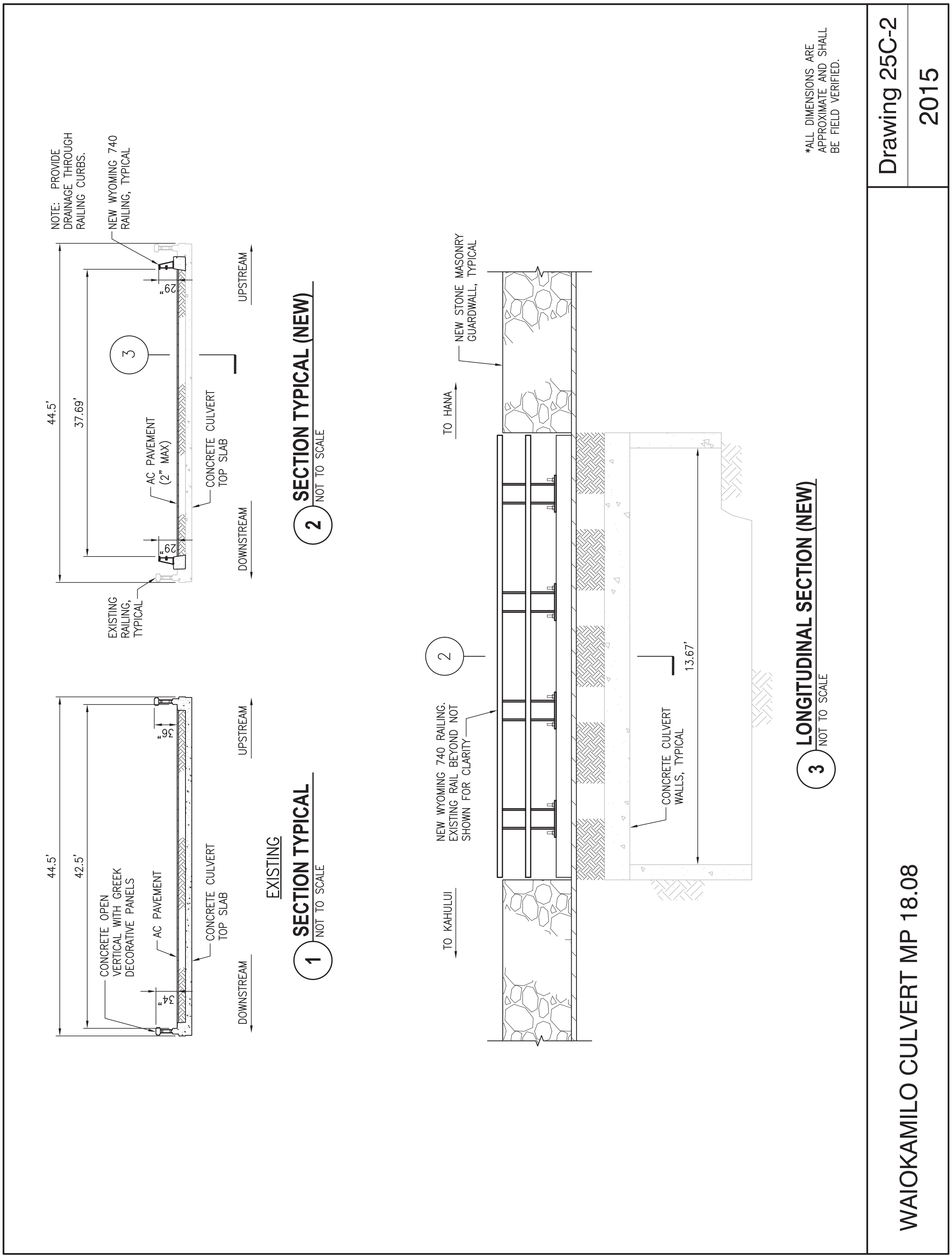
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Waiokamilo Culvert at this time.



Courtesy of NOEI



Courtesy of NOEI

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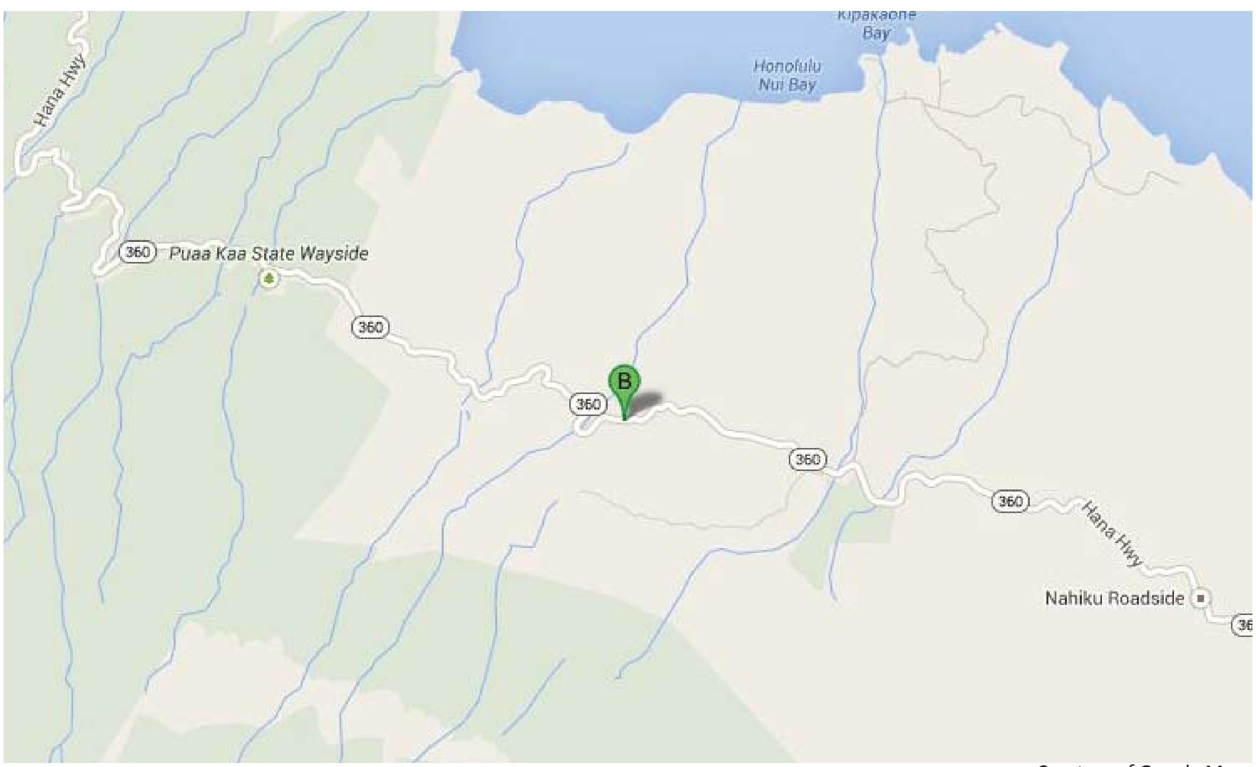
42C

East Hanawi Culvert

EAST HANAWI CULVERT

Culvert Number				**Island**	Maui		
Date of Construction	Unknown			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

CULVERT INFORMATION

Location

Latitude	20d 48m 36s
Longitude	156d 06m 26s
Mile Point	24.20

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 16.50 feet (approx)
Number of Spans	1
Clear Span	12 feet
Clear Height	7.5 feet (approx)
Deck Width	Curb-to-Curb = 15.10 feet
Abutment Material	• Concrete Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Solid Panel Parapets
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 23.5 inches • Downstream Railing Height = 26 inches
Parapet Profile	• Saddle Coping Cap • Parapet with Exterior Paneled Face
Parapet Inscription	None

Culvert Features

East Hanawi Culvert is located at mile point 24.20 and has a clear opening of approximately 12 feet wide by 7.5 feet high. The culvert is 16.5 feet long. The top slab and walls are concrete and the bottom is an unlined channel.

Culvert elevation, upstream side
Courtesy of NOEI

Solid concrete parapet with saddle coping, upstream side
Courtesy of NOEI

Solid concrete parapet with saddle coping, downstream side
Courtesy of NOEI

Upstream CRM approach wall, Kahului side
Courtesy of FAI

Significance & Context

Ahupuaa	Hopenui
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Culvert spans a small stream • Open, partly shaded area with a view to the ocean • Mossy growth on culvert components
Character Defining Features	• Box Culvert • Concrete Abutment Walls • CRM Wingwalls • Reinforced Concrete Walls and Top Slab • Concrete Solid Paneled Parapets
Detracting Features	• Excessive asphalt overlay • Existing non-historic cementitious materials on the face of wingwalls

Significance & Context

Archaeological / Cultural Significance

The place name *Hanawi* is defined as, "seeking freshwater shellfish. Stream, Koolau. Maui."[1] The East Hanawi Culvert is adjacent to the East Hanawi Bridge, which spans the East Branch of the Hanawi Stream in Hopenui Ahupuaa.[2]

The Koolau Ditch, an irrigation canal over 40 miles long, runs along the windward side of Haleakala from above Nahiku to the sugar fields of Paia and Puunene. In the Nahiku region, the Koolau Ditch was described in 1915 as crossing through areas rich in field watercress, white ginger, water lemons, and mountain apples. The lands surrounding the village of Nahiku, located directly east of the mouth of the Hanawi Stream, were planted in rubber trees in the early decades of the 1900s.[3]

The Hanawi Stream in Nahiku contained a large fresh water source called Big Spring, which was the subject of a 12-year study conducted by W.O. Clark, the geologist for the Hawaiian Sugar Planters Association, between 1930 and 1942. Geologic studies were carried out at Hanawi Canyon by G.A. MacDonald between 1939 and 1940, during which he succeeded in mapping a number of perched springs and high water tables. The structure of the artesian spring which supplied the large water source was not discovered at that time, but subsequent work by the East Maui Irrigation Company located an artesian source at Hanawi for fresh water 395 feet above sea level.[4]

Refer to Section G, Appendix 1, Section 3.1.2.8 for the regional history of Nahiku, and to Section G, Appendix 1, Figure 10 for nearby archaeological study areas.[5]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of East Hanawi Culvert.

1 Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Honolulu: The Board of Commissioners of Public Archives of the Territory of Hawaii, 1922).

2 U.S. Geological Survey, ed., *Keanae Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

3 Alexander Hume Ford, "Around About Nahiku," *The Mid-Pacific Magazine*, 1915.

4 Territory of Hawaii, *Geology and Ground-Water Resources of the Island of Maui, Hawaii* (Including Haleakala Section, Hawaii National Park), Harold T. Stearns and Gordon A. MacDonald, Bulletin 7 of Division of Hydrography, prepared in cooperation with the Geological Survey, United States Department of the Interior (Honolulu: Advertiser Pub. Co. 1942).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Ko'olau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawai'i, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	N/A
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass on downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic.

This culvert receives its runoff from a 26-acre (approximate) drainage area and has a terrain that consists of mostly forest type. In addition, the culvert may also receive some runoff from the nearby Hanawi stream in areas where the stream either branches off or over tops. After traveling through the culvert, the runoff eventually makes its way back into the Hanawi Stream. The absolute outlet of the stream is unidentifiable from the highway travel way due to its overgrown nature.

Structural

East Hanawi Culvert is a one-lane reinforced concrete slab culvert. CRM walls are located at each corner of the approaches to the culvert. The upstream and downstream concrete parapets have a height of 23.5 and 26 inches, respectively. The upstream and downstream parapets are not crash-tested for a TL-2.

The current curb-to-curb dimension is 15.10 feet, which for a one-lane culvert does not meet the design criteria minimum of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of East Hanawi Culvert be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If East Hanawi Culvert is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

The name of this culvert shall be verified through a process to be determined during future development of a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. Hawaiian Place Names Research for further research and discussion.

Recommendations have been identified per culvert component, as follows:

Deck

The East Hanawi Culvert currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane culvert; therefore, it is recommended to widen the downstream side of the culvert. Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum. Thickness of the fill on the culvert, between the deck and the asphaltic concrete overlay, shall be limited as shown on the following drawings so as to not affect the height of the new crash-tested railings (refer to "Railings/Parapets" section for more information).

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

CRM Approach Walls

This culvert has a CRM approach wall of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance. Approach walls of similar quality are shown in the following bridges and may be used for reference: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The existing CRM walls at the approaches to the culvert do not meet the TL-2 crash requirements and cannot act as the culvert's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a reconstructed rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The approach walls shall also contain a concrete bridge name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

Exemplary CRM approach wall, East Hanawi Culvert
Courtesy of FAI

To achieve the reconstructed rock façade appearance, the existing CRM façades of the CRM approach walls are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM approach walls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended so as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM approach walls are to be placed in front of the new reinforced concrete approach walls, functioning as their new façade. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship. The surface of the rock façade shall not exceed 0.5 inches in variation.

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

The upstream and downstream Hana approach corners have adequate room to curve the approach walls away from the roadway so as to eliminate the potential of a blunt end collision occurring. Bridge #27 East Hanawi Stream Bridge is in close proximity to this culvert; therefore, it is recommended to have the stone masonry guardwall be continuous between the upstream and downstream Kahului parapets.

Railings / Parapets

The concrete culvert parapets do not meet TL-2 crash requirements. It is recommended to preserve, relocate, and connect the existing downstream parapet to the new widened portion of the deck. A crash-tested railing will be constructed in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the deck is recommended (refer to ”Deck” section). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with a reconstructed CRM rock façade. To achieve this, the existing facades of the CRM wingwalls is to have their rock configurations documented and recorded. Once documentation has been completed, the CRM wingwalls is to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended so as to assist with the later reconstruction of the façades. The original rocks removed from the historic CRM wingwalls are to be placed in front of the new reinforced concrete wingwalls functioning as their new façade. The appearance of the reconstructed facades shall closely match the shape, proportions, and style as that of the original historic craftsmanship.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert’s lifespan.

Following investigation of concrete abutments and foundations, if it is determined necessary that this component is to be replaced, the abutments and foundations are recommended to replace with a reinforced concrete structure. Until future rehabilitation work is determined, retention of the existing appearance of CRM wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

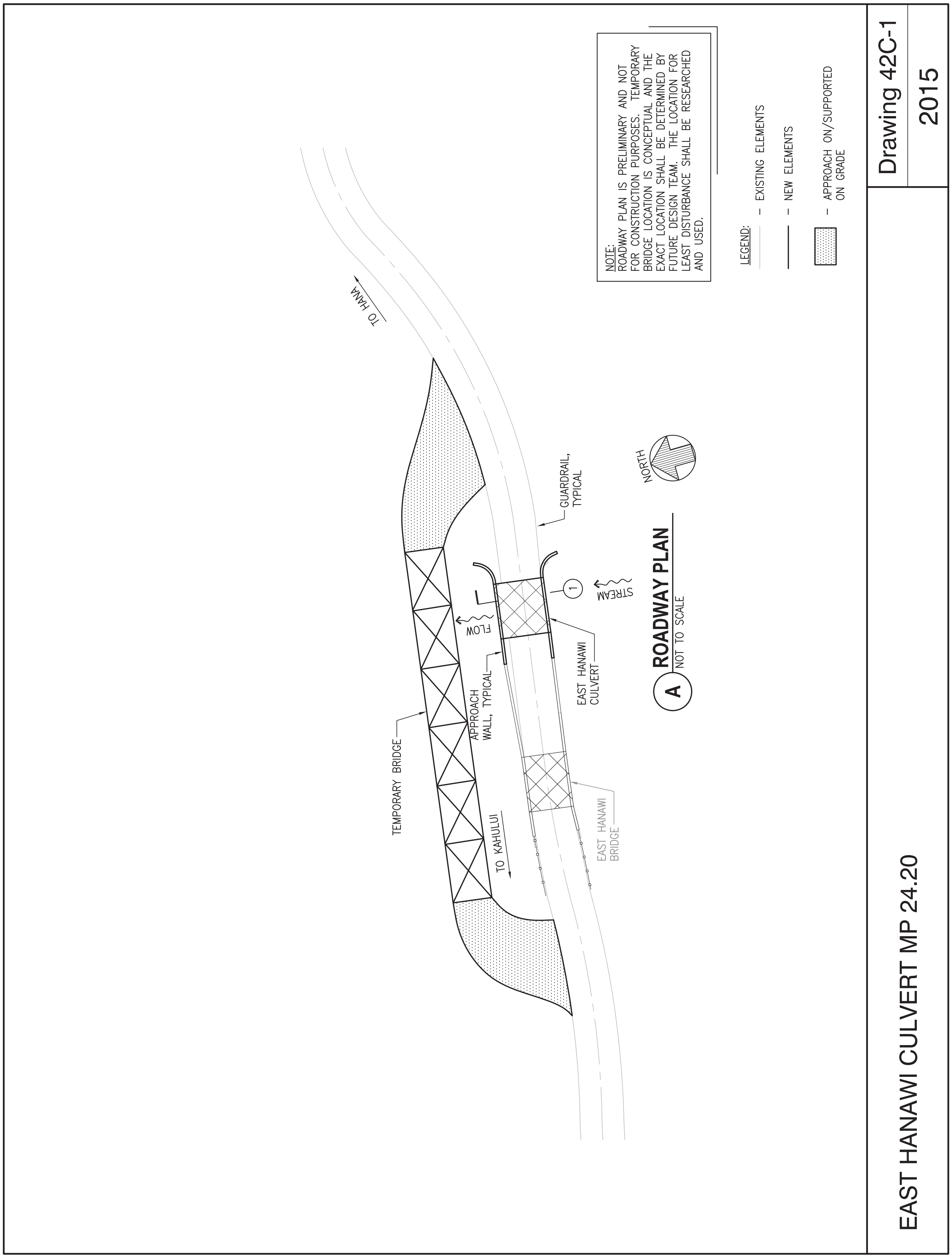
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

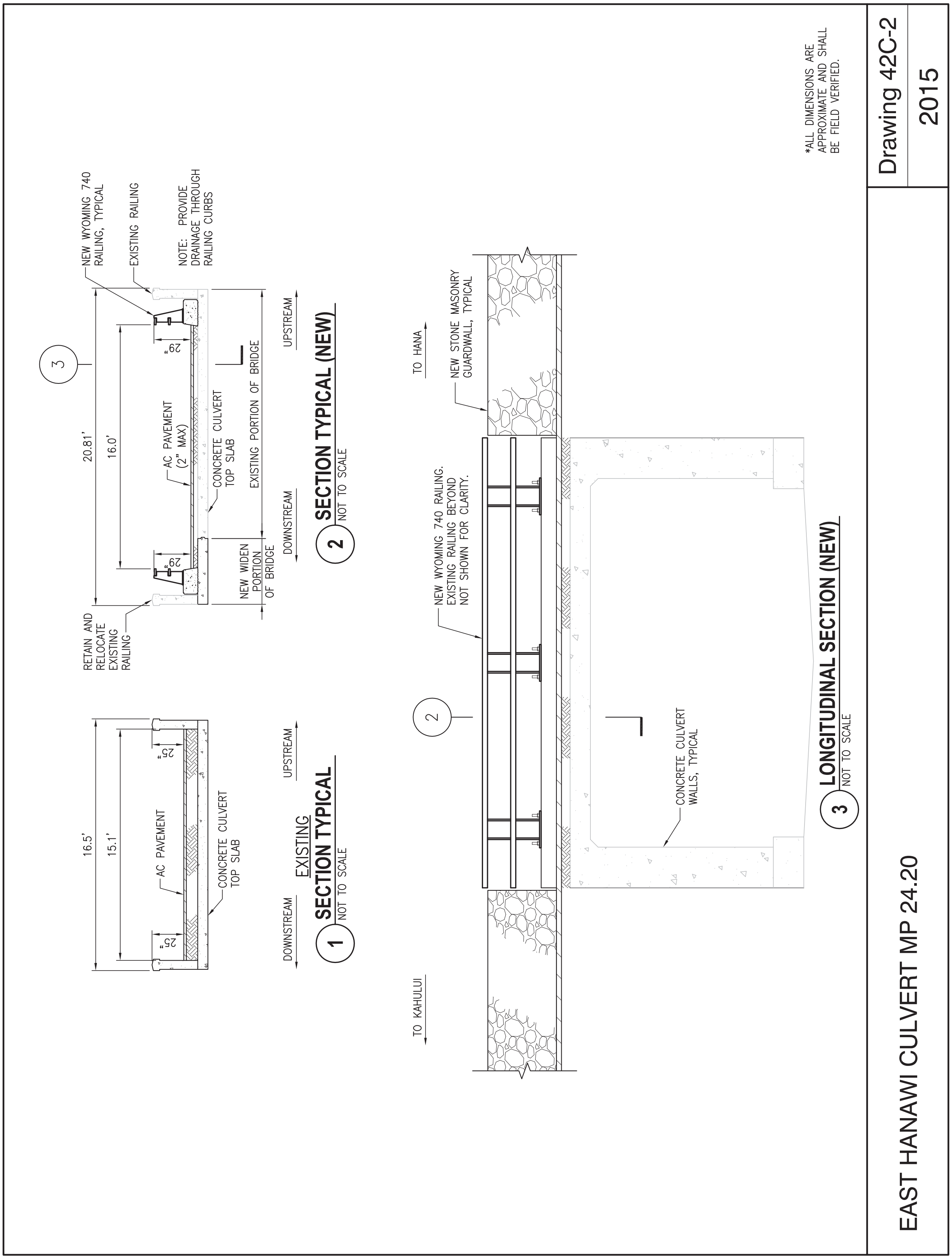
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for East Hanawi Culvert at this time.



Courtesy of NOEI



Courtesy of NOEI

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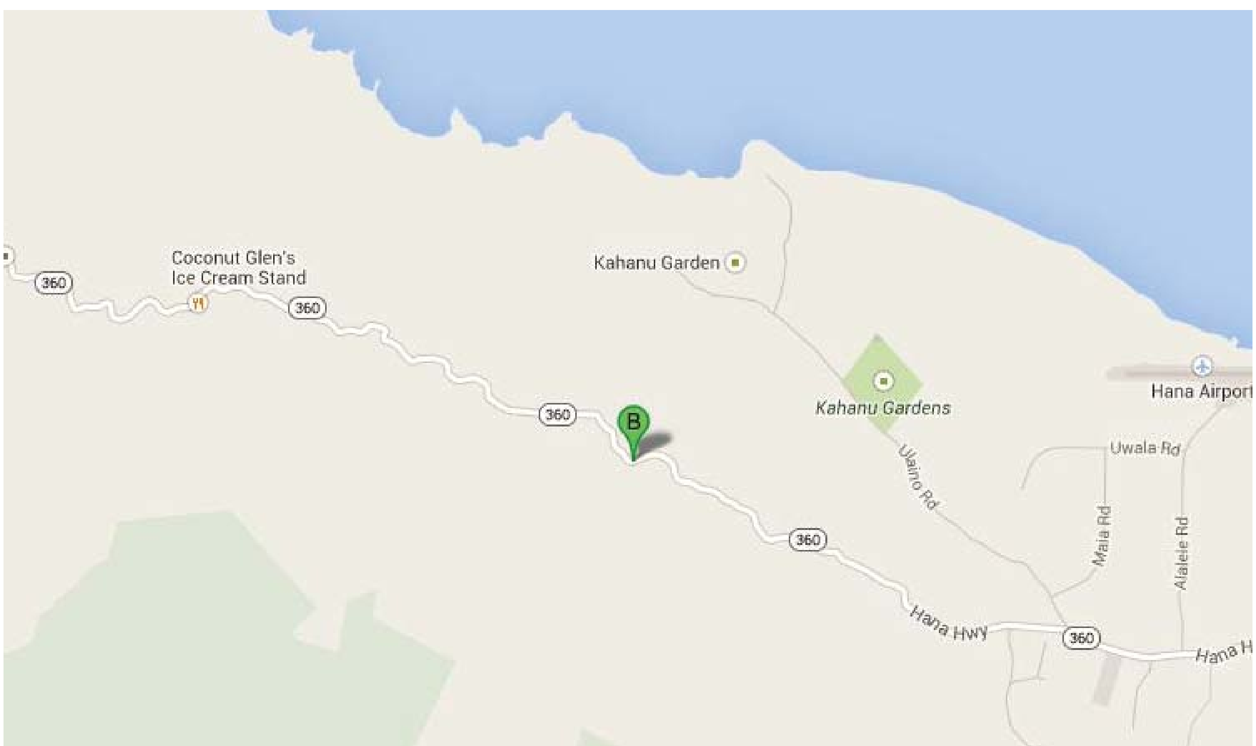
Culvert #5 52C

CULVERT #5

Culvert Number				**Island**	Maui		
Date of Construction	Unknown			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

CULVERT INFORMATION

Location

Latitude	20d 47m 16s
Longitude	156d 02m 17s
Mile Point	29.78

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 16.25 feet (approx)
Number of Spans	1
Clear Span	14.5 feet
Clear Height	10.5 feet (approx)
Deck Width	Curb-to-Curb = 14.83 feet
Abutment Material	• CRM Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 25 inches • Downstream Railing Height = 27 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet Cap Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Culvert Features

Culvert #5 is located at mile point 29.78 and has a clear opening of approximately 14.5 feet wide by 10.5 feet high. The culvert is 16.25 feet long. The culvert is comprised of a concrete top slab that bears on CRM walls and the invert of the culvert is an unlined channel.

Concrete open vertical railing, upstream side
Courtesy of FAI

Concrete open vertical railing, downstream side
Courtesy of FAI

CRM abutment, Hana side
Courtesy of NOEI

CRM abutment, Kahului side
Courtesy of NOEI

Significance & Context

Ahupuaa	East Honomaele
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Located at open area • Mossy growth on culvert components
Character Defining Features	• Box Culvert • CRM Abutment Walls • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt • Existing non-historic cementitious materials on the face of wingwalls

Historic Significance & Context

Archaeological / Cultural Significance

Culvert #5 is located in East Honomaele Ahupuaa.[1] The place name *Honomaele* is defined as, "Land division, Hana qd., Maui. *Lit*., numb bay."[2]

According to Native Hawaiian traditions, around the year A. D. 1570, a high chief from the western side of Maui named Kiha-a-Piilani conquered the formerly independent chiefdoms of the Hana region, uniting the entire island into one *moku*, or polity. At the time of his conquest, Kiha-a-Piilani may have dedicated the massive *heiau* of Piilanihale, which looms above the wind-swept cliffs of Honomaele.[3]

In Native Hawaiian legends, the battles of Kapalipilo describe the assault by the combined forces of Maui, Molokai, and Lanai on the fort at Kauiki that were meant to dislodge the Hawaii forces.[4] According to Kamakau, the field of battle started with the massing of the Maui armies from Heleleikeoha to Nahiku. Wananalua soon became the battlefield. At a signal from the islet of Mokuhano, the fortified walls of Kauiki were attacked. Soon, the battlefield shifted to the districts of Akiala and Keawaikau. The fighting soon came down to a challenge between Kaohele, a chief from Molokai, and Kamakaukii, a famous fighter from Hawaii. After a time, Kaohele gained the advantage, and Kamakaukii attempted to escape the battlefield, but the Molokai chief chased the Hawaii fighter through the *ahupuaa* of Honomaele to Kawaipapa. Kaohele overtook Kamakaukii at Waialanahu near Pihehe and thrust him through the scrotum with a spear. Despite the victory by Kaohele, the fort did not surrender, Kamehamehanui retired, leaving Hana in the hands of the warriors of Hawaii.[5]

Refer to Section G, Appendix 1, Section 3.1.3.1 for the background history of Honomaele; Section 3.1.3.3.1.6, and Section 3.1.3.3.1.10 for the battle at Kauiki; and to Section G, Appendix 1, Figure 14 for nearby archaeological study areas.[6]

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of Culvert #5.

1 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii,* 7.5 Minute Series (United States Department of the Interior, 1992).

2 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

3 Patrick V. Kirch, *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory* (Honolulu: University of Hawaii Press, 1985).

4 Abraham Fornander, *An Account of the Polynesian Race, Its Origin and Migrations, Vol. II* (London: Trubner & Co. Ludgate Hill, 1880).

5 S. M. Kamakau, *Ruling Chiefs of Hawaii,* rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

6 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	N/A
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass on downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic.

This culvert receives its runoff from a 110-acre (approximate) drainage area and has a terrain that consists of mostly forest type. The upstream and downstream ends of the culvert are highly vegetated and overgrown. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural & Electrical

Culvert #5 is a one-lane reinforced concrete slab culvert. Concrete end walls with metal guardrail transitions are located at each corner of the approaches. The upstream and downstream concrete parapets have a height of 25 inches and 27 inches, respectively. The upstream and downstream parapets are not crash-tested for a TL-2.

The current curb-to-curb dimension is approximately 14.8 feet, which for a one-lane culvert does not meet the design criteria minimum of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #5 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #5 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological intensive survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future Contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per culvert component, as follows:

Deck

Culvert #5 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane culvert; therefore, it is recommended to widen the upstream side of the culvert. Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing railings and lowers the height below code minimum.

Existing guardrails
Courtesy of NOEI

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

Culvert Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other culverts along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The surface of the rock façade shall not exceed 0.5 inches in variation. The approaches do not have adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision; therefore, it is recommended to install guardrails and an end treatment at each corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the culvert railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between culvert railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. Approach Walls and Safety Features at the Approaches).

Railings / Parapets

The concrete culvert railings do not meet TL-2 crash requirements. It is recommended to preserve, relocate, and connect the existing upstream railings to the new widened portion of the deck. A crash-tested railing will be constructed in front of the existing railings. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the deck is recommended (refer to "Deck" section). Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM abutments and wingwalls are recommended to be replaced with a reinforced concrete structure with a reconstructed CRM rock façade. To achieve this, the existing facades of the CRM abutments and wingwalls are to have their rock configurations documented and recorded. Once documentation has been completed, the CRM abutments and wingwalls are to be carefully disassembled. Thorough documentation of the disassembling rock process is highly recommended so as to assist with the later reconstruction of the façades. Reinforced concrete abutments and wingwalls are to be designed and constructed to support the new 40-ton load carrying capacity and comply with current seismic codes (refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information). The original rocks removed from the historic CRM abutments and wingwalls are to be placed in front of the new reinforced concrete abutments and wingwalls, functioning as their new façade. The appearance of the reconstructed facades shall closely match that of the original historic craftsmanship.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. If it is determined necessary to rehabilitate the concrete foundations, it is recommended to be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic & Signage

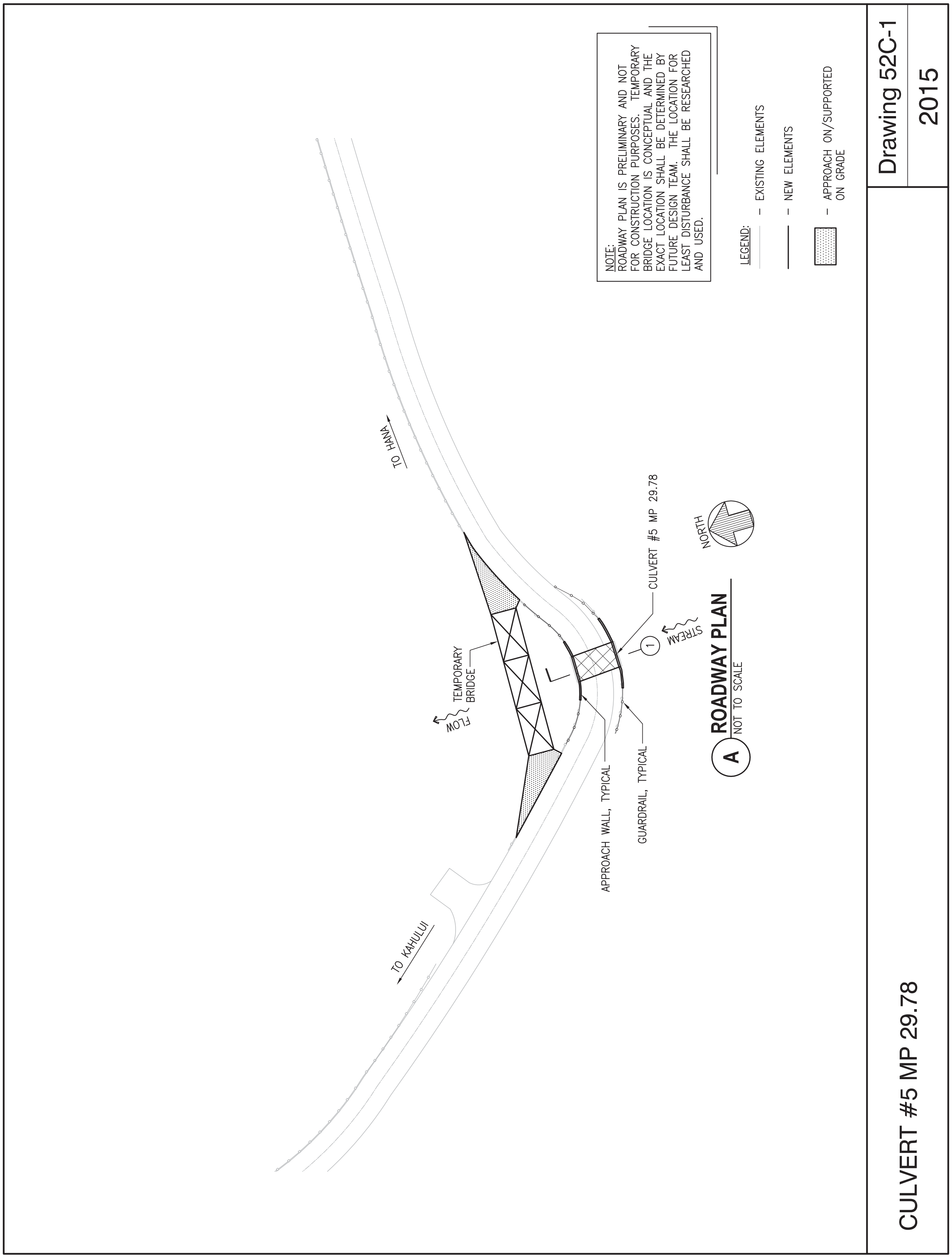
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

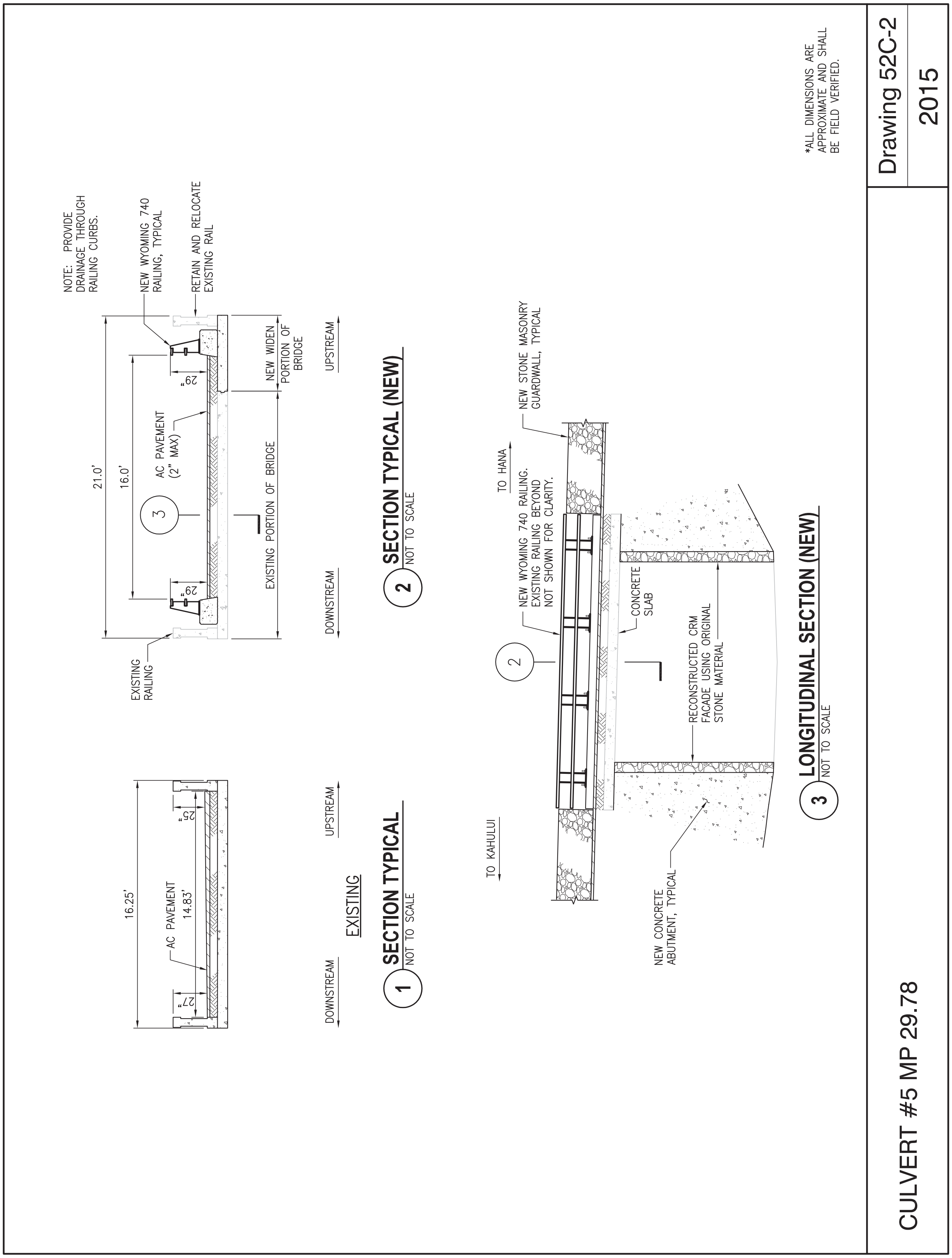
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #5 at this time.



Courtesy of NOEI

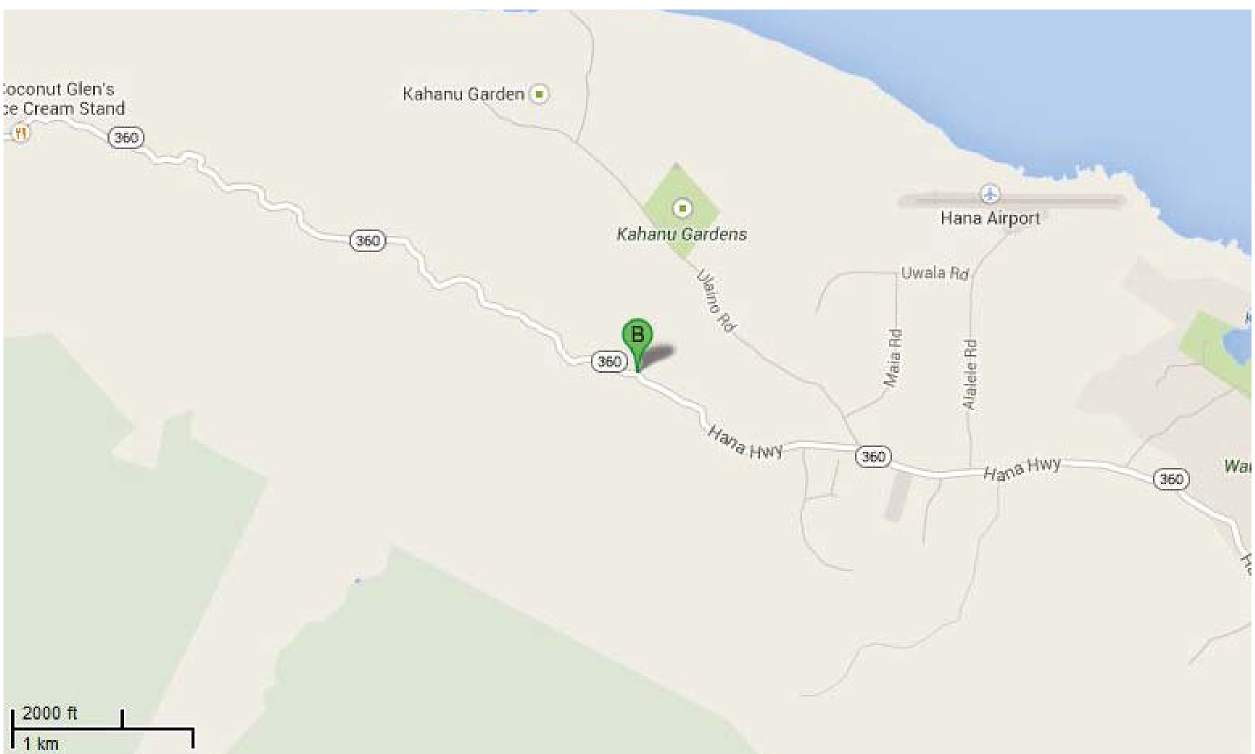


Courtesy of NOEI

Culvert #6 53C

CULVERT #6

Culvert Number					Island		Maui
Date of Construction	Unknown				Route		Hana Highway
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 47m 13s
Longitude	156d 02m 06s
Mile Point	30.02

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 16.50 feet
Number of Spans	1
Clear Span	11.58 feet
Clear Height	7 feet (approx)
Deck Width	Curb-to-Curb = 15.08 feet
Abutment Material	• CRM Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Open Vertical Railings
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 25 inches • Downstream Railing Height = 25 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet Cap Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Culvert Features

Culvert #6 is located at mile point 30.02 and has a clear opening of approximately 11.6 feet wide by 7 feet high. The culvert is 16.50 feet long. The culvert is comprised of a concrete top slab that bears on CRM walls and the invert of the culvert is an unlined channel.

Concrete open vertical railing, downstream side
Courtesy of NOEI

View of Culvert #6 substructure
Courtesy of NOEI

Kahului approach to Culvert #6 toward Hana
Courtesy of NOEI

Hana approach to Culvert #6 toward Kahului
Courtesy of NOEI

Significance & Context

Ahupuaa	Kawela
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Heavy vegetation
Character Defining Features	• Box Culvert • CRM Abutment Walls • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt

Significance & Context

Archaeological / Cultural Significance

Culvert #6 is located in Kawela Ahupuaa.[1, 2] The place name *Kawela* is defined as, "Land division, Hana qd., Maui… *Lit*., the heat."[3]

According to Native Hawaiian legend, in about 1760 the chief of Hawaii Island, Kalaniopuu, attacked the southern coast of Maui and captured the fort of Kauiki. This attack then made Hana and Kipuhulu a part of his domain. Kalaniopuu appointed Puna, a famous warrior and chief, to be in charge of protecting the fortress of Kauiki. It was soon decided by the chiefs of Maui, Molokai, and Lanai that the fortress should be in the hands of Kamehameha-nui, the ruler of Maui. This war was long, and involved widespread warfare primarily in the *ahupuaa* of Honomaele, Kawela, both Kuukuukamanu, both Kahalili, two Kaeleku, Honokalani, Wakiu and part of Kawaipapa.[4]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.10 for the battle at Kauiki; and to Section G, Appendix 1, Figure 14 for nearby archaeological study areas.

Adjacent Cultural Sites

No documented archaeological sites are currently located within 200 meters of Culvert #6.

1 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

2 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

3 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

4 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass upstream side
Electrical Utilities	An existing telephone pole is in conflict with the temporary bridge
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic.

This culvert receives its runoff from a 200-acre (approximate) drainage area and has a terrain that consists of mostly forest type. The upstream and downstream ends of the culvert are highly vegetated and overgrown. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #6 is a one-lane reinforced concrete slab culvert. Concrete end walls with metal guardrail transitions are located at each corner of the approaches. The upstream and downstream concrete railings have a height of 25 inches. The upstream and downstream railings are not crash-tested for a TL-2.

The current curb-to-curb dimension is 15.08 feet, which for a one-lane culvert does not meet the design criteria minimum of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #6 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #6 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. . The future Contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per bridge component, as follows:

Deck

Culvert #6 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane culvert; therefore, it is recommended to widen the upstream side of the culvert. Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

CRM Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other culverts along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The surface of the rock façade shall not exceed 0.5 inches in variation. The approaches do not have adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision; therefore, it is recommended to install guardrails and an end treatment at each corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the culvert railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between culvert railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

Railings / Parapets

The concrete culvert railings do not meet TL-2 crash requirements. It is recommended to preserve, relocate, and connect the existing upstream railings to the new widened portion of the deck. A crash-tested railing will be constructed in front of the existing railings. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the deck is recommended (refer to “Deck” section). Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM culvert walls and CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. If it is determined necessary to rehabilitate the concrete foundations, it is recommended to be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to “Deck” section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity.

Civil, Traffic, & Signage

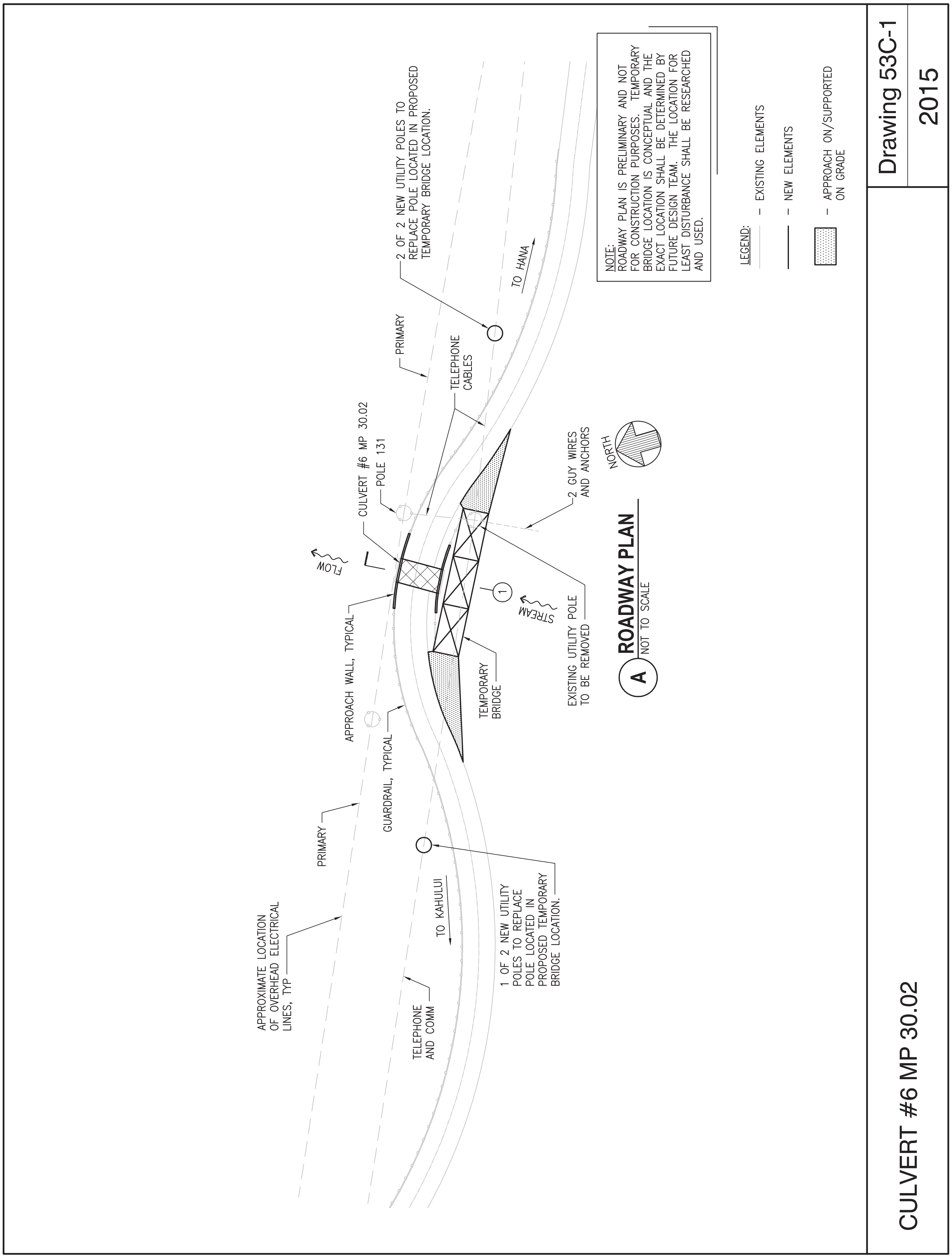
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

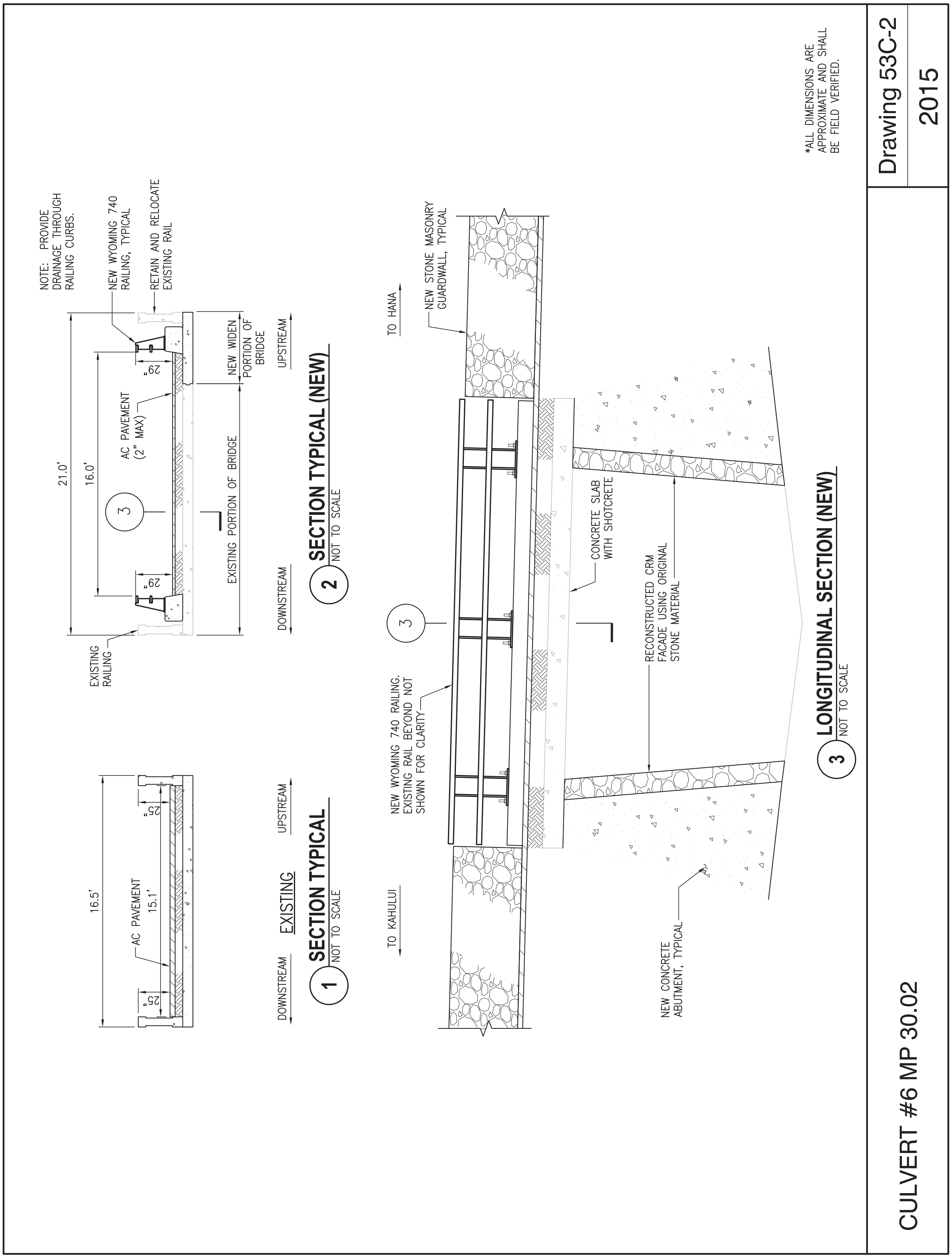
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

An existing telephone pole is in conflict with the temporary bridge. The existing telephone pole should be replaced with two new telephone poles that will allow the existing span to remain. The telephone lines are over the area of work but the contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements.



Courtesy of NOEI



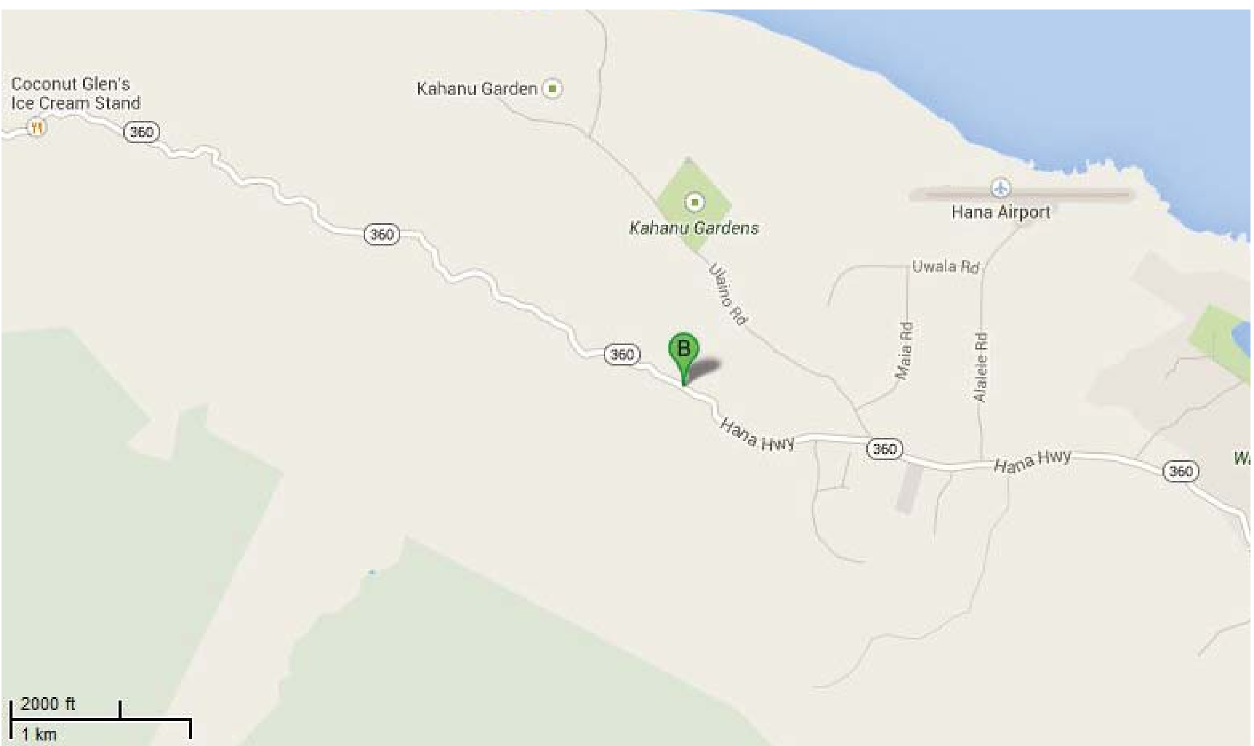
Courtesy of NOEI

Culvert #7 54C

54C

CULVERT #7

Culvert Number				**Island**	Maui		
Date of Construction	Unknown			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 47m 11s
Longitude	156d 02m 00s
Mile Point	30.13

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 15.66 feet
Number of Spans	1
Clear Span	5.33 feet
Clear Height	5.5 feet (approx)
Deck Width	Curb-to-Curb = 14.58 feet
Abutment Material	• CRM Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 27 inches • Downstream Railing Height = 29 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet Cap Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

Culvert Features

Culvert #7 is located at mile point 30.13 and has a clear opening of approximately 5.3 feet wide by 5.5 feet high. The culvert is 15.66 feet long. The culvert is comprised of a concrete top slab that bears on CRM walls and the invert of the culvert is an unlined channel.

Concrete open railings with inset panels at end caps, downstream side
Courtesy of NOEI

CRM abutments
Courtesy of NOEI

Hana approach to Culvert #7 toward Kahului
Courtesy of NOEI

Kahului approach to Culvert #7 toward Hana
Courtesy of NOEI

Significance & Context

Ahupuaa	Kawela
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Heavy vegetation
Character Defining Features	• Box Culvert • CRM Abutment Walls • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt

Significance & Context

Archaeological / Cultural Significance

Culvert #7 is located in Kawela Ahupuaa.[1, 2] The place name *Kawela* is defined as, "Land division, Hana qd., Maui… *Lit*., the heat."[3]

According to Native Hawaiian legend, in about 1760 the chief of Hawaii Island, Kalaniopuu, attacked the southern coast of Maui and captured the fort of Kauiki. This attack then made Hana and Kipuhulu a part of his domain. Kalaniopuu appointed Puna, a famous warrior and chief, to be in charge of protecting the fortress of Kauiki. It was soon decided by the chiefs of Maui, Molokai, and Lanai that the fortress should be in the hands of Kamehameha-nui, the ruler of Maui. This war was long, and involved widespread warfare primarily in the *ahupuaa* of Honomaele, Kawela, both Kuukuukamanu, both Kahalili, two Kaeleku, Honokalani, Wakiu and part of Kawaipapa.[4]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.10 for the battle at Kauiki; and to Section G, Appendix 1, Figure 14 for nearby archaeological study areas.[5]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of Culvert #7.

1 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

2 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

3 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

4 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic.

This culvert receives its runoff from a 72-acre (approximate) drainage area and has a terrain that consists of mostly forest type. The upstream and downstream ends of the culvert are highly vegetated and overgrown. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #7 is a one-lane reinforced concrete slab culvert. Concrete end walls with metal guardrail transitions are located at each corner of the approaches. The upstream and downstream concrete railings have a height of 27 inches and 29 inches, respectively. The upstream and downstream railings are not crash-tested for a TL-2.

The current curb-to-curb dimension is 14.58 feet, which for a one-lane culvert does not meet the design criteria minimum of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #7 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #7 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future Contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per bridge component, as follows:

Deck

Culvert #7 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane culvert; therefore, it is recommended to widen the upstream side of the culvert. Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

CRM Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other culverts along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The surface of the rock façade shall not exceed 0.5 inches in variation. The approaches do not have adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision; therefore, it is recommended to install guardrails and an end treatment at each corner after the stone masonry guardwall.

New approach walls shall be designed to be independent of the culvert railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between culvert railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. Approach Walls and Safety Features at the Approaches).

Railings / Parapets

The concrete culvert railings do not meet TL-2 crash requirements. It is recommended to preserve, relocate, and connect the existing upstream railings to the new widened portion of the deck. A crash-tested railing will be constructed in front of the existing railings. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the deck is recommended (refer to “Deck” section). Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM culvert walls and CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. If it is determined necessary to rehabilitate the concrete foundations, it is recommended to be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to “Deck” section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, &Signage

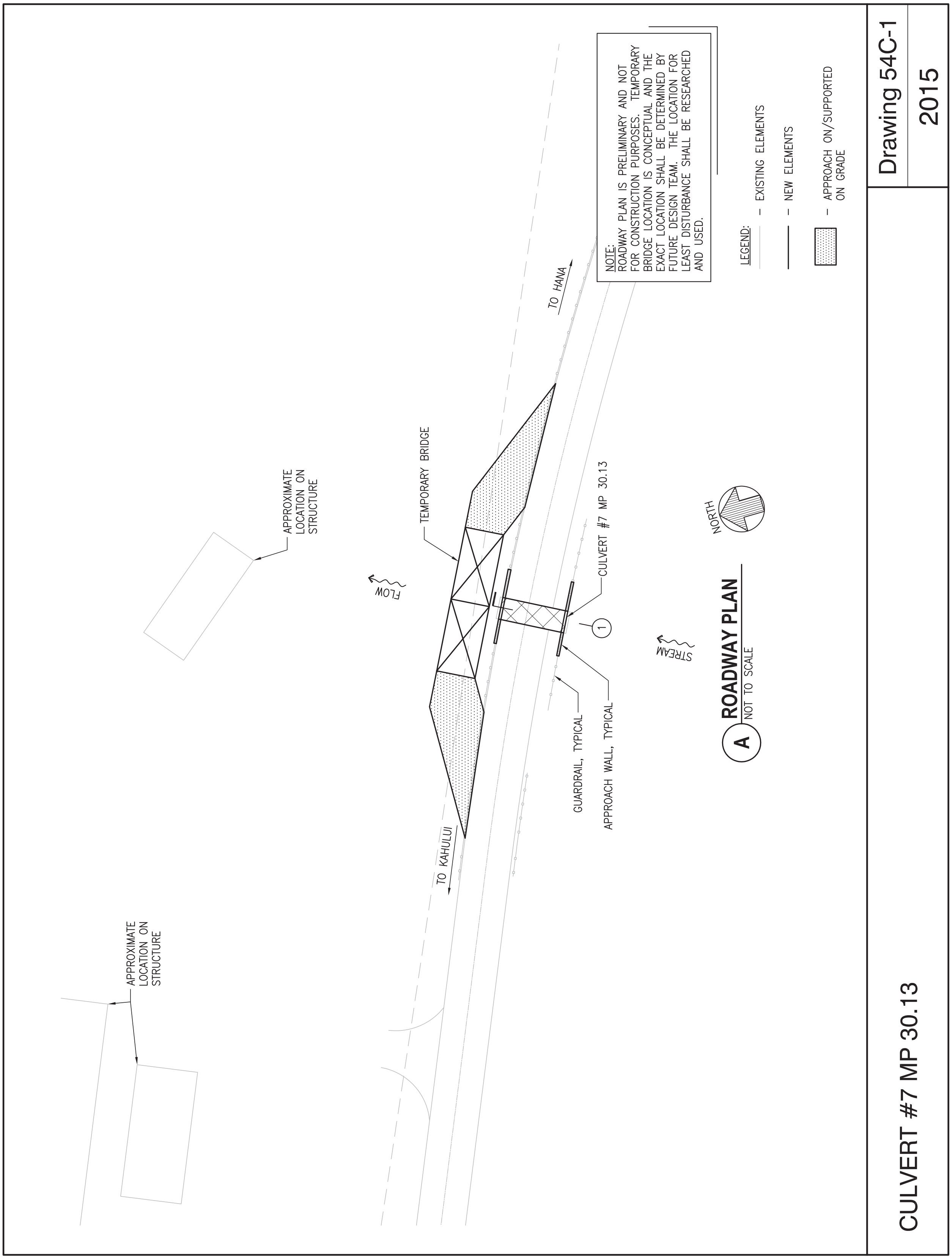
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

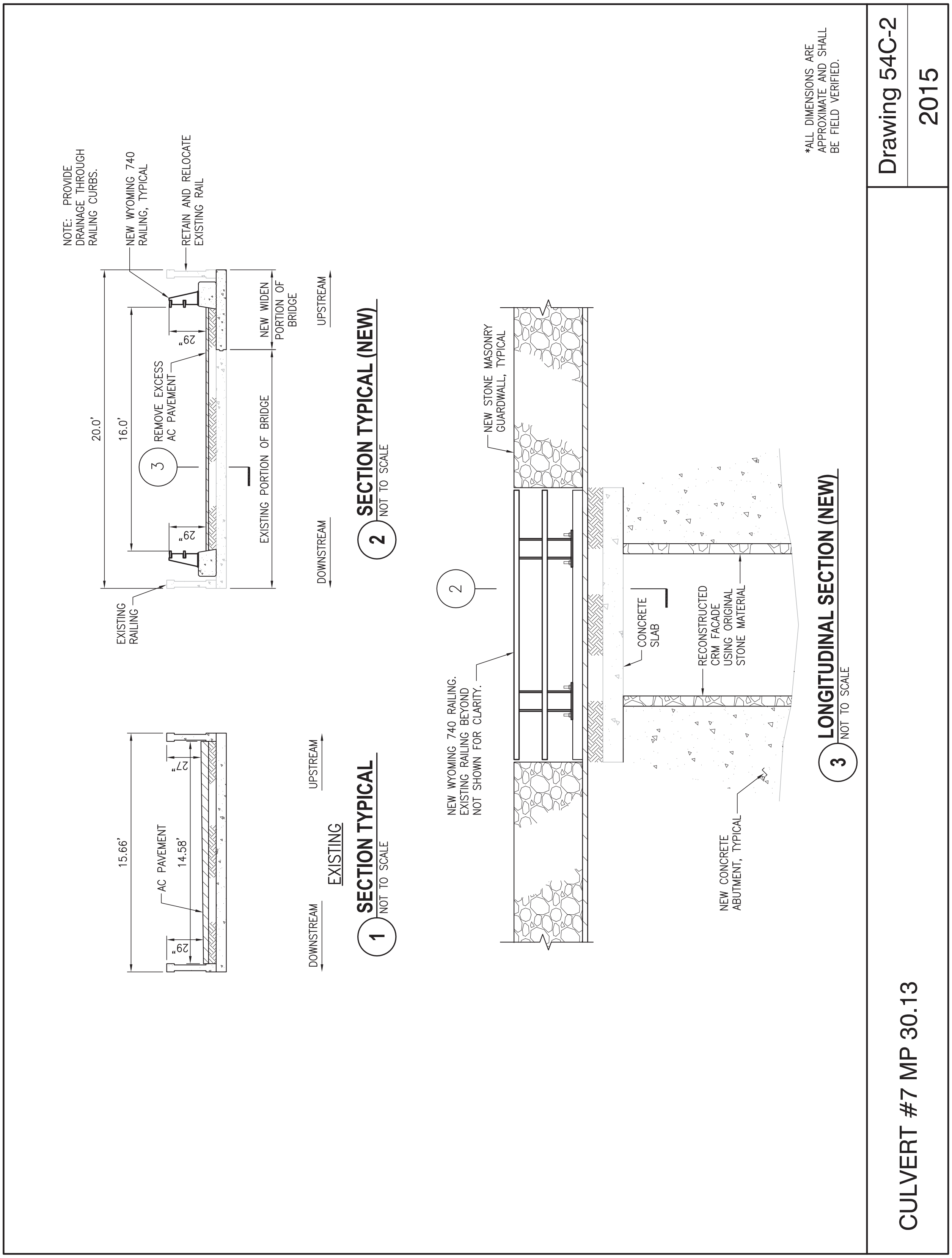
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #7 at this time.



Courtesy of NOEI



Courtesy of NOEI

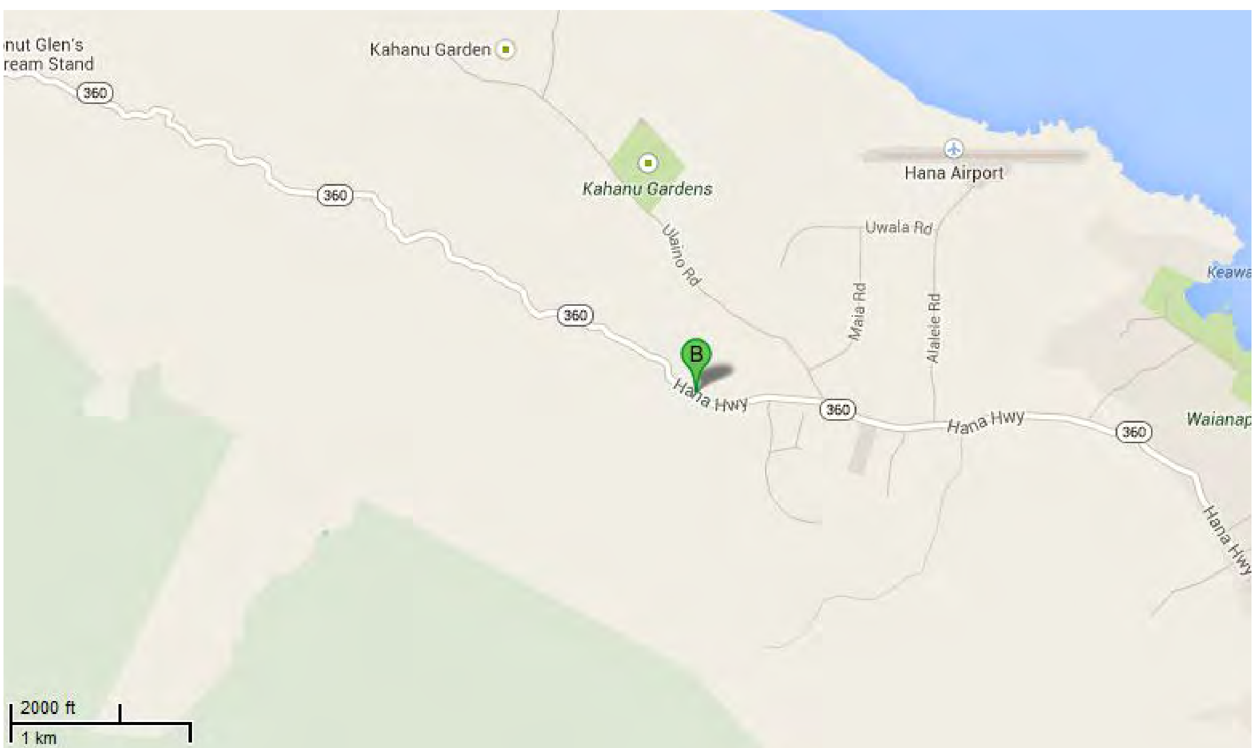
Culvert #8 55C

55C

CULVERT #8

Culvert Number		**Island**	Maui
Date of Construction	Unknown	**Route**	Hana Highway

Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

Location

Latitude	20d 47m 02s
Longitude	156d 01m 47s
Mile Point	30.44

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 16.25 feet (approx)
Number of Spans	1
Clear Span	11.5 feet
Clear Height	8.67 feet (approx)
Deck Width	Curb-to-Curb = 15.08 feet
Abutment Material	• CRM Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Open Vertical
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 25 inches • Downstream Railing Height = 25 inches
Baluster Dimensions	• Posts = 6 inches x 6 inches • Posts spaced approx. 16 inches on-center • End posts = 12 inches x 12 inches
Parapet Cap Profile	• Rectangular Cap • Railing cap = 6 inches x 8 inches

CULVERT INFORMATION

Culvert Features

Culvert #8 is located at mile point 30.44 and has a clear opening of approximately 11.5 feet wide by 8.7 feet high. The culvert is 16.25 feet long. The culvert is comprised of a concrete top slab that bears on CRM walls and the invert of the culvert is an unlined channel.

Concrete open vertical railing, upstream side
Courtesy of NOEI

Concrete open vertical railing, downstream side
Courtesy of NOEI

Hana approach to Culvert #8 toward Kahului
Courtesy of NOEI

Kahului approach to Culvert #8 toward Hana
Courtesy of NOEI

Significance & Context

Ahupuaa	Kawela
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Heavy vegetation
Character Defining Features	• Box Culvert • CRM Abutment Walls • CRM Wingwalls • Concrete Open Vertical Railings
Detracting Features	• Excessive asphalt

Significance & Context

Archaeological / Cultural Significance

Culvert #8 is located in Kawela Ahupuaa.[1, 2] The place name *Kawela* is defined as, “Land division, Hana qd., Maui… *Lit*., the heat.”[3]

According to Native Hawaiian legend, in about 1760 the chief of Hawaii Island, Kalaniopuu, attacked the southern coast of Maui and captured the fort of Kauiki. This attack then made Hana and Kipuhulu a part of his domain. Kalaniopuu appointed Puna, a famous warrior and chief, to be in charge of protecting the fortress of Kauiki. It was soon decided by the chiefs of Maui, Molokai, and Lanai that the fortress should be in the hands of Kamehameha-nui, the ruler of Maui. This war was long, and involved widespread warfare primarily in the *ahupuaa* of Honomaele, Kawela, both Kuukuukamanu, both Kahalili, two Kaeleku, Honokalani, Wakiu and part of Kawaipapa.[4]

Refer to Section G, Appendix 1, Section 3.1.3.3.1.10 for the battle at Kauiki; and to Section G, Appendix 1, Figure 14 for nearby archaeological study areas.[5, 6]

Adjacent Cultural Sites

No documented archaeological sites are located within 200 meters of Culvert #8.

1 U.S. Geological Survey, ed., *Hana Quadrangle, Hawaii*, 7.5 Minute Series (United States Department of the Interior, 1992).

2 F. S. Dodge, “Maui, Hawaiian Islands,” Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

3 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

4 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

5 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, “An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13),” Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

6 K. W. Bushnell and Hallett H. Hammatt, “Archaeological Inventory Survey of the 34 Acre Perman Property, Hana, Kawela Ahupuaʻa, Maui (TMK 1-3-03:15),” inventory survey, Cultural Surveys Hawaiʻi, Inc. (2000).

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	None
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	An existing telephone pole is adjacent to the temporary bridge
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic.

This culvert receives its runoff from an 8.5-acre (approximate) drainage area and has a terrain that consists of mostly forest type. The upstream and downstream ends of the culvert are highly vegetated and overgrown. The absolute outlet of the stream is unidentifiable from the highway travel way.

Structural

Culvert #8 is a one-lane reinforced concrete slab culvert. Concrete end walls with metal guardrail transitions are located at each corner of the approaches. The upstream and downstream concrete railings have a height of 25 inches. The upstream and downstream railings are not crash-tested for a TL-2.

The current curb-to-curb dimension is 15.08 feet, which for a one-lane culvert does not meet the design criteria minimum of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #8 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #8 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future Contractor shall be responsible for providing and maintaining the temporary bridge during the course of the bridge rehabilitation.

Recommendations have been identified per bridge component, as follows:

Deck

Culvert #8 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane bridge; therefore, it is recommended to widen the upstream side of the culvert. Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the bridges.

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

CRM Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other bridges along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). The approaches do not have adequate room to curve the approach walls away from the roadway as to eliminate the potential of a blunt end collision; therefore, it is recommended to install guardrails and an end treatment at each corner after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the bridge railings; a space is recommended between railings and approach walls. A maximum space of 0.5 inches shall be maintained between bridge railings and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The concrete culvert railings do not meet TL-2 crash requirements. It is recommended to preserve, relocate, and connect the existing upstream railings to the new widened portion of the deck. A crash-tested railing will be constructed in front of the existing railings. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available, additional investigation of the deck is recommended (refer to “Deck” section above). Also, drainage should be provided through the base of each railing curb.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM culvert walls and CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current condition of the foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. If it is determined necessary to rehabilitate the concrete foundations, it is recommended to be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM culvert walls and wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the bridge is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the bridge shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

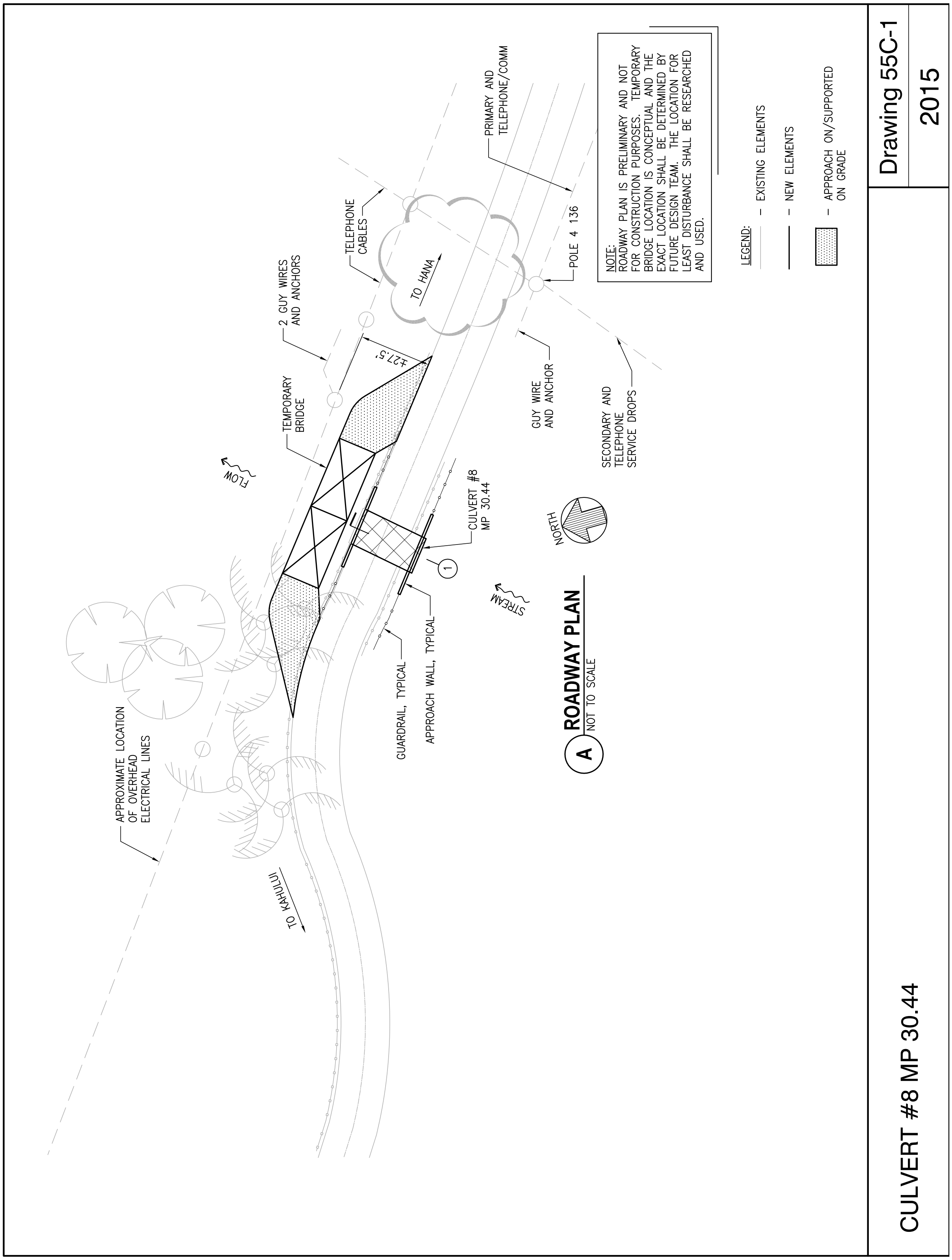
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be made compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

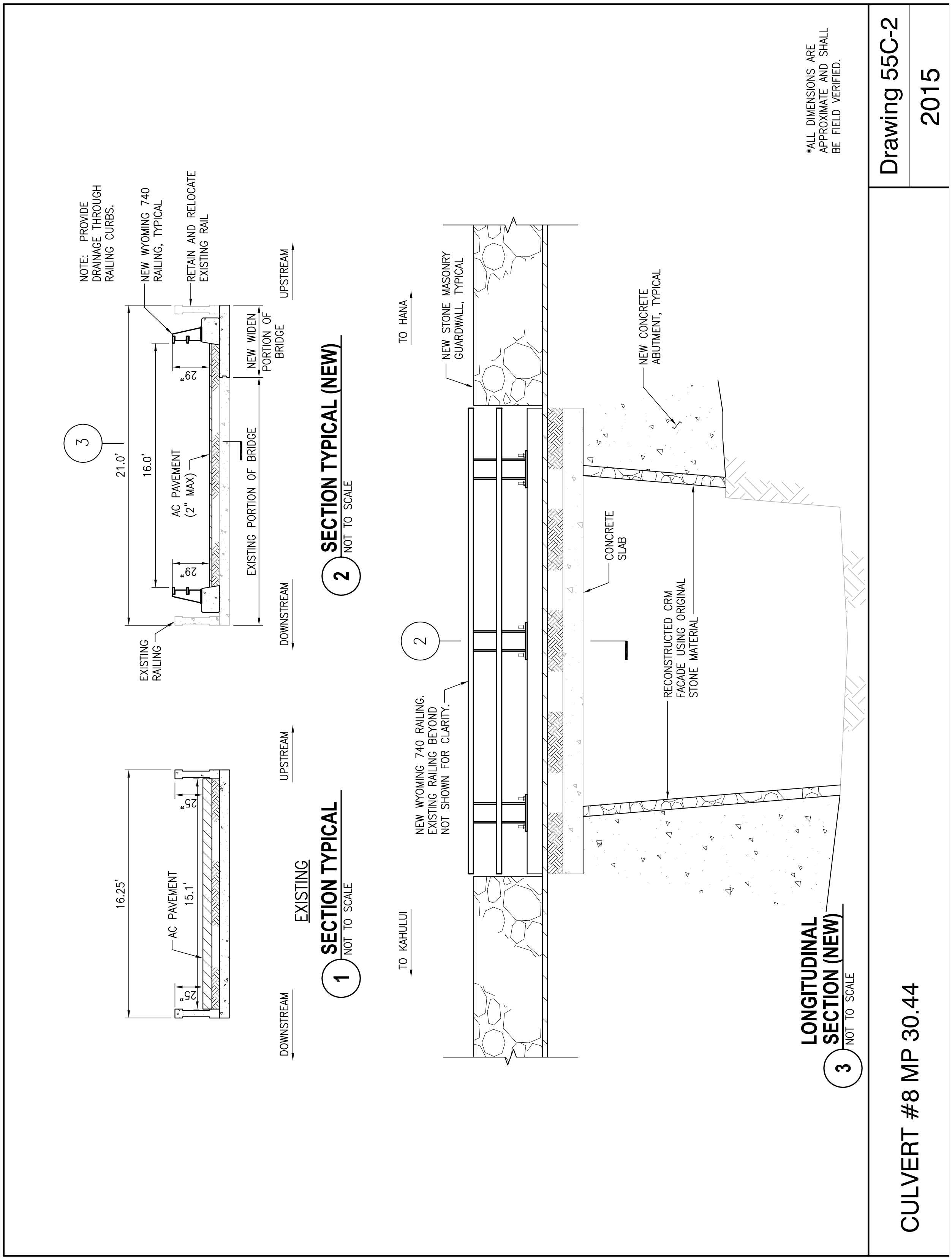
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

An existing telephone pole is immediately adjacent to the proposed temporary bridge. The existing telephone pole should be replaced with two new telephone poles that will allow the existing span to remain. The existing telephone lines are to the side of the area of work but the contractor can coordinate work with the utility companies and take steps to ensure the safety of the crew and that existing utilities are not disturbed. The temporary bridge can pass underneath the existing overhead electrical lines but the contractor should verify with Hawaiian Telcom that the overhead clearance meets vehicle traffic requirements (refer to figures below).



Courtesy of NOEI



Courtesy of NOEI

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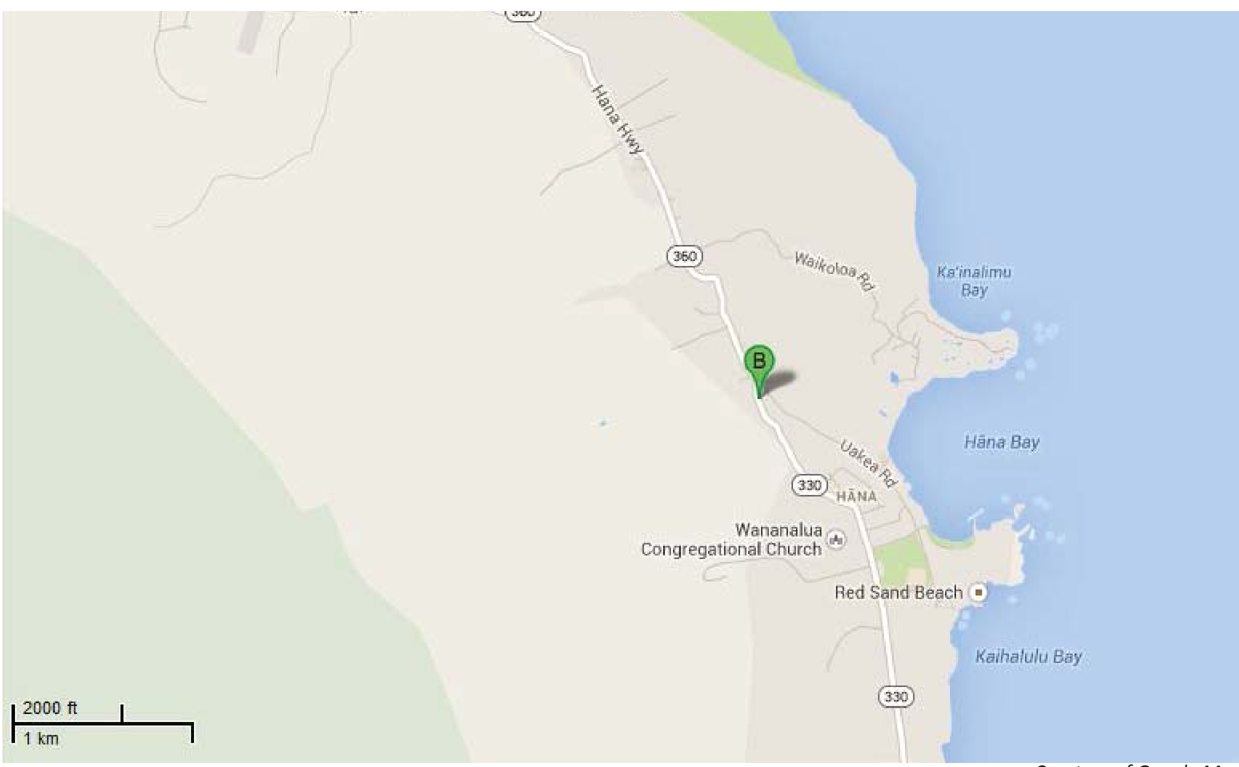
Culvert #9 56C

56C

CULVERT #9

Culvert Number				Island	Maui		
Date of Construction	1915			Route	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

CULVERT INFORMATION

Location

Latitude	20d 45m 44s
Longitude	155d 59m 38s
Mile Point	33.65

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 28.16 feet (approx)
Number of Spans	1
Clear Span	Varies between 14.08 feet (upstream) & 23 feet (downstream)
Clear Height	5.42 feet (approx)
Deck Width	Curb-to-Curb = 26.30 feet
Abutment Material	• Concrete Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Concrete Solid Parapets (downstream side was replaced in 2014)
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 27 inches • Downstream Railing Height = 30 inches
Parapet Profile	• Saddle Coping Cap • Railing cap = 6 inches x 8 inches • Flat Parapet
Parapet Inscription	• Original: "1915" on downstream face (based on HAER HI-75 report), no longer extant • Current: "Holoina wa wae Gulch 1951" with diacritical marks on upstream face (replacement inscription during 2014 rehabilitation project)

Culvert Features

Culvert #9 is located at mile point 33.65 in Hana. The culvert measures 28.2 feet in length and has an upstream clear span of 14.1 feet and a downstream clear span of 23 feet. According to the HAER report,[1] the original date of construction is 1915. Record drawings[2] show that the culvert underwent improvements in 2014 to widen the culvert on the downstream side; a site visit on June 26, 2014 confirmed that the improvements were still underway. A site visit in early 2015 confirmed the completion of the improvement work. The top slab and walls are concrete and the bottom is an unlined channel.

Culvert #9 downstream elevation
Courtesy of NOEI

Concrete abutment, Hana side
Courtesy of NOEI

Kahului approach to Culvert #9 toward Hana, during construction
Courtesy of NOEI

Solid concrete parapet, downstream side, and approach wall
Courtesy of NOEI

1 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005).

2 State of Hawaii, Department of Transportation, Highways Division, "Plans for Route 360 Hana Highway Improvements, Uakea Road to Keawe Place," Project No. 360B-01-03 (December 2011).

Significance & Context

Ahupuaa	Niumalu
Designer / Builder	Unknown
Historic Drawings	None
Alterations	2014 widening, downstream parapet replaced; downstream CRM approach wall extended, Hana side
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	• Three adjacent archaeological sites, see detailed culvert description for further information
Geographical Features / Setting	• Nearby structures
Character Defining Features	• Box Culvert • Concrete Abutment Walls • CRM Wingwalls • Historic upstream solid concrete parapet
Detracting Features	• Incorrect parapet inscription on upstream face

Significance & Context

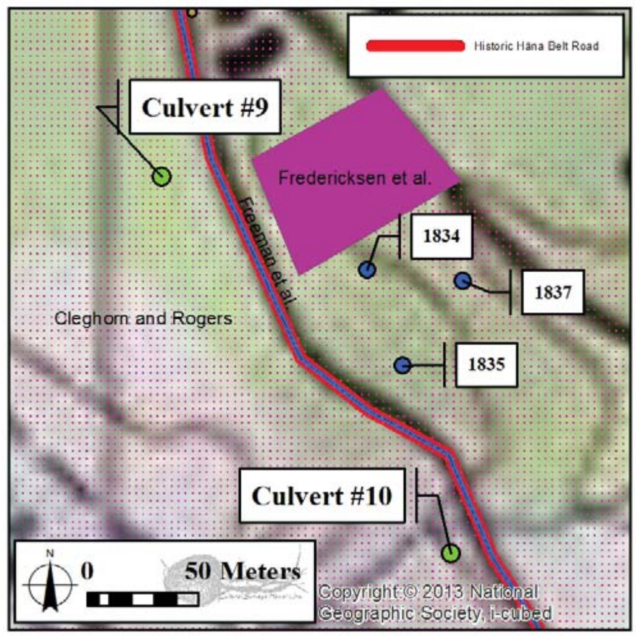
Archaeological / Cultural Significance

Culvert #9 is located along Hana Highway, Route 330, just south of the junctions with Hana Highway, Route 360. The culvert lies in Niumalu Ahupuaa.[3] The place name *Niumalu* is defined as, "Land sections, Kau-po and Hana qds… *Lit*., shade [of] coconut trees."[4]

Kamakau describes the region of the Hana District in his book *Ruling Chiefs of Hawaii* as a place:

> *….where taro, sweet potatoes, bananas, sugar cane and wild fruits grew in abundance, and there was always much food to be had. Kawaipapa was rich in fish from the ponds and from the sea.*[5]

No other specific cultural or archaeological background information could be located for this small section of land near Kawaipapa. However, refer to Section G, Appendix 1, Section 3.1.3.3 for the overall regional history of the Hana town vicinity; and to Section G, Appendix 1, Figure 17 for nearby archaeological study areas.[6, 7, 8, 9]



Adjacent Cultural Sites

Three archaeological sites are located near historic Culvert #9 (refer to figure at right); SIHP -1834 (approximately 100 meters southeast), SIHP -1835 (approximately 140 meters southeast), and SIHP -1837 (approximately 144 meters southeast). These sites were recorded by Cleghorn and Rogers in their 1987 study of the Hana Ranch Lands, which consisted of compiling a list of known sites, analysis of aerial

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3 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

4 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

5 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

6 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

7 Paul L. Cleghorn and Kathie Rogers, *Preliminary Historical and Archaeological Investigations of Hāna Ranch Lands, Maui Hawaiian Islands*, prepared for EDAW, Inc.(Honolulu: Department of Anthropology, Bernice Pauahi Bishop Museum, 1987).

8 David Perzinski and Michael F. Dega, "Archaeological Inventory Survey of a Hāna Highway Widening Area at Mile Marker 33.88, Culvert #9, Hāna, Kawaipapa Ahupuaʻa, Hāna District, Maui Island, Hawaiʻi [TMK: 1-4-006:999]," Scientific Consultant Services, Inc. (Honolulu: 2009).

9 Walter M. Fredericksen, Erik M. Fredericksen, and Demaris L. Fredericksen, "An Archaeological Inventory Survey on a Parcel of Land Located in the Ahupuaʻa of Kawaipapa and Niumalu, Hana District, Maui TMK: 1-4-06:2," Xamanek Researches (Pukalani: 1993).

photographs, and a brief field inspection.[10] SIHP -1834 was documented as a double-faced, core-filled stone wall that was disturbed due to road construction. SIHP -1835 consists of an overhang shelter with associated midden remains. SIHP -1837 appeared to be an historic stone retaining wall.[11] Refer to Section G, Appendix 1, Table 2: Previous archaeological studies conducted along Hana Highway, Route 360.

10 Paul L. Cleghorn and Kathie Rogers, Preliminary Historical and Archaeological Investigations of Hāna Ranch Lands, Maui Hawaiian Islands, prepared for EDAW, Inc. (Honolulu: Department of Anthropology, Bernice Pauahi Bishop Museum, 1987).

11 Ibid.

Civil & Traffic

Number of Lanes	Two Lanes
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	• Signs are in good condition • Missing Object Marker Type 3 - Left (West Bound) • Missing Object Marker Type 3 - Right (East Bound)
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	None
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

Culvert #9 is located at mile point 33.65 along Hana Highway, Route 360. Both ends of the culvert can be easily identified when traveling along the highway.

The roadway above the culvert is striped for two lanes, allowing vehicles to travel along the span of the culvert without yielding to oncoming traffic. Signage at the west culvert approach includes a “Left Object Marker” sign (OM3-L) located on the end of the left approach wall. Signage at the east culvert approach includes a “Right Object Marker” sign (OM3-R) located on the end of the right approach wall.

Structural

Culvert #9 is a reinforced concrete slab culvert. At the time of the initial site visit on July 26, 2014, the culvert was still under construction. A site visit in early 2015 confirmed the completion of the construction work. The new curb-to-curb width of 26.3 feet allows for two-lane two-way traffic.

The upstream approach walls and parapet are original over the culvert. The downstream parapet and approach guardrails were demolished. The downstream Hana approach wall was constructed with a CRM facade and metal guardrails were placed at the downstream Kahului approach corner. The downstream parapet was replaced with a similarly designed concrete parapet.

At the time of the July 26, 2014 site visit, the upstream and downstream concrete parapets had a height of 27 inches and 30 inches, respectively.

Based on the record drawings:

- Downstream culvert parapet was designed “in accordance with AASHTO TL-2 design factors”,
- Design live load was AASHTO HL-93, and
- Seismic design based on “AASHTO Guide Specifications for LRFD Seismic Bridge Design (May 2007), as modified by the State of Hawaii Department of Transportation”.

Recommendation

It is recommended that the existing culvert structure of Culvert #9 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #9 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is not recommended since a detour through Hana Town can be utilized during repair and/or rehabilitation of this culvert.

Regarding the name and date of this culvert, discrepancies have been identified by comparing available modern and historic resources and in response to community comments during the preparation of this report. According to the HAER HI-75 report, Culvert #9 was constructed in 1915, identified by an inscription on the original downstream parapet (no longer extant).[12]

During the 2014 rehabilitation project, the downstream parapet was replaced with a new, solid concrete parapet without an inscription. However, a simple concrete name and date plaque was added to the exterior side of the upstream parapet during this project. The concrete plaque is inscribed "Holoina wa wae 1951" with diacritical marks; the date is incorrectly inscribed. Additionally, a 1934 parcel tax map indicates the feature crossed at this location is "Holoinawae Stream."[13]

It is recommended that the culvert name and feature crossed at this location be confirmed, and that the name and date plaque be changed to reflect the correct date of 1915 original construction. It is also recommended that the plaque be re-located at a more visible portion of Culvert #9 in approach walls (refer to "CRM Approach Walls" section). The name of this culvert shall be verified through a process to be determined during future development of

12 "Hana Belt Road," Historic American Engineering Record, HAER HI-75 (2005), 86.

13 Tax Maps Bureau & Survey Department, "Hana, Maui," file number: M14003, dwg no: 2088, Second Division, Zone 1, Section 4, Plat 03, County of Maui, State of Hawaii (1934).

a PA between the ACHP, SHPD, FHWA, and HDOT, including other concurring parties. Refer to Section G, Appendix 10. *Hawaiian Place Names Research* for further research and discussion.

Recommendations have been identified per culvert component, as follows:

Deck

There are no record drawings for the original portion (upstream end) of this culvert. It is recommended to have the original deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the original deck is capable of supporting the new railing and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

The widened portion of the culvert is not to be affected.

AC overlay thickness shall not obstruct the base or lower the height of the existing railings. If excessive AC overlay is present at the time of the future design team's site survey, then it is recommended to remove the excess AC overlay and reapply. As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

CRM Approach Walls

The existing upstream CRM walls at the approaches to the culvert do not meet the TL-2 crash requirements and cannot act as the culvert's traffic features. The existing CRM approach walls are recommended to be replaced with a reinforced concrete wall with a new natural rock façade. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the upstream approach corners to the culvert after the stone masonry guardwall.

Culvert #9 upstream elevation with incorrect date inscription
Courtesy of FAI

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*). The approach walls shall also contain a concrete culvert name panel, pending confirmation of the Hawaiian place name by community and scholarly experts. Refer to Section A, Chapter 5. iii. a. *Approach Walls & Safety Features at the Approaches* for an example of the stone masonry guardwall with bridge name detail.

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Railings / Parapets

The upstream concrete culvert parapet does not meet TL-2 crash requirements. It is recommended to construct a crash-tested railing in front of the existing upstream parapet. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). Since record drawings are not available for the original portion of the culvert, additional investigation of the deck is recommended (refer to “Deck” section). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the original concrete abutments, upstream CRM wingwalls, and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The original portion of the culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert’s lifespan. If it is determined necessary to rehabilitate the concrete foundations, it is recommended to be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the original portion of the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3). The widen portion of the culvert is able to support the 40-ton load criteria.

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

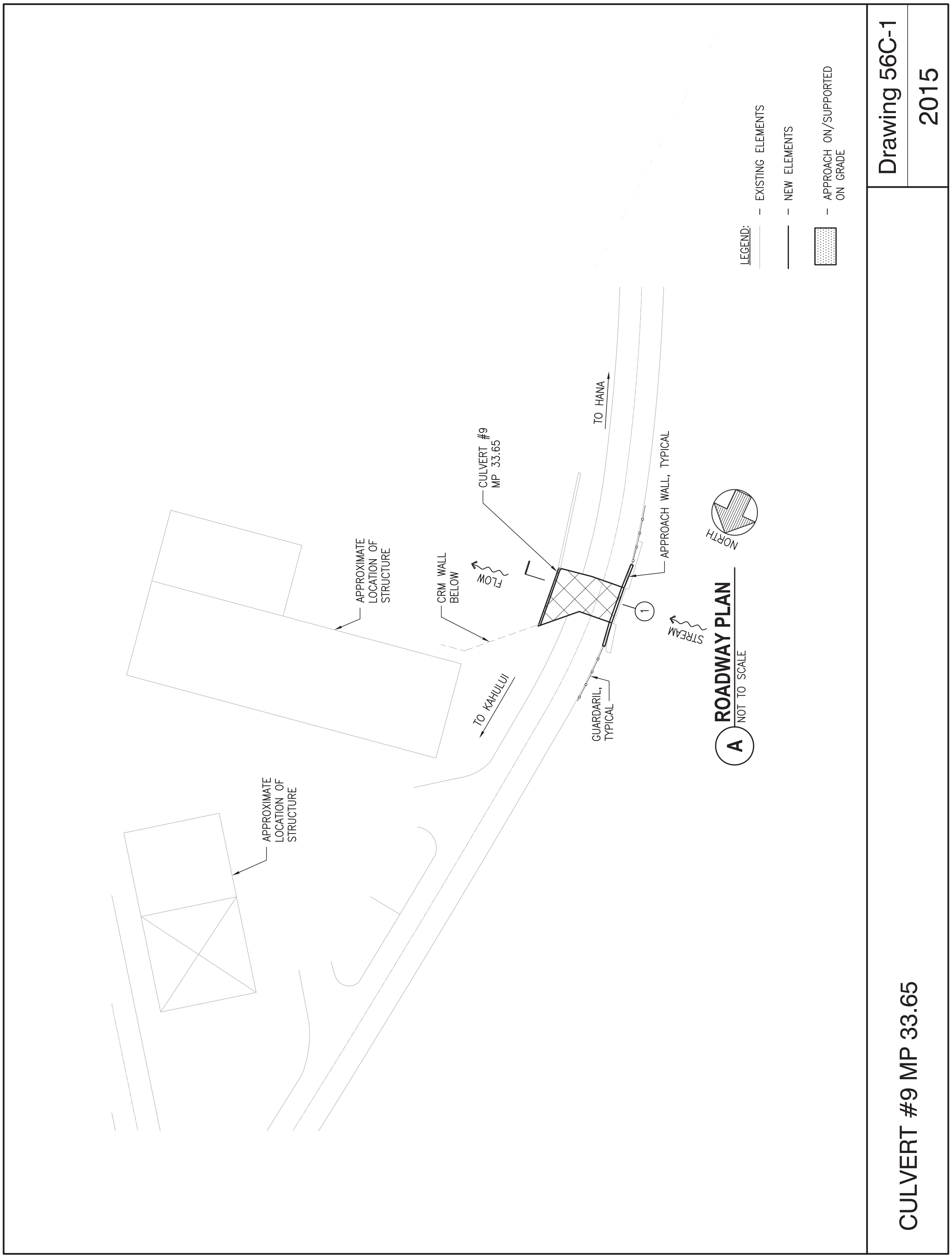
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

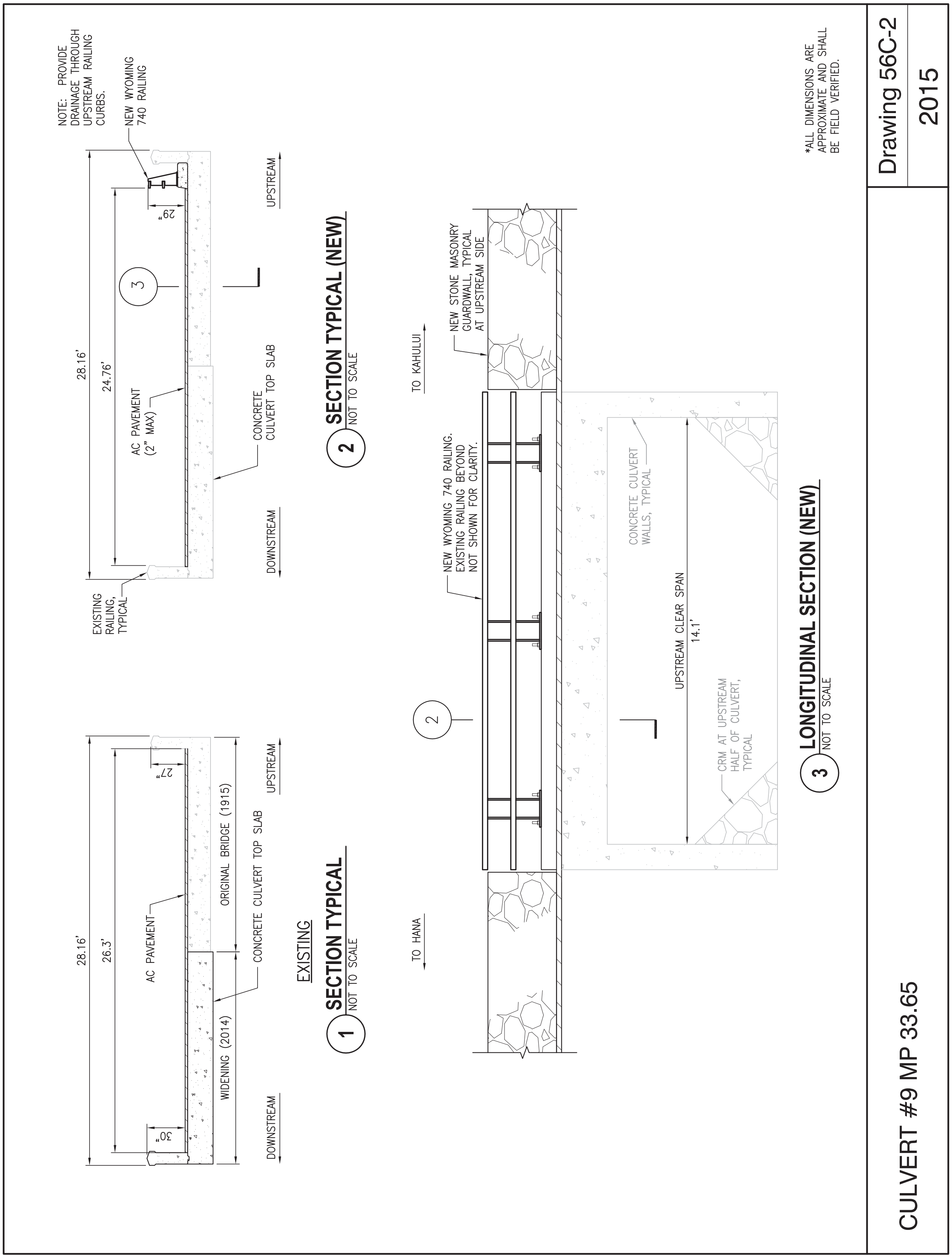
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #9 at this time.



Courtesy of NOEI



Courtesy of NOEI

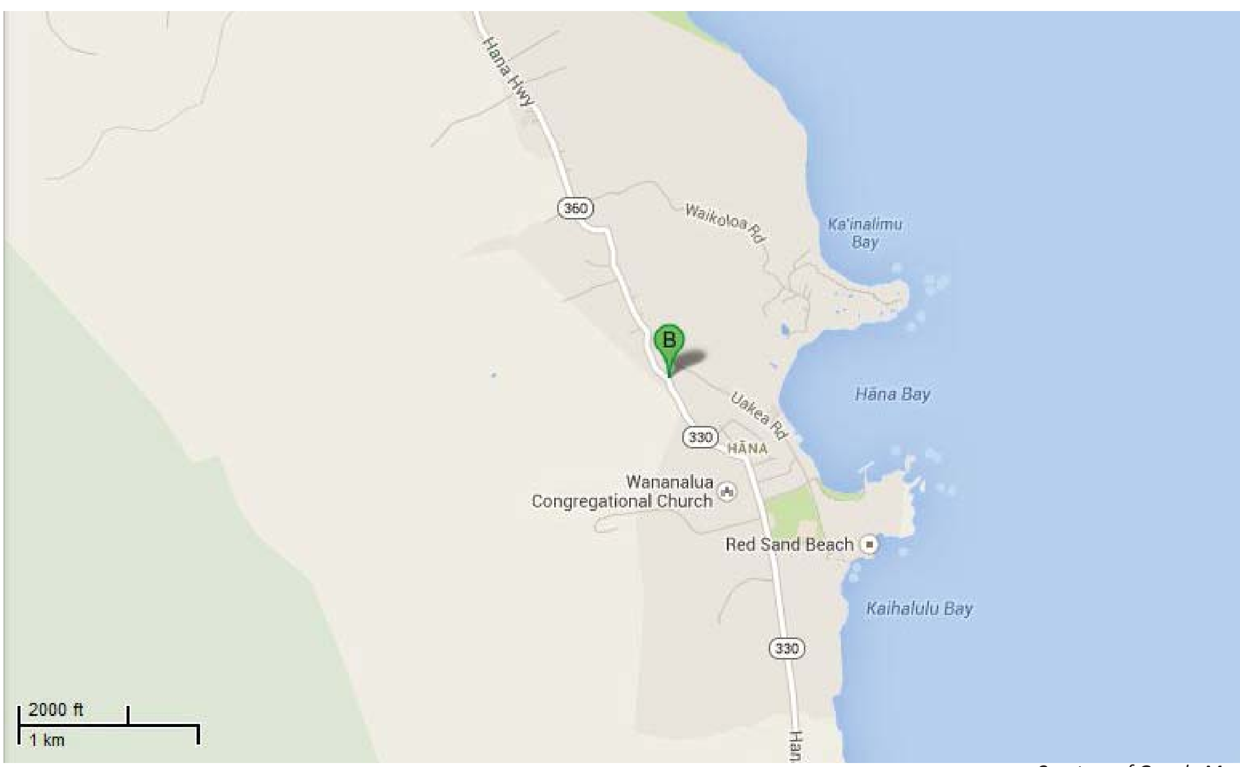
Culvert #10

57C

57C

CULVERT #10

Culvert Number				**Island**	Maui		
Date of Construction	Unknown			**Route**	Hana Highway		
Treatment Recommendation	X	Preservation	X	Rehabilitation		Restoration		Replacement



Courtesy of Google Maps

CULVERT INFORMATION

Location

Latitude	20d 45m 38s
Longitude	155d 59m 33s
Mile Point	34.00

Culvert Features

Culvert Type	Concrete Slab Culvert
Total Length	Culvert Length = 14.10 feet
Number of Spans	1
Clear Span	14.08 feet
Clear Height	8 feet (approx)
Deck Width	Curb-to-Curb = 12.5 feet
Abutment Material	• Reinforced Concrete Walls
Wingwall Material	• CRM Wingwalls
Floor / Decking Material	• Reinforced Concrete Top Slab • Unlined Bottom
Parapet / Railing Type	Solid Concrete Parapets
Parapet / Railing Segments	1
Parapet / Railing Height	• Upstream Railing Height = 27 inches • Downstream Railing Height = 27 inches
Parapet Profile	• Rectangular Cap • Flat Parapet with Board-Formed Concrete Texture • No Panel
Parapet Inscription	“1915” on downstream face

CULVERT INFORMATION

Culvert Features

Culvert #10 is located at mile point 34.00. The culvert measures 14.1 feet in length and has a clear opening of approximately 14.1 feet wide by 8 feet high. The top slab and walls are concrete and the bottom is an unlined channel.

Kahului approach to Culvert #10 toward Hana
Courtesy of NOEI

Hana approach to Culvert #10 toward Kahului
Courtesy of NOEI

Concrete abutments
Courtesy of NOEI

Solid parapet
Courtesy of NOEI

Significance & Context

Ahupuaa	Kawela
Designer / Builder	Unknown
Historic Drawings	None
Alterations	None
Replacement	None
Preservation Priority	Contributing Culvert
State / National Register	Yes
Areas of Significance	Engineering, Social History, Transportation, Commerce
Significance Statement	• Contributes to the Hana Highway Historic Bridge District • Part of best remaining intact example of a belt road system in the state • 20th century example of culvert engineering and construction • See National Register of Places Nomination Form in appendices • HAER Recordation: HI-75 (2005)
Archaeological / Cultural Significance	• Greater than 50 years in age • Part of the Hana Belt Road, which retains a high level of historic integrity and character, and which includes the highest concentration of stylistically consistent historic bridges and culverts in the State of Hawaii • Relatively unaltered in terms of historic setting and character, including location, width, alignment, scenery, and vistas
Adjacent Cultural Sites	None Documented
Geographical Features / Setting	• Heavy vegetation
Character Defining Features	• Box Culvert • Concrete Abutment Walls • CRM Wingwalls • Concrete Solid Parapet with Board-Formed Texture • Inset inscription “1915” on outside face of downstream parapet
Detracting Features	• Excessive asphalt

Significance & Context

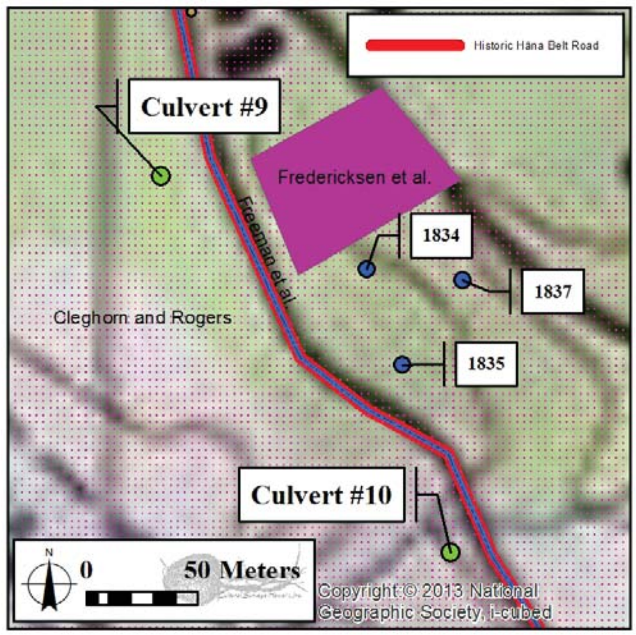
Archaeological / Cultural Significance

Culvert #10 is located along Hana Highway, Route 330, just south of the junctions with Hana Highway, Route 360. The culvert lies in Niumalu Ahupuaa.[1] The place name *Niumalu* is defined as, "Land sections, Kau-po and Hana qds… *Lit*., shade [of] coconut trees.."[2]

Kamakau describes the region of the Hana District in his book *Ruling Chiefs of Hawaii* as a place:

> *…where taro, sweet potatoes, bananas, sugar cane and wild fruits grew in abundance, and there was always much food to be had. Kawaipapa was rich in fish from the ponds and from the sea.*[3]

No other specific cultural or archaeological background information could be located for this small section of land near Kawaipapa. However, refer to Section G, Appendix 1, Section 3.1.3.3 for the overall regional history of the Hana town vicinity; and to Section G, Appendix 1, Figure 17 for nearby archaeological study areas.[4, 5]



Adjacent Cultural Sites

Three archaeological sites are located near historic Culvert #10 (refer to figure at right); SIHP -1834 (approximately 135 meters north-northwest), SIHP -1835 (approximately 85 meters north-northwest), and SIHP -1837 (approximately 125 meters north). These sites were recorded by Cleghorn and Rogers in their 1987 study of the Hana Ranch Lands, which consisted of compiling a list of known sites, analysis of aerial photographs, and a brief field inspection.[6] SIHP -1834 was documented as a double-faced, core-filled stone wall that was disturbed due to road construction. SIHP -1835 consists of an overhang shelter with associated midden remains. SIHP -1837 appeared to be an historic stone retaining wall.[7] Refer to Section G, Appendix 1, Table 2: Previous archaeological studies conducted along Hana Highway, Route 360.

1 F. S. Dodge, "Maui, Hawaiian Islands," Library of Congress Geography and Map Division Washington, D.C. 20540-4650: Hawaiian Government Survey (Washington, D.C.: 1885).

2 Mary Kawena Pukui, Samuel H. Elbert, and Esther K. Mookini, *Place Names of Hawaii*, rev. and enl. ed. (Honolulu: University Press of Hawaii, 1974).

3 S. M. Kamakau, *Ruling Chiefs of Hawaii*, rev. ed. (Honolulu: The Kamehameha Schools Press, 1992).

4 Sallie D. M. Freeman, Holly J. Formolo, and Hallett H. Hammatt, "An Archaeological Monitoring Report for Hāna Highway Improvements Huelo to Hāna, M.P. 4.20 to 23.70 Districts of Makawao (Hāmākualoa and Koʻolau) and Hana, Island of Maui (TMK: 2-1-1; 2-1-2; 2-1-3; 2-1-4; 01-05; and 2-2-9:05, 06, 09, 10, 12, 13)," Cultural Surveys Hawaiʻi, Inc. (Wailuku: 2004).

5 Paul L. Cleghorn and Kathie Rogers, *Preliminary Historical and Archaeological Investigations of Hāna Ranch Lands, Maui Hawaiian Islands*, prepared for EDAW, Inc. (Honolulu: Department of Anthropology, Bernice Pauahi Bishop Museum, 1987).

6 Ibid.

7 Ibid.

Civil & Traffic

Number of Lanes	One Lane
Bicycle / Pedestrian Access	N/A
Visibility / Approach	N/A
Signage (as of September 2014)	• Signs are in good condition • Missing Object Marker Type 3 - Left & Right (West Bound)
Apron	None
Civil Utilities	None
Easements	None
Public Right-of-Way	Per HDOT, there are no Right-of-Way maps in this area

Structural

Construction Access / Bypass Bridge	Temporary bypass downstream side
Electrical Utilities	None
Load Rating	Unknown
Condition	Unknown

Civil & Traffic

Culvert #10 is located at mile point 34.00 along Hana Highway, Route 360. Both ends of the culvert can be easily identified when traveling along the highway.

The travel way above the culvert is striped for one-way travel, forcing vehicles to yield to oncoming traffic. Signage and striping at the east and west culvert approach include a “Yield” sign (R1-1), a “To Oncoming Traffic” sign (R1-2a), and a yield line. The east culvert approach also includes a “Left Object Marker” sign (OM3-L) on the end of the left side approach wall and a “Right Object Marker” sign (OM3-R) on the end of right side approach wall.

Structural

Culvert #10 is a one-lane reinforced concrete slab culvert. There are no approach walls or guardrails at this culvert. The upstream and downstream concrete parapets have a height of 27 inches. Neither parapet has been crash-tested for a TL-2.

The current curb-to-curb dimension is approximately 12.50 feet. This curb-to-curb dimension does not meet this project’s design criteria of 16 feet.

Load rating for this culvert unknown and therefore, it is assumed that the minimum load is 10 tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

Recommendation

It is recommended that the existing culvert structure of Culvert #10 be rehabilitated. Any rehabilitation work to this culvert will need to consider the historical and cultural areas in its surroundings during design and construction. Recommendations are based on site visits conducted during the months of May, June, and July of 2014. Refer to Section A, Chapter 5. *Application of Design Standards & Guidelines* for more information.

Preservation and maintenance of the existing structure should be continued until structural deficiencies and/or upgrades to address current safety standards are determined necessary. A list of maintenance activities specific to Hana Highway, Route 360 historic culverts is included in Section A, Chapter 4. iv. *Preservation Solutions Following Secretary of the Interior's Standards*, and Chapter 5. iii. f. *Activities to Prolong the Life of the Bridge*, for reference. Damaged character-defining features should be stabilized and repaired to prevent future deterioration. If Culvert #10 is to be rehabilitated, any rehabilitation work to this culvert will need to comply with the SOI Standards. All strengthening or rehabilitation construction activities are subject to NHPA Section 106 and HRS Chapter 6E consultation with SHPD and Maui CRC.

An archaeological inventory survey is recommended prior to any construction in the APE for culvert rehabilitation, as this culvert contributes to the Hana Highway Historic Bridge District (refer to Section G, Appendix 4 for Hana Belt Road National Register Nomination Form).

A localized topographic study is recommended in order to give further analysis of the drainage patterns and runoff capacity of the culvert in question.

A temporary bypass bridge is recommended during repair and/or rehabilitation for all culverts in this report. The future contractor shall be responsible for providing and maintaining the temporary bridge during the course of the culvert rehabilitation.

Recommendations have been identified per culvert component, as follows:

Deck

Culvert #10 currently does not meet the minimum curb-to-curb width of 16 feet for a one-lane culvert; therefore, it is recommended to widen the upstream side of the culvert. Special attention should be paid to removing excess asphalt overlay on the deck because it obscures the base of the existing parapets and lowers the height below code minimum.

There are no record drawings for this culvert. It is recommended to have the deck scanned for reinforcing and have core samples extracted. The results will assist in determining whether the deck is capable of supporting the new railings and a 40-ton load carrying capacity. A chloride concentration analysis is recommended to be conducted on the concrete core samples.

As a design consideration, suggested by the communities adjacent to Hana Highway, the future design team shall consult with FHWA, HDOT, and SHPD whether to provide a concrete topping versus AC on the culverts.

CRM Approach Walls

Currently, there are no approach walls at this culvert; therefore, it is recommended to install approach walls at all approach corners. The approach wall will consist of a reinforced concrete wall with a natural rock façade to match the appearance of other culverts along Hana Highway. For this purpose, a stone masonry guardwall is recommended to be used (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing Options*). To eliminate the potential of a blunt end collision occurring, it is recommended to install guardrails and an end treatment at the approach corners to the culvert after the stone masonry guardwall.

Exemplary CRM approach wall, Bridge #19 Kopiliula Stream Bridge
Courtesy of NOEI

New approach walls shall be designed to be independent of the culvert parapets; a space is recommended between parapets and approach walls. A maximum space of 0.5 inches shall be maintained between culvert parapets and adjacent approach walls using joint filler (refer to Section A, Chapter 5. iii. a. *Approach Walls and Safety Features at the Approaches*).

Exemplary CRM approach wall, Bridge #38 Heleleikeoha Stream Bridge
Courtesy of NOEI

The appearance of the reconstructed CRM façades shall closely match that of the original historic craftsmanship along Hana Highway. The surface of the rock façade shall not exceed 0.5 inches in variation. Examples of exemplary historic craftsmanship, with tight joints, minimal exposed mortar, and varied rock sizes for a natural, rustic appearance, may be seen at the approach walls to the following bridges: #19 Kopiliula Stream Bridge, #38 Heleleikeoha Stream Bridge, #39 Ulaino Stream Bridge, and #40 Mokulehua Stream Bridge for reference. The rock wall portions of the EMI system at #06 Kaaiea Stream Bridge and #19 Kopiliula Stream Bridge are also excellent examples of historic rock walls showing original craftsmanship.

Culvert #10 downstream elevation with inscription
Courtesy of NOEI

Railings / Parapets

The concrete culvert parapets do not meet TL-2 crash requirements. It is recommended to preserve, relocate, and connect the existing upstream parapet to the new widened portion of the deck. A crash-tested railing will be constructed in front of the existing parapets. For this purpose, it is recommended to use a Wyoming 740 railing which will be attached to the deck of the culvert (refer to Section G, Appendix 5. *Proposed Crash-Tested Railing*

Options). Since record drawings are not available, additional investigation of the deck is recommended (refer to "Deck" section). Also, drainage should be provided through the base of each parapet.

At the time of design, the recommended railings shall be verified whether they meet current crash-test standards. Substitution of the recommended railing may be necessary if they are no longer acceptable.

Foundations, Wingwalls, & Abutments

The CRM wingwalls are recommended to be replaced with a reinforced concrete structure with new natural rock façades. The appearance of the reconstructed façades shall closely match that of the original historic craftsmanship along Hana Highway.

It is recommended to investigate the current material composition of the concrete abutments and foundations to determine whether they need to be rehabilitated to be compliant with current seismic codes and the increase to a 40-ton load carrying capacity. The culvert should be scanned for reinforcing and have concrete core samples extracted. A condition survey is recommended to determine corrosion potential to base the selection of repair and protection strategy to prolong the culvert's lifespan. . If it is determined necessary to rehabilitate the concrete abutments and foundations, they are recommended to be replaced in-kind with a reinforced concrete structure.

Until future rehabilitation work is determined, retention of the existing appearance of CRM wingwalls, which show evidence of historic craftsmanship is recommended through preservation and routine maintenance.

Load Rating

Load rating for the culvert has not been completed due to lack of information (refer to "Deck" section). It is assumed that the culvert can support at a minimum the posted 10-tons per the general posted load sign at the beginning of Hana Highway (between mile markers 2 and 3).

After rehabilitation at the culvert is complete, a load rating calculation shall be performed per current load rating standards. Per the request of the communities adjacent to the Hana Highway, the culvert shall not be posted with a 40-ton sign after rehabilitation is completed.

Civil, Traffic, & Signage

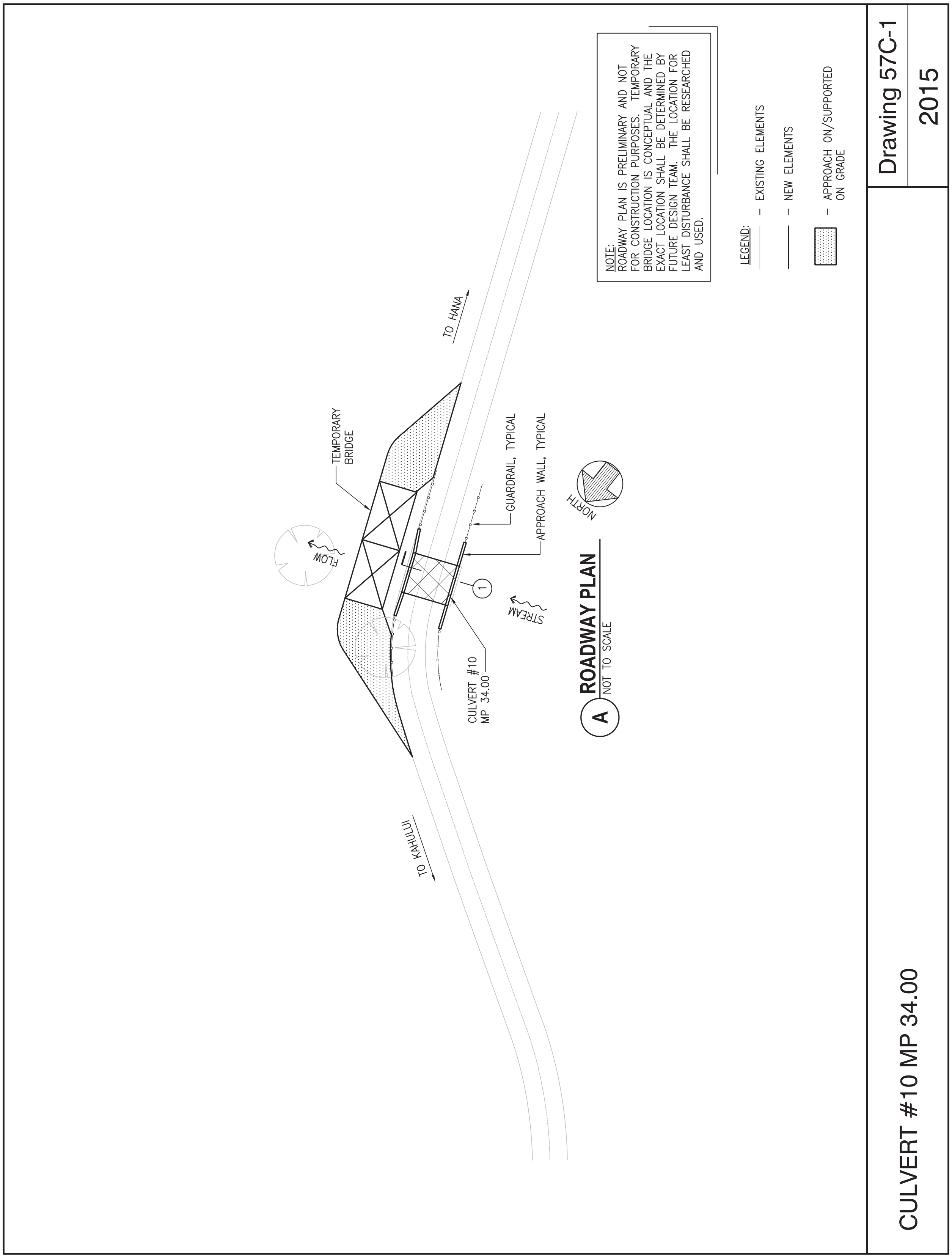
In regard to visibility on each approach, any obstructions blocking the driver's visibility should be trimmed or removed per an approved landscape plan. Signage and striping shall be compliant with current standards by referring to the *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2009 edition by the FHWA or the most current edition/revision of this book. Signage, visibility, and traffic recommendations include the following:

- Add Object Markers to approach walls

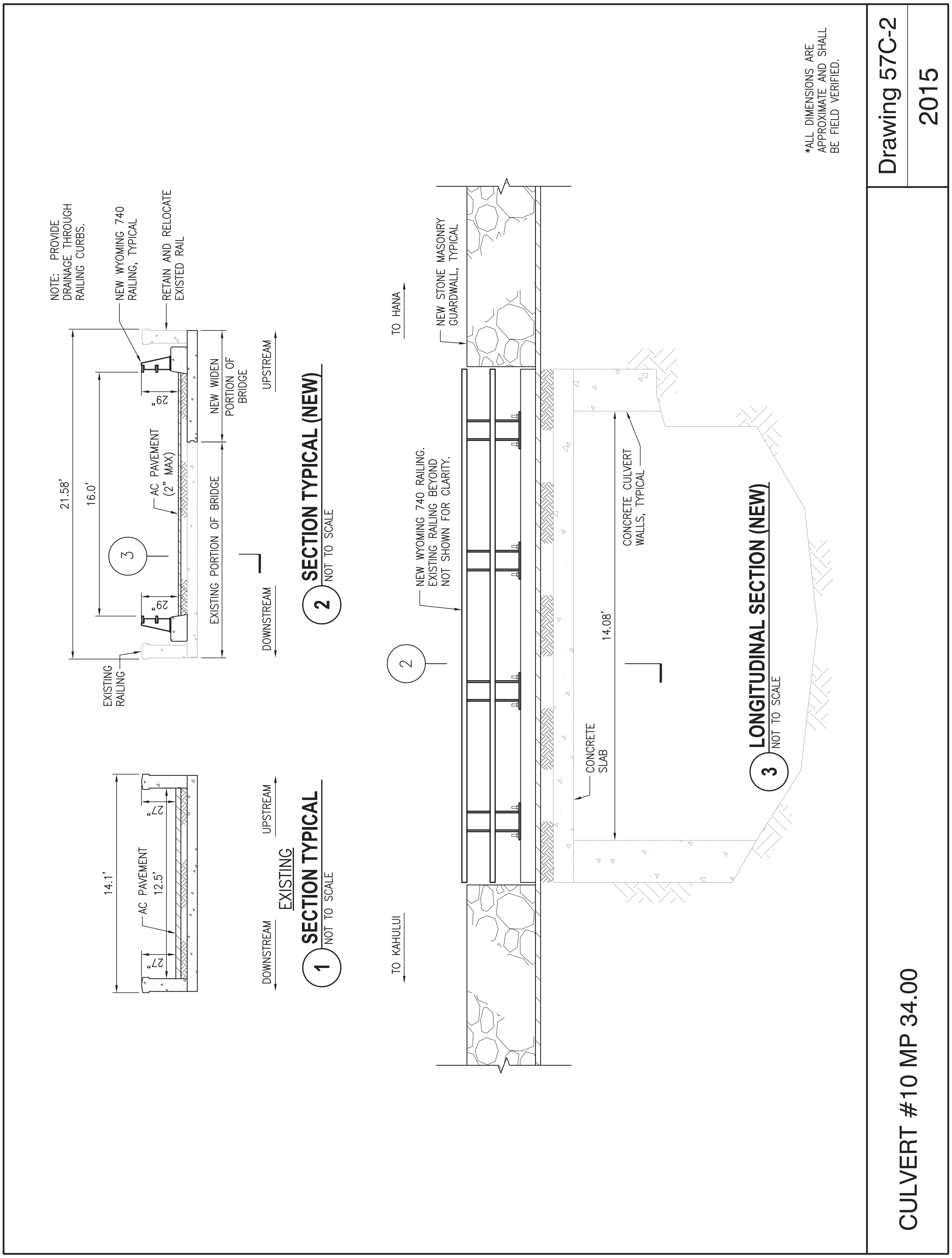
Existing field conditions should be field verified before applying any recommendations as maintenance work could have been conducted and corrected the deficiencies noted in this report. Refer to Section G, Appendix 2. *Transportation Management Plan - Hana Highway Bridge Preservation Plan* for more information.

Electrical

Based on site visit observations and current conditions at the time this report was prepared, there are no electrical recommendations for Culvert #10 at this time.



Courtesy of NOEI



Courtesy of NOEI

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SECTION D

FOUND CULVERTS

F O U N D C U L V E R T S O V E R V I E W

In addition to the 43 bridges and 12 HAER culverts, there are numerous smaller culverts along Hana Highway's Historic Belt Road. Most of these culverts are documented on past HDOT paving plans; however, their locations were not confirmed and they are not inspected on a regular basis due to their sizes and intended purpose. The majority of these culverts are small box or pipe culverts that travel under the highway and appear to be utilized as a means of drainage from upstream properties.

The HDOT requested that the additional culverts and their locations be confirmed through a visual drive of Hana Highway, Route 360 with guidance from past paving project plans. Some of the culverts could not be located; therefore, culverts that were confirmed during the course of this project were referred to as "found" culverts. A total of 45 found culverts with visible headwalls above or next to the AC roadway were discovered. The found culverts can be categorized by the following structure types and materials:

- Reinforced concrete pipes (RCP): 19 total found,
- Reinforced concrete and rock box culverts: 20 total found,
- Corrugated metal pipes (CMP): Five total found, and
- Unknown: One total found.

The unknown culvert was found at mile point 14.91 with a CRM headwall, but the upstream inlet did not have any openings (refer to *Figure D – 1,* below).

Figure D – 1: Backside view of upstream headwall at mile point 14.91
Courtesy of NOEI

Record drawings do not exist for these found culverts and it is unknown as to when they were constructed. The HAER report mentions and describes culvert types found along the Hana Highway, Route 360 (refer to *Figure D – 2*). The load carrying capacities of these culverts are unknown since as-built drawings are not available for these structures, nor have condition evaluations for them been performed. At the time of the survey, the found culverts were found to be in good condition. It is recommended that the found culverts be investigated to determine their load carrying capacity and code compliancy.

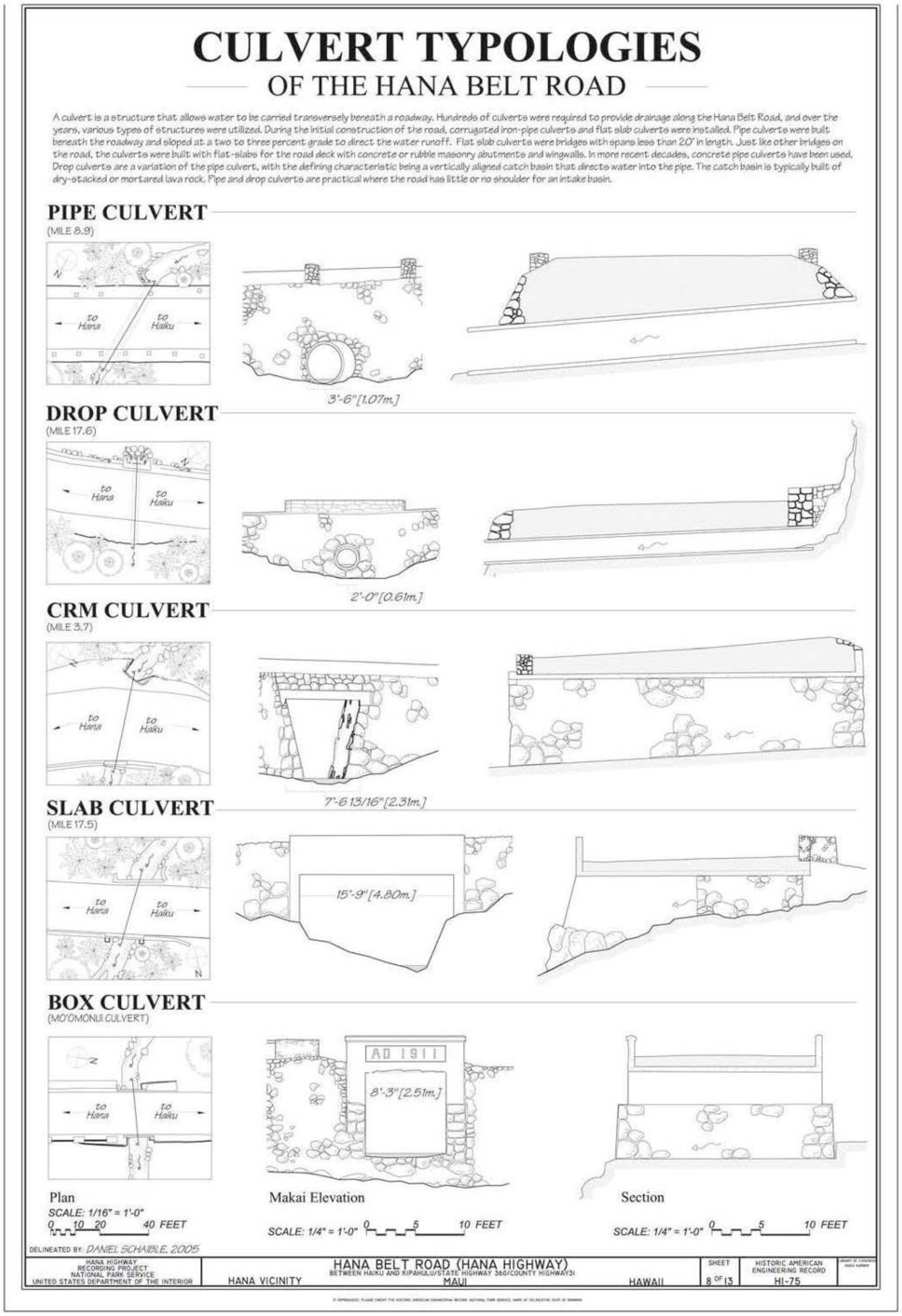


Figure D – 2: Culvert typologies of the Hana Belt Road
Courtesy of HAER HI-75

It is recommended that culverts with CRM approach walls have the existing approach walls replaced with a crash-tested reinforced concrete wall with a natural rock façade to match the appearance of the existing CRM wall. For this purpose, a stone masonry guardwall is recommended. It is also recommended to install guardrails and an end treatment at the corners after the stone masonry guardwall, to eliminate the possibility of a blunt end collision.

Found Culvert Matrix

Hana Highway, Route 360

	Mile Point (MP)	Culvert Type	Drawing No. for		"A"	"B" Ht of wall (or metal guardrail) above roadway***		"C"	"D"
			Plan	Section	Length of wall**	Upstream	Downstream	Interior width or Diameter	Interior Height
1C	6.57	Pipe	1C-1	C-2	-	2'-0"	N/A	2'-0"	-
3C	9.13	Pipe	3C-1 & 4C-1	C-2	5'-0" (upstream)	0'-3"	2'-0"	2'-0"	-
4C	9.24	Rectangular	3C-1 & 4C-1	C-2	62'-0" (upstream) & 43'-6" (downstream)	1'-6"	1'-6"	5'-0"	10'-0"
5C	10.18	Rectangular	5C-1	C-2	37'-0" (upstream)	2'-0"	N/A	8'-0"	8'-0"
6C	10.48	Rectangular	6C-1	C-2	28'-0" (upstream) & 25'-0" (downstream)	2'-6"	2'-2"	3'-0"	3'-0"
7C	11.82	Pipe	7C-1	C-2	30'-0" (upstream)	1'-9"	N/A	2'-0"	-
8C	12.12	Rectangular	8C-1	C-2	24'-0" (upstream)	2'-0"	N/A	2'-0"	1'-0"
9C	12.65	Pipe	9C-1	C-2		N/A	2'-0"	2'-0"	-
10C	14.63	Rectangular	10C-1	C-2	16'-0" (upstream) & 27'-7" (downstream)	2'-0"	2'-0"	4'-0"	8'-0"
11C	14.91	Unknown*	11C-1	C-2	15'-0" (upstream) & 15'-0" (downstream)	2'-0"	1'-8"	-	-
12C	15.40	Pipe	12C-1	C-2	22'-6" (upstream)	2'-0"	N/A	2'-0"	-
13C	16.06	Rectangular	13C-1	C-2	44'-8" (upstream) & 1'-9" (downstream)	2'-0"	1'-9"	12'-0"	5'-0"
14C	17.03	Pipe	14C-1 & 15C-1	C-2	10'-0" (upstream)	1'-0"	2'-6"	2'-0"	-
15C	17.19	Pipe	14C-1 & 15C-1	C-2	6'-0" (upstream)	1'-6"	N/A	2'-0"	-
16C	17.27	Pipe	16C-1	16C-2	32'-6" (downstream)	N/A	2'-3"	3'-6" (3 pipes) & 2'-0" (1 pipe)	-
17C	17.31	Pipe	17C-1	17C-2	14'-0" (downstream)	2'-6"	N/A	2'-0" (1 pipe) & 3'-0" (1 pipe)	-
18C	17.36	Pipe	18C-1	C-2	-	N/A	N/A	Unknown	-
22C	17.51	Rectangular	22C-1 & 23C-1	C-2	-	2'-7"	1'-4"	11'-9"	5'-4" (upstream) & 9'-2" (downstream)
23C	17.55	Pipe	22C-1 & 23C-1	C-2	-	1'-0"	N/A	2'-0"	-
24C	17.65	Pipe	24C-1	C-2	-	1'-7"	2'-4"	2'-0"	-
26C	20.01	Pipe	26C-1	C-2	-	2'-0"	2'-6"	2'-6"	-
27C	20.03	Pipe	27C-1	C-2	-	1'-6"	2'-6"	3'-0"	-
28C	20.05	Pipe	28C-1	C-2	-	1'-9"	2'-0"	4'-0"	-
29C	21.00	Rectangular	29C-1	C-2	22'-0" (upstream) & 28'-6" (downstream)	1'-1"	2'-1"	6'-0"	8'-0"
30C	21.11	Rectangular	30C-1	C-2	39'-0" (upstream) & 38'-2" (downstream)	2'-3"	1'-3"	9'-0"	8'-0"
31C	21.29	Pipe	31C-1	31C-2	-	2'-2"	2'-4"	2'-0"	-
32C	21.92	Pipe	32C-1	32C-2	-	0'-6"	2'-4"	2'-0" (2 pipes)	-

Found Culvert Matrix

Hana Highway, Route 360

	Mile Point (MP)	Culvert Type	Drawing No. for		"A"	"B" Ht of wall (or metal guardrail) above roadway***		"C"	"D"
			Plan	Section	Length of wall**	Upstream	Downstream	Interior width or Diameter	Interior Height
33C	22.10	Rectangular	33C-1	C-2	-	2'-4"	2'-0"	4'-0"	4'-0"
34C	22.52	Rectangular	34C-1 & 35C-1	C-2	-	2'-2"	2'-4"	4'-0"	4'-0"
35C	22.54	Pipe	34C-1 & 35C-1	C-2	-	2'-1" (parapet) & 2'-4" (metal guardrail)	2'-2" (parapet) & 2'-3" (metal guardrail)	1'-6"	-
36C	22.79	Rectangular	36C-1	C-2	-	2'-4"	2'-4"	8'-0"	3'-0"
37C	22.90	Pipe	37C-1	C-2	-	2'-4"	2'-1"	2'-0"	-
38C	23.04	Pipe	38C-1	C-2	-	2'-0"	2'-0"	4'-0"	-
39C	23.21	Rectangular	39C-1 & 40C-1	C-2	-	2'-0"	2'-0"	4'-0"	6'-0"
40C	23.26	Pipe	39C-1 & 40C-1	C-2	-	0'-10"	2'-5"	3'-0"	-
41C	23.70	Pipe	41C-1	C-2	-	1'-7"	2'-3"	4'-0"	-
43C	24.38	Pipe	43C-1	C-2	-	N/A	0'-11"	2'-0"	-
44C	24.71	Rectangular	44C-1	C-2	-	N/A	1'-6"	2'-0"	2'-0"
45C	24.90	Rectangular	45C-1	C-2	-	N/A	1'-2"	3'-0"	3'-0"
46C	26.13	Rectangular	46C-1	C-2	-	2'-0"	2'-5"	4'-0"	4'-0"
47C	26.33	Rectangular	47C-1	C-2	-	N/A	2'-0"	2'-0"	1'-0"
48C	27.26	Pipe and Rectangular	48C-1 & 49C-1	48C-2	-	1'-8"	0'-10"	3'-0" diameter (upstream) & 8'-0" width (downstream)	5'-0"
49C	27.41	Pipe	48C-1 & 49C-1	C-2	-	N/A	0'-9"	2'-0"	-
50C	27.60	Rectangular	50C-1 & 51C-1	C-2	-	N/A	2'-3"	2'-6"	2'-6"
51C	27.70	Rectangular	50C-1 & 51C-1	C-2	-	N/A	1'-6"	2'-6"	1'-0"

*Culvert MP 14.91 - culvert was not found, and may be buried under debris. Refer to Section D, *Found Culverts* Drawing D: 11C - 1 for more information.

**All dimensions are approximate and shall be field verified.

***N/A for culverts that do not have parapets/metal guardrail.

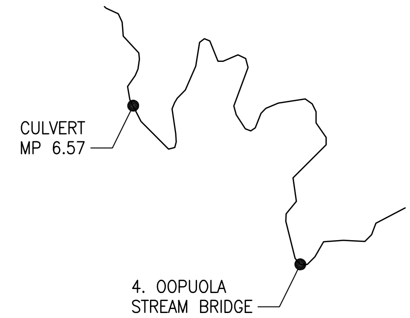
1C	CULVERT MP 6.57			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana on upstream side.

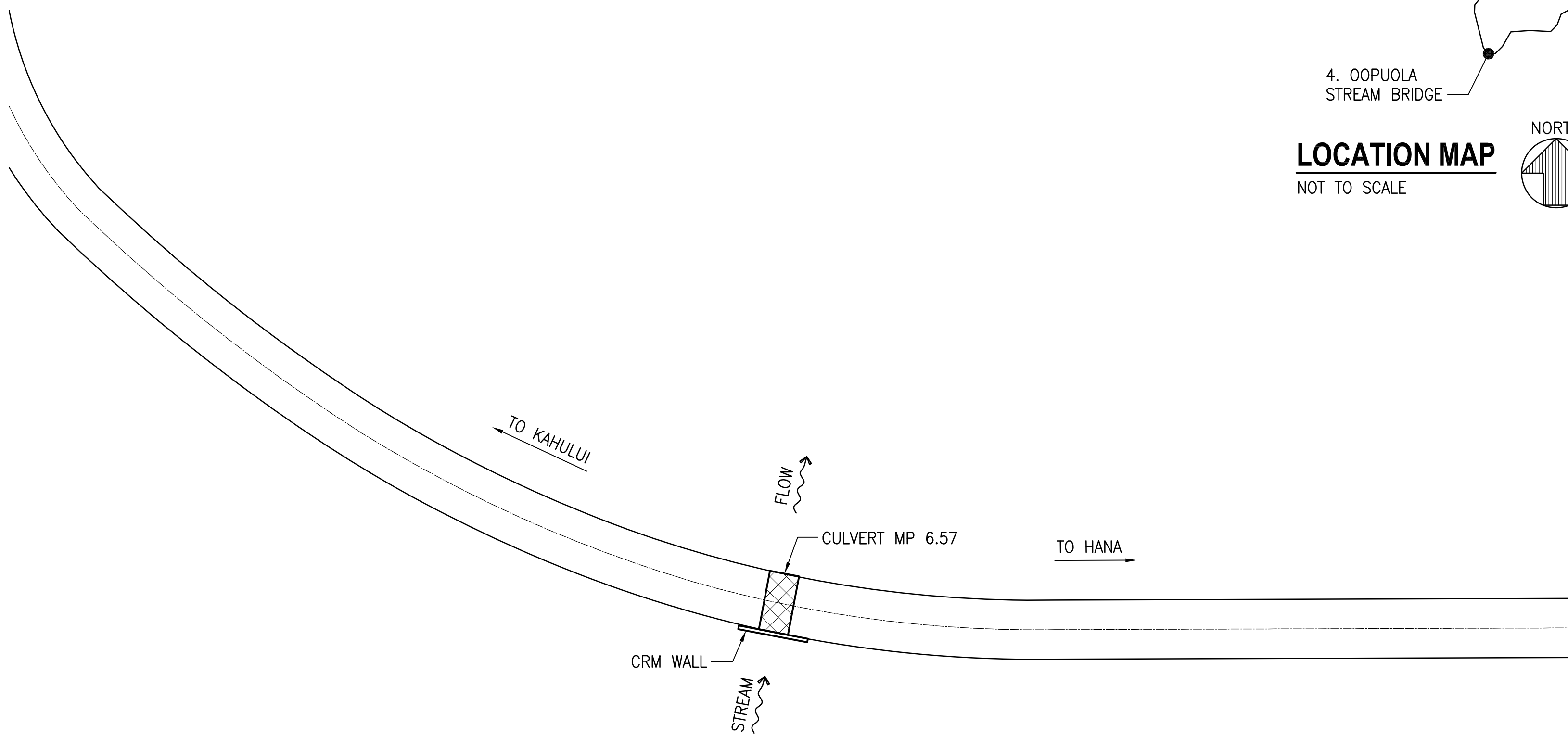
Backside view of upstream / Hana corner of CRM parapet.

1C	CULVERT MP 6.57				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

24" diameter RCP outlet at downstream side.



LOCATION MAP
NOT TO SCALE

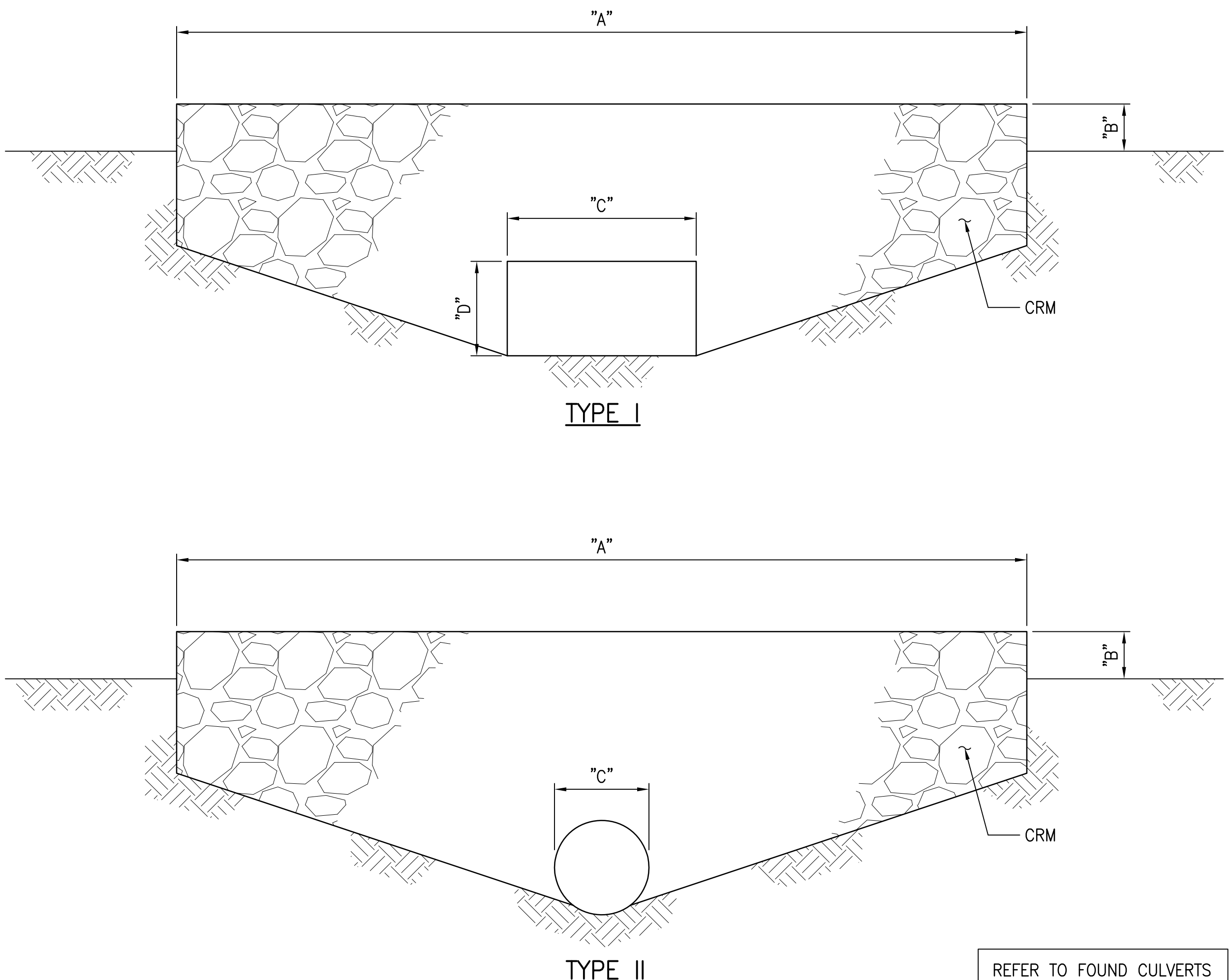


(A) ROADWAY PLAN
NOT TO SCALE

CULVERT MP 6.57

Drawing D: 1C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

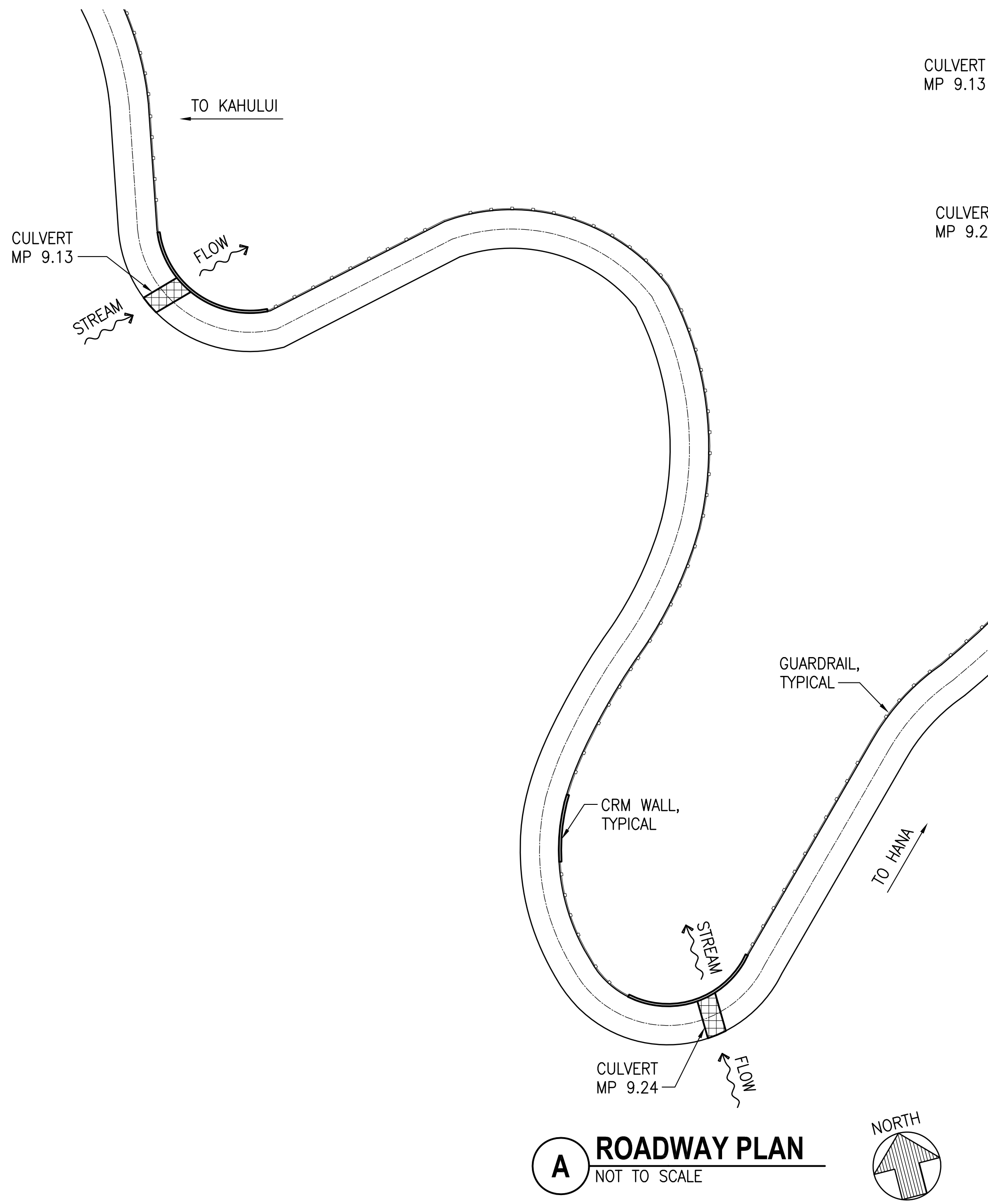
3C	CULVERT MP 9.13			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

View of upstream CRM parapet looking upstream.

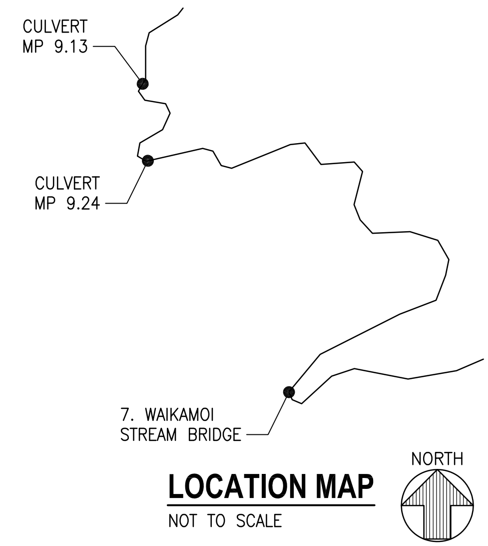
View of downstream CRM parapet looking south-east.

3C	CULVERT MP 9.13						
	Bridge Number:	N/A		**Island:**	Maui		
	Date of Construction:	Unknown		**Route:**	Hana Highway		
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement	

24" diameter RCP inlet at upstream side.



A ROADWAY PLAN
NOT TO SCALE

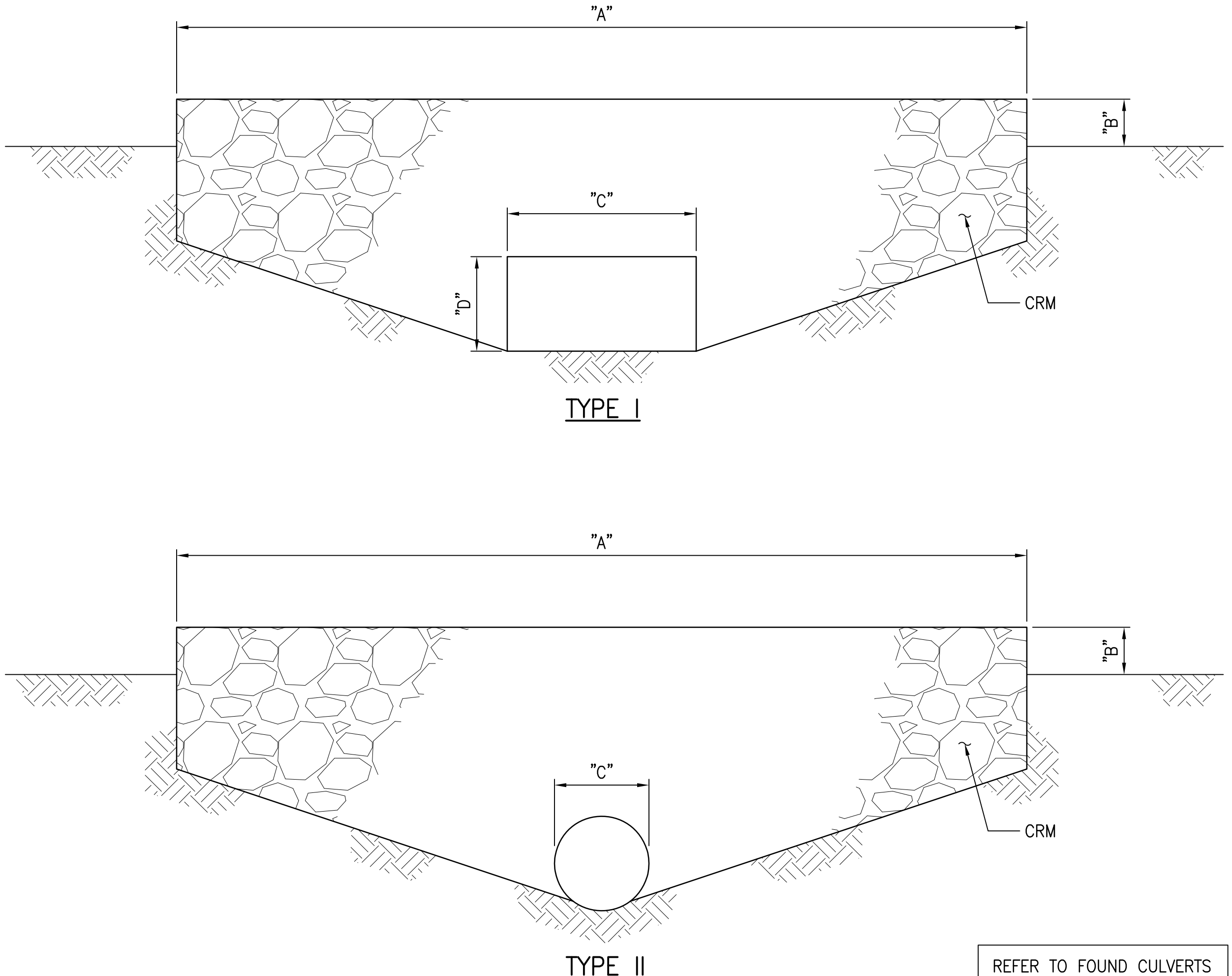


LOCATION MAP
NOT TO SCALE

CULVERT MP 9.13 & CULVERT MP 9.24

Drawing D: 3C-1 & 4C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

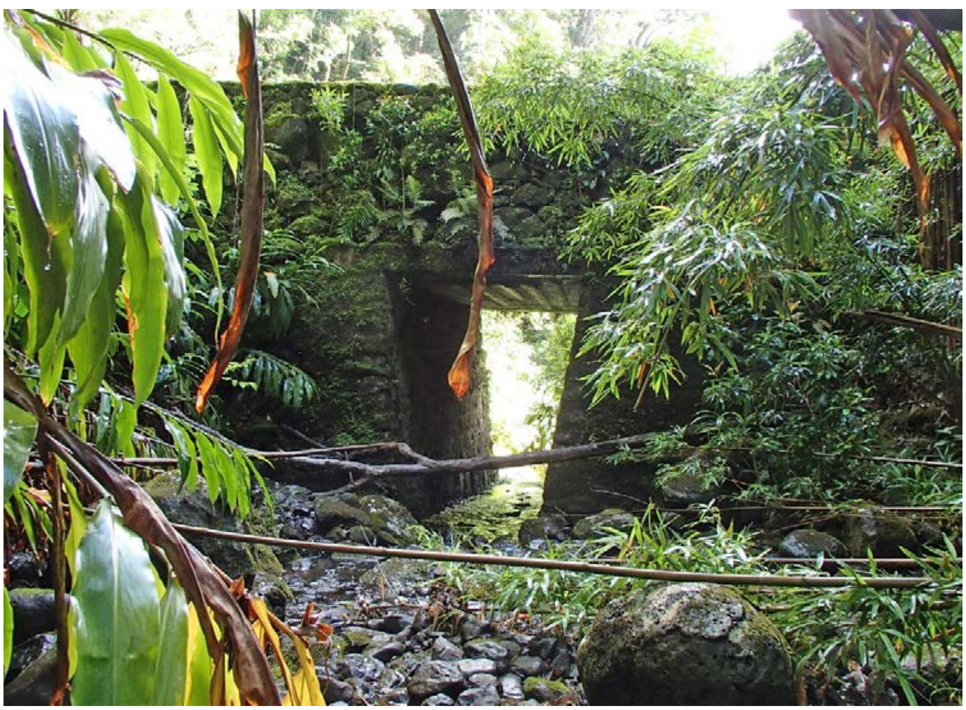
2015

4 C CULVERT MP 9.24

Bridge Number:	N/A	**Island:**	Maui
Date of Construction:	Unknown	**Route:**	Hana Highway

Treatment Recommendations: ☑ Preservation ☑ Rehabilitation ☐ Restoration ☐ Replacement

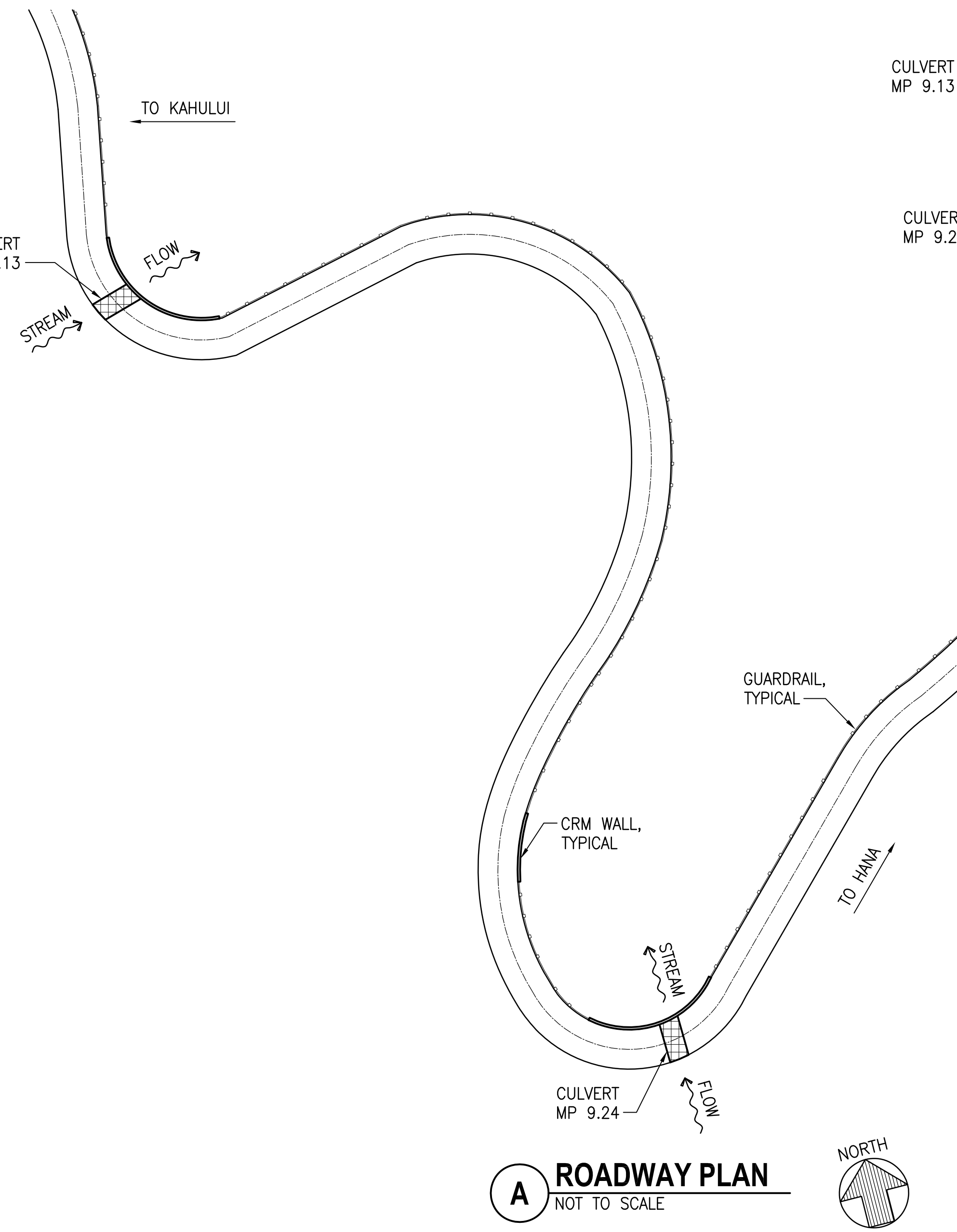
Kahului approach looking toward Hana.



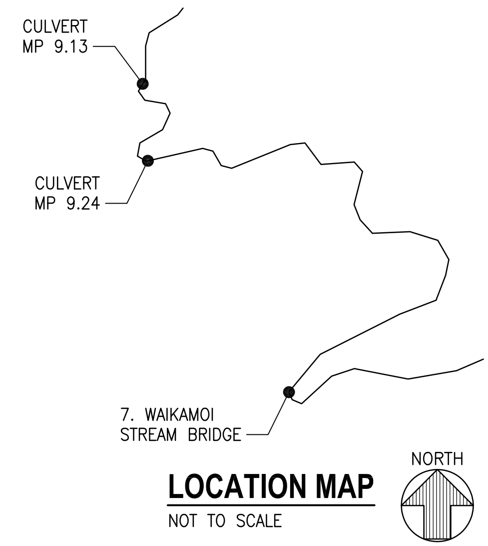
Upstream elevation view of culvert.

4 C	CULVERT MP 9.24			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

Close-up of culvert opening at upstream side.



A ROADWAY PLAN
NOT TO SCALE

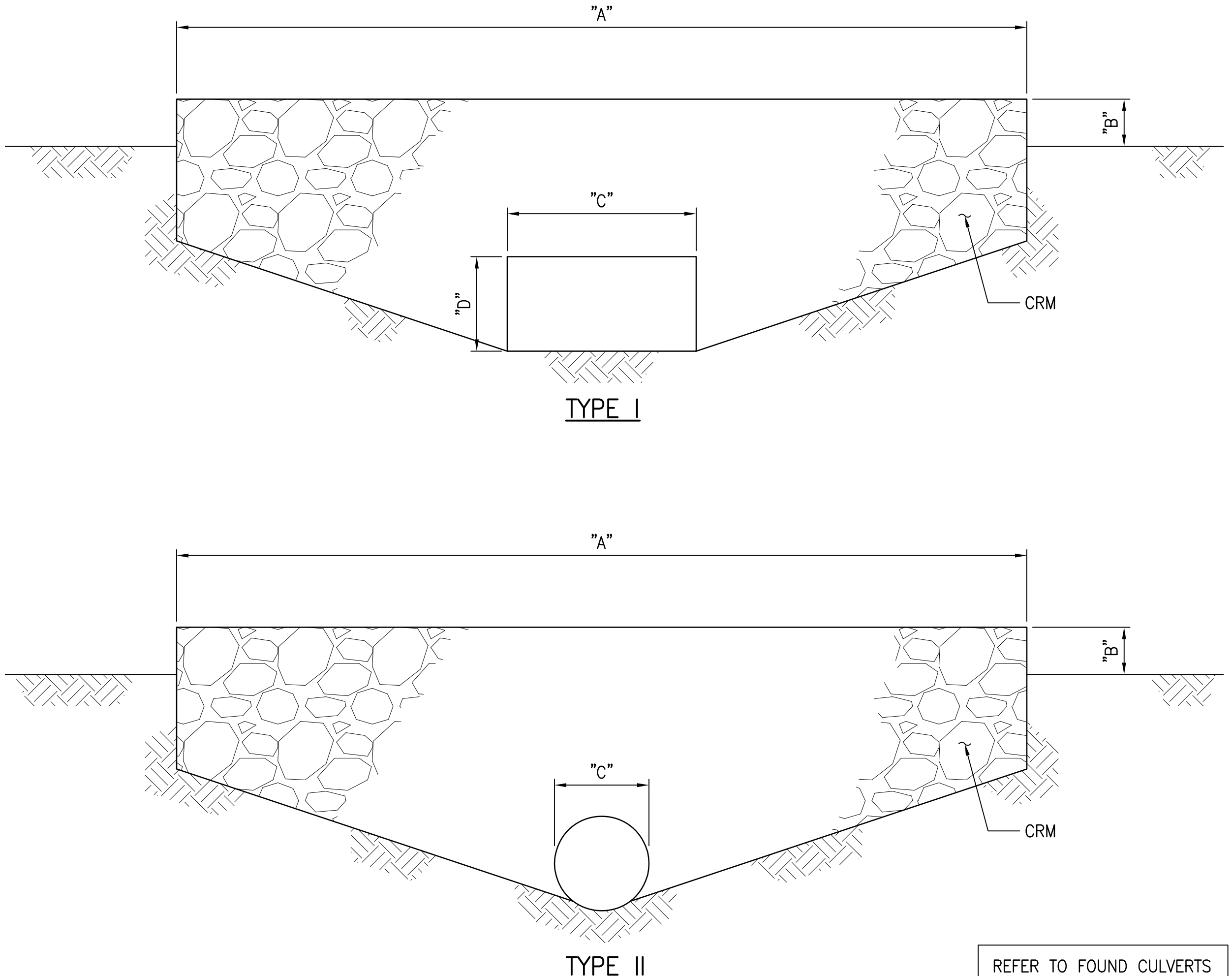


LOCATION MAP
NOT TO SCALE

CULVERT MP 9.13 & CULVERT MP 9.24

Drawing D: 3C-1 & 4C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

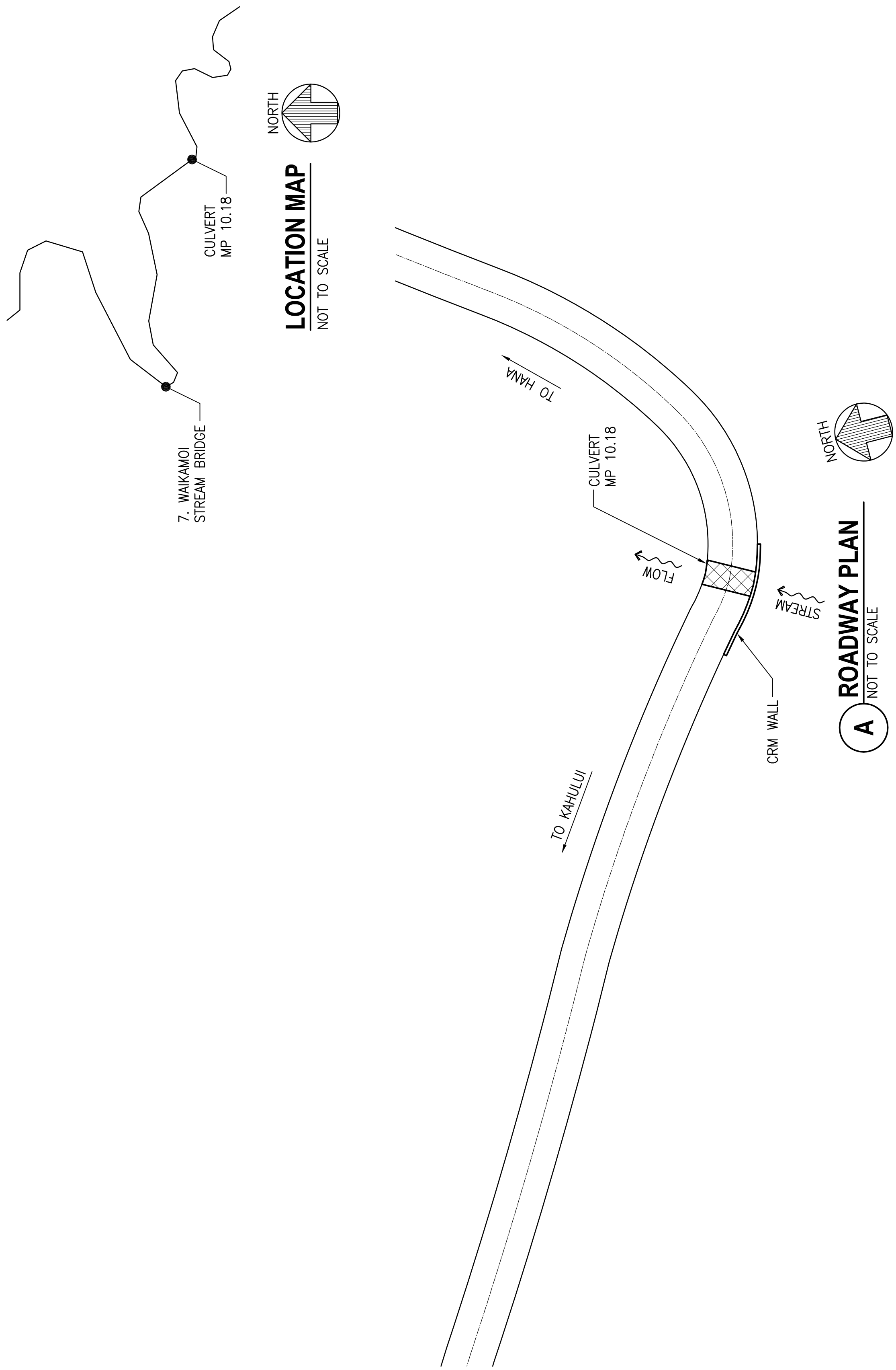
5C	CULVERT MP 10.18			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

View of upstream CRM parapet.

5C	CULVERT MP 10.18			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

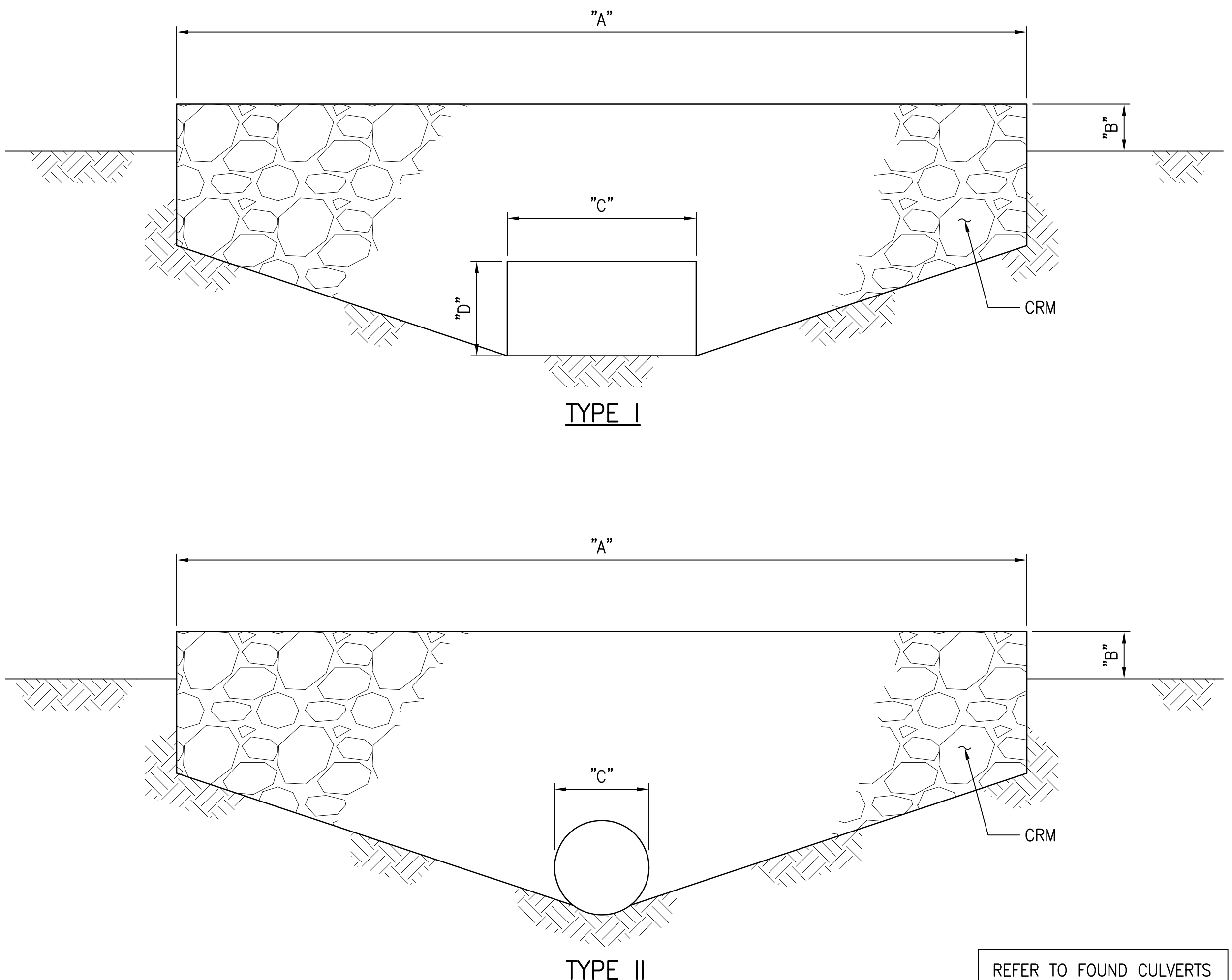
Upstream view through concrete box culvert.



CULVERT MP 10.18

Drawing D: 5C-1

2015



1 **TYPICAL ELEVATION**
NOT TO SCALE

REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

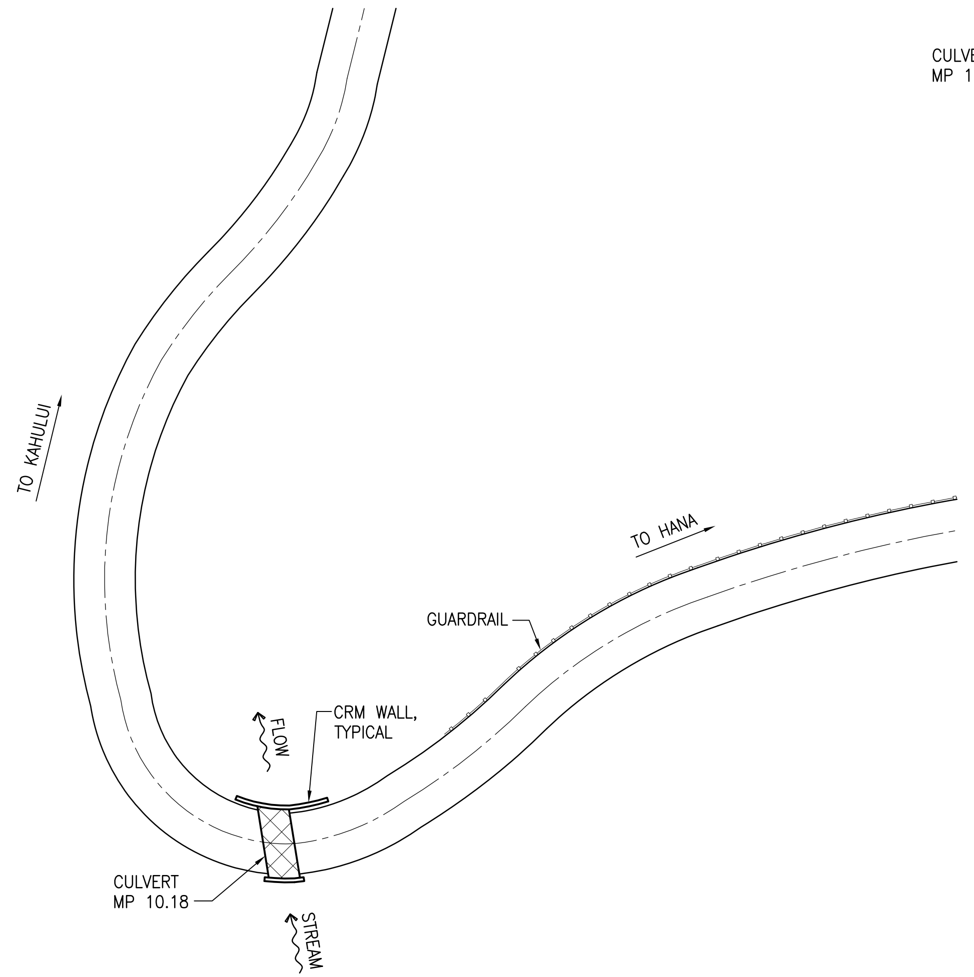
6C	CULVERT MP 10.48					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

Kahului approach looking toward Hana.

Backside view of upstream CRM headwall / parapet.

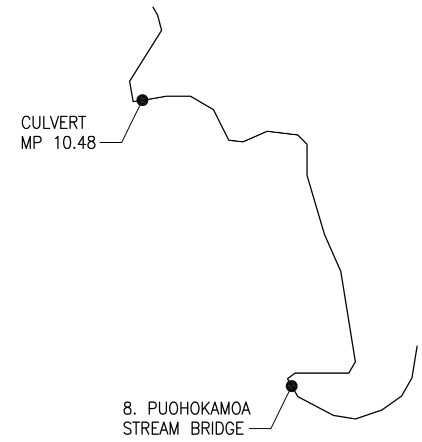
6C	CULVERT MP 10.48				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

Close-up view of upstream culvert opening.



A ROADWAY PLAN
NOT TO SCALE

NORTH



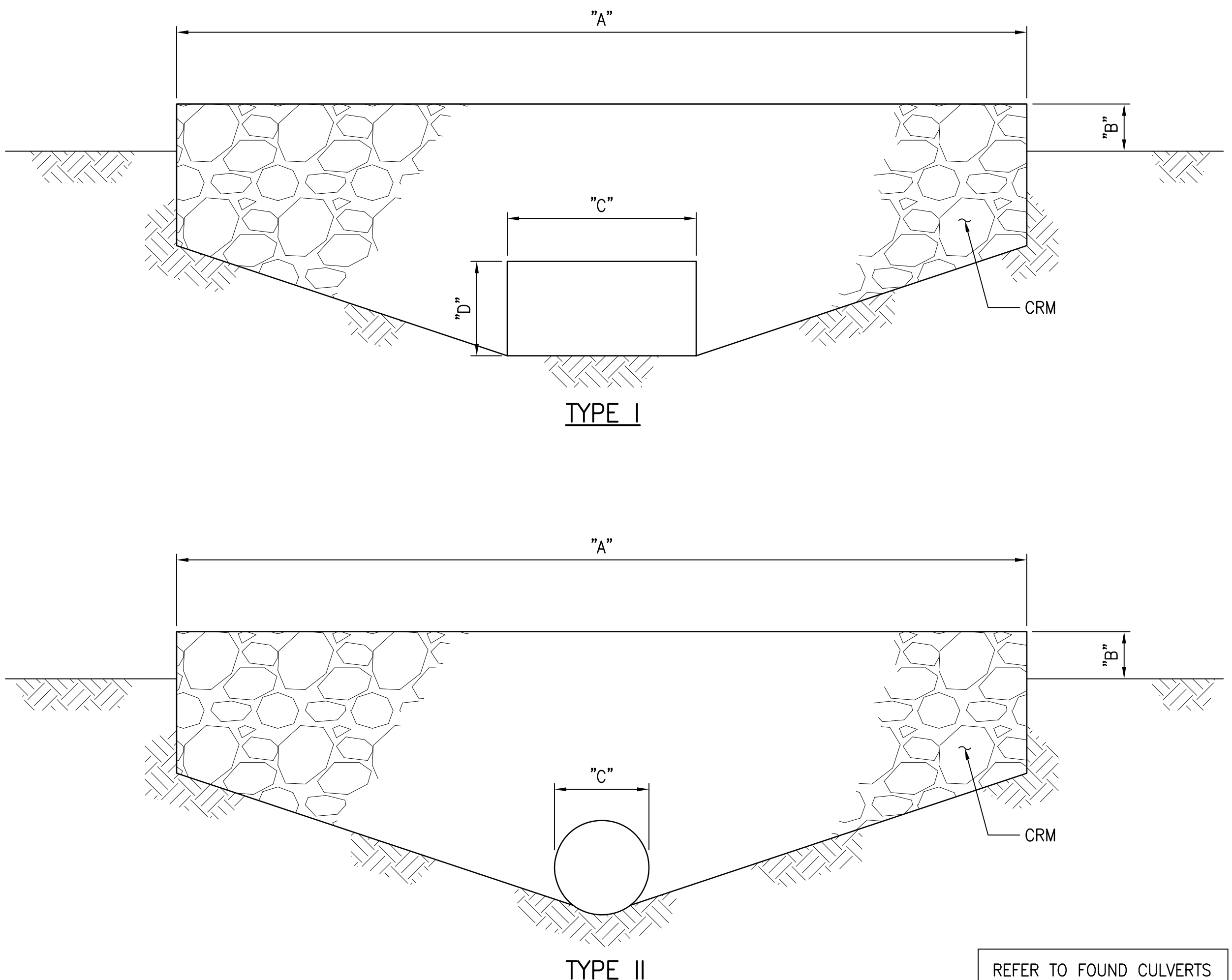
LOCATION MAP
NOT TO SCALE

NORTH

CULVERT MP 10.48

Drawing D: 6C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

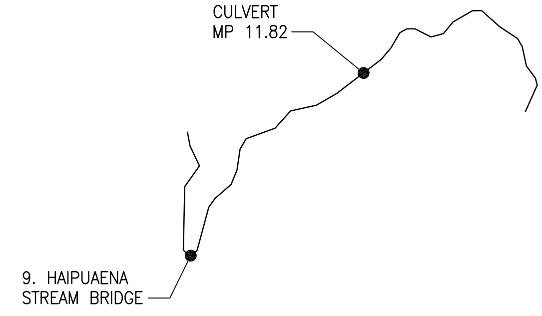
7C	CULVERT MP 11.82				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

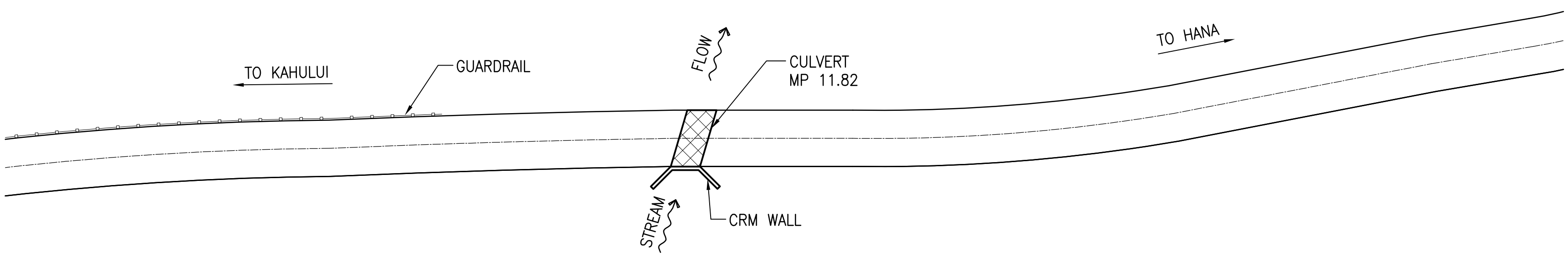
View of upstream CRM parapet.

7C	CULVERT MP 11.82					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

24" diameter RCP inlet at upstream side.



LOCATION MAP
NOT TO SCALE

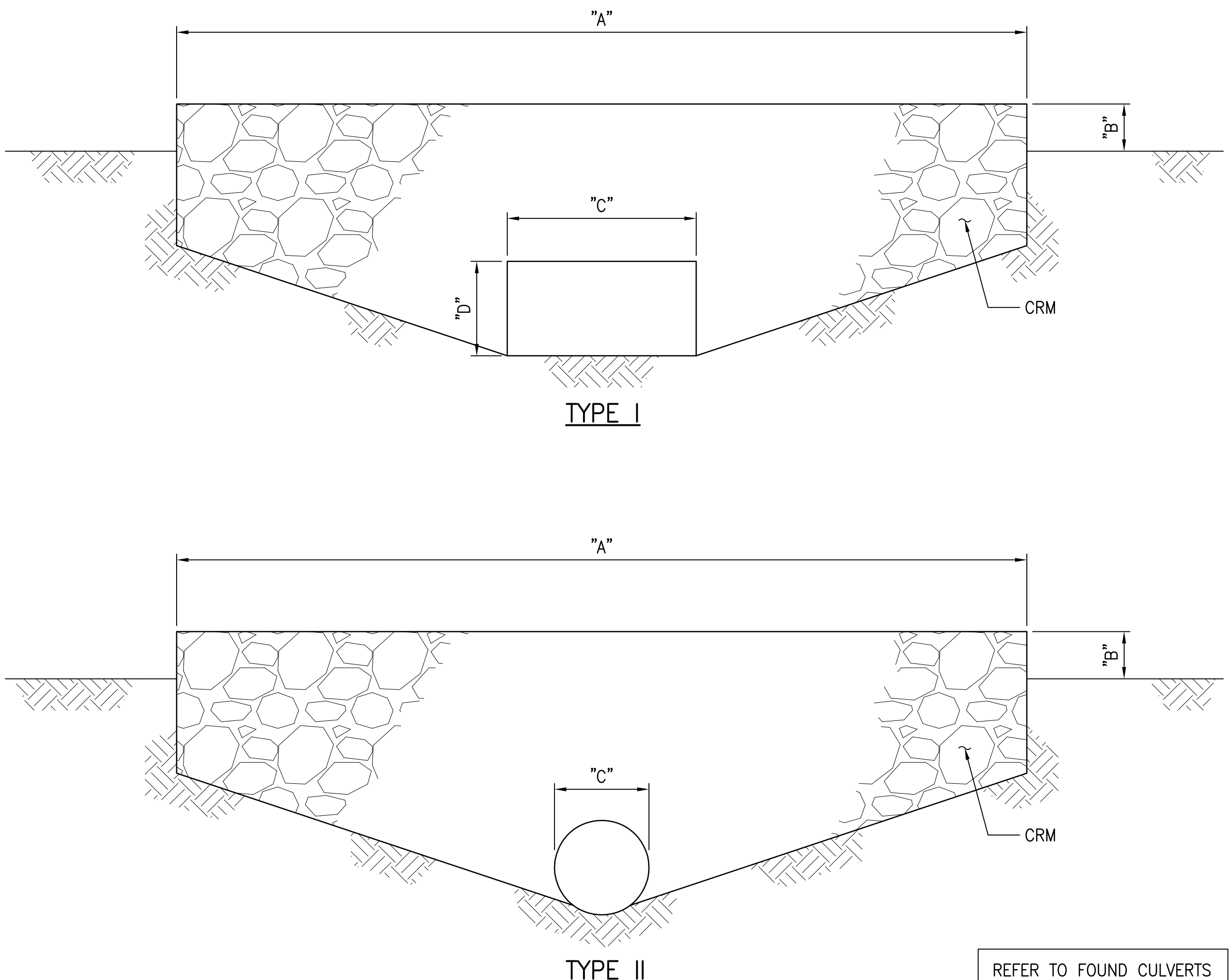


(A) ROADWAY PLAN
NOT TO SCALE

CULVERT MP 11.82

Drawing D: 7C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

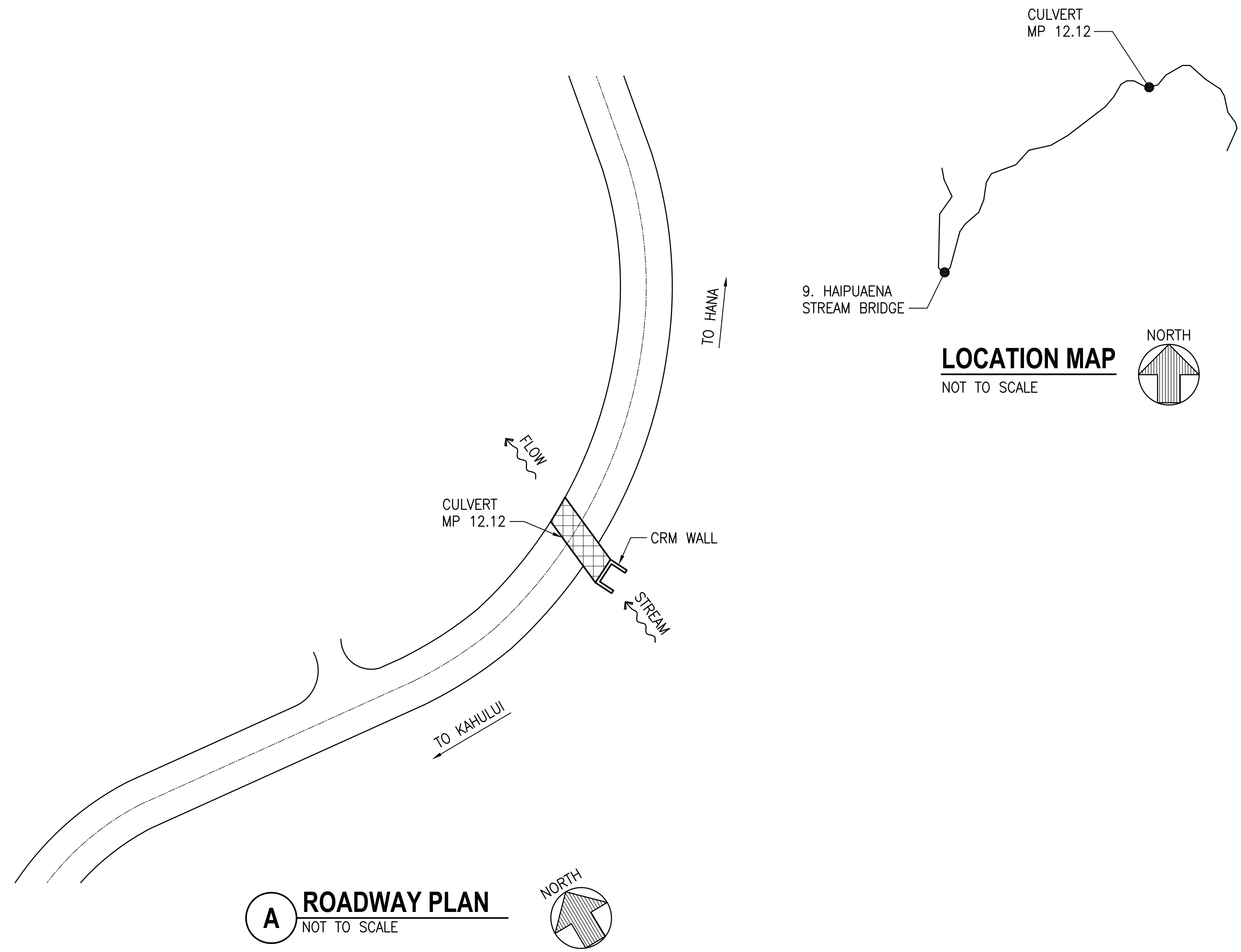
8C	CULVERT MP 12.12					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

Kahului approach looking toward Hana.

View of upstream CRM parapet.

8C	CULVERT MP 12.12			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

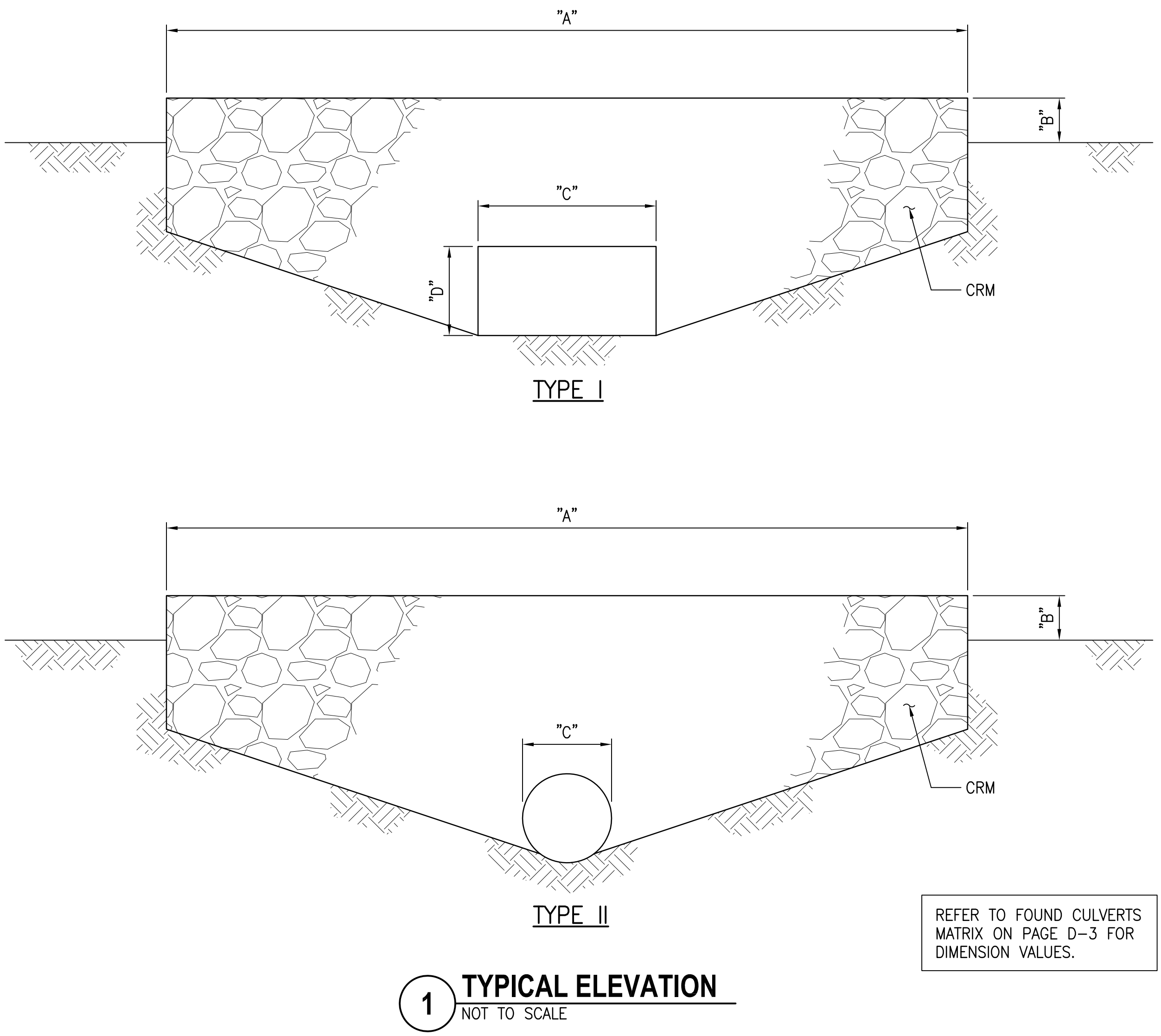
View of upstream CRM headwall / parapet and culvert inlet.



CULVERT MP 12.12

Drawing D: 8C-1

2015



Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

9C CULVERT MP 12.65

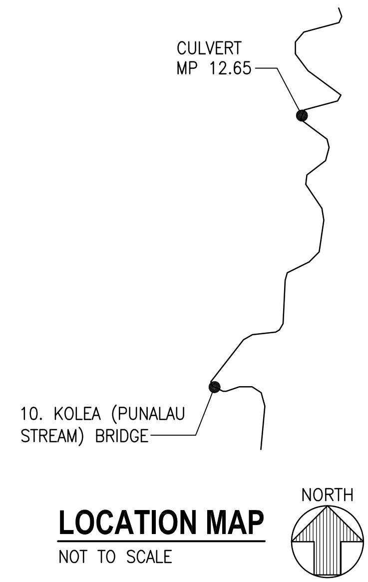
Bridge Number:	N/A	**Island:**	Maui
Date of Construction:	Unknown	**Route:**	Hana Highway
Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

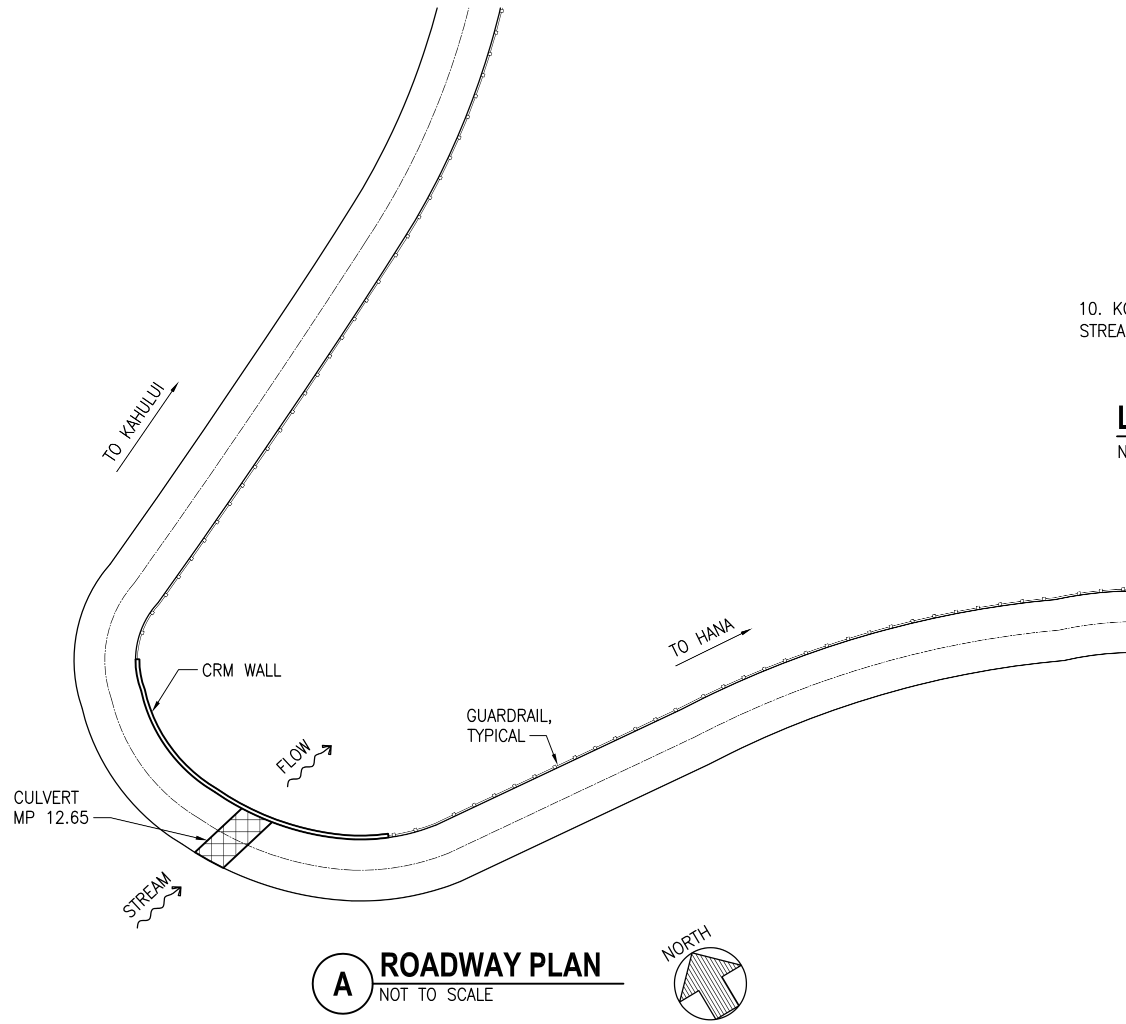
View of downstream CRM parapet looking south-east.

9C	CULVERT MP 12.65				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

24" diameter RCP inlet at upstream side.



LOCATION MAP
NOT TO SCALE

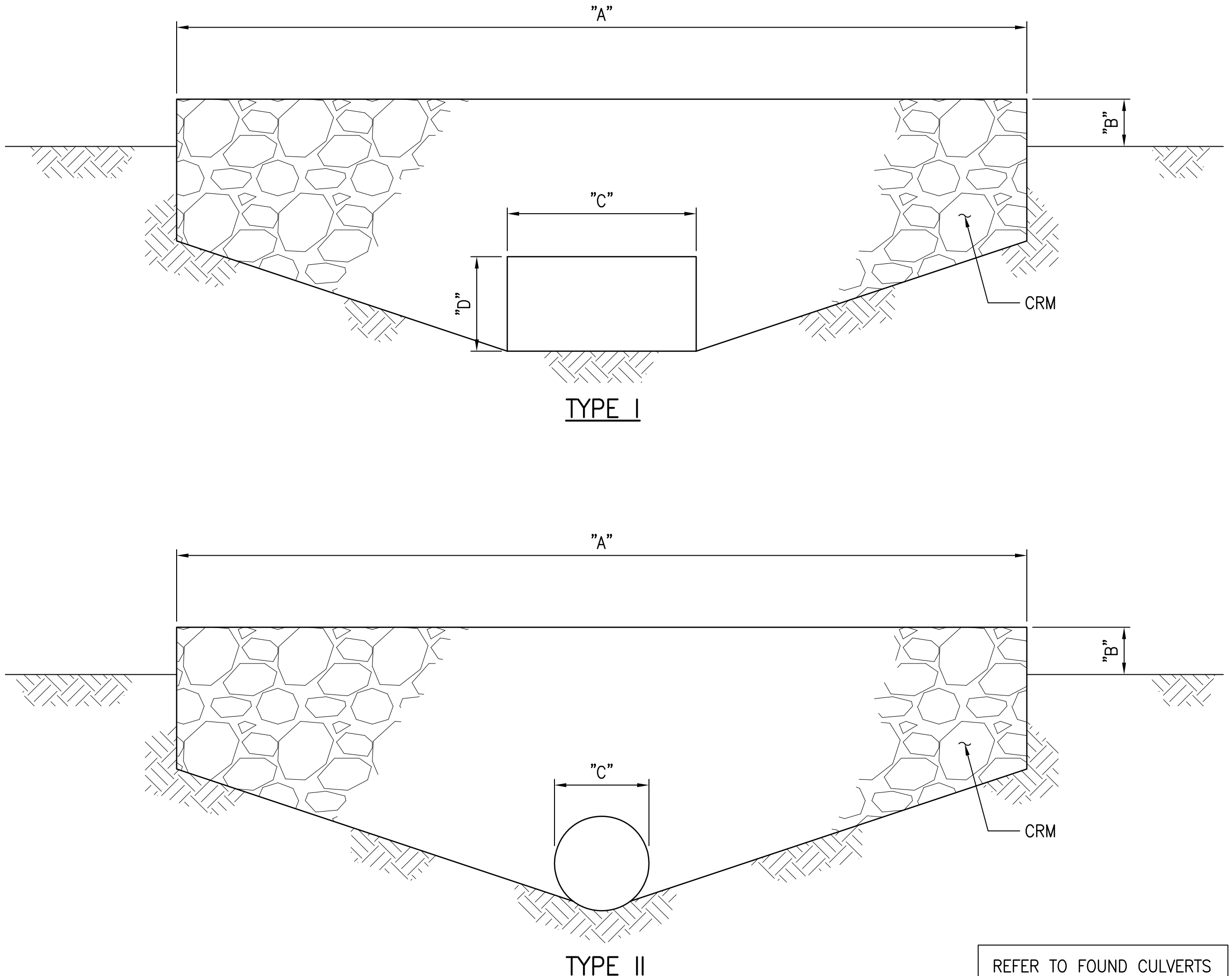


(A) ROADWAY PLAN
NOT TO SCALE

CULVERT MP 12.65

Drawing D: 9C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

10 C	CULVERT MP 14.63				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

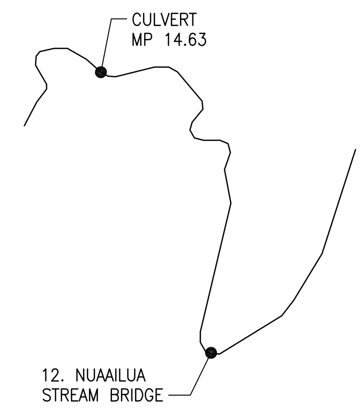
Kahului approach looking toward Hana.

View of upstream metal guardrail.

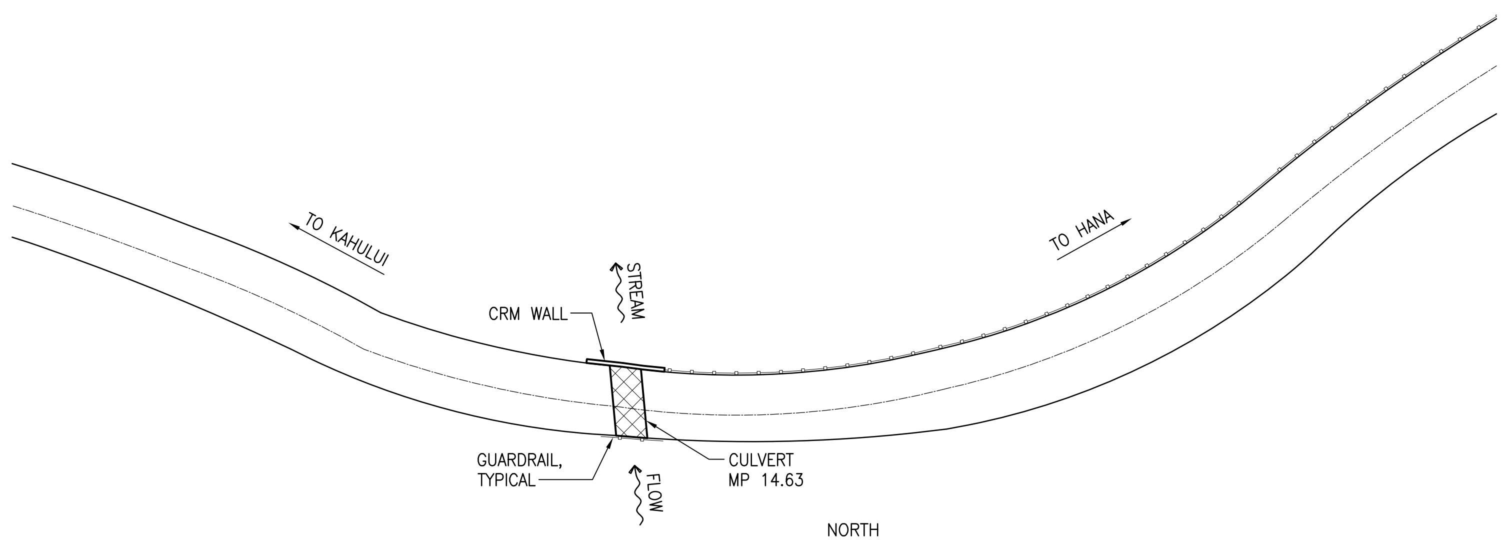
10 C	CULVERT MP 14.63			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream CRM parapet.

View through culvert from the upstream end.

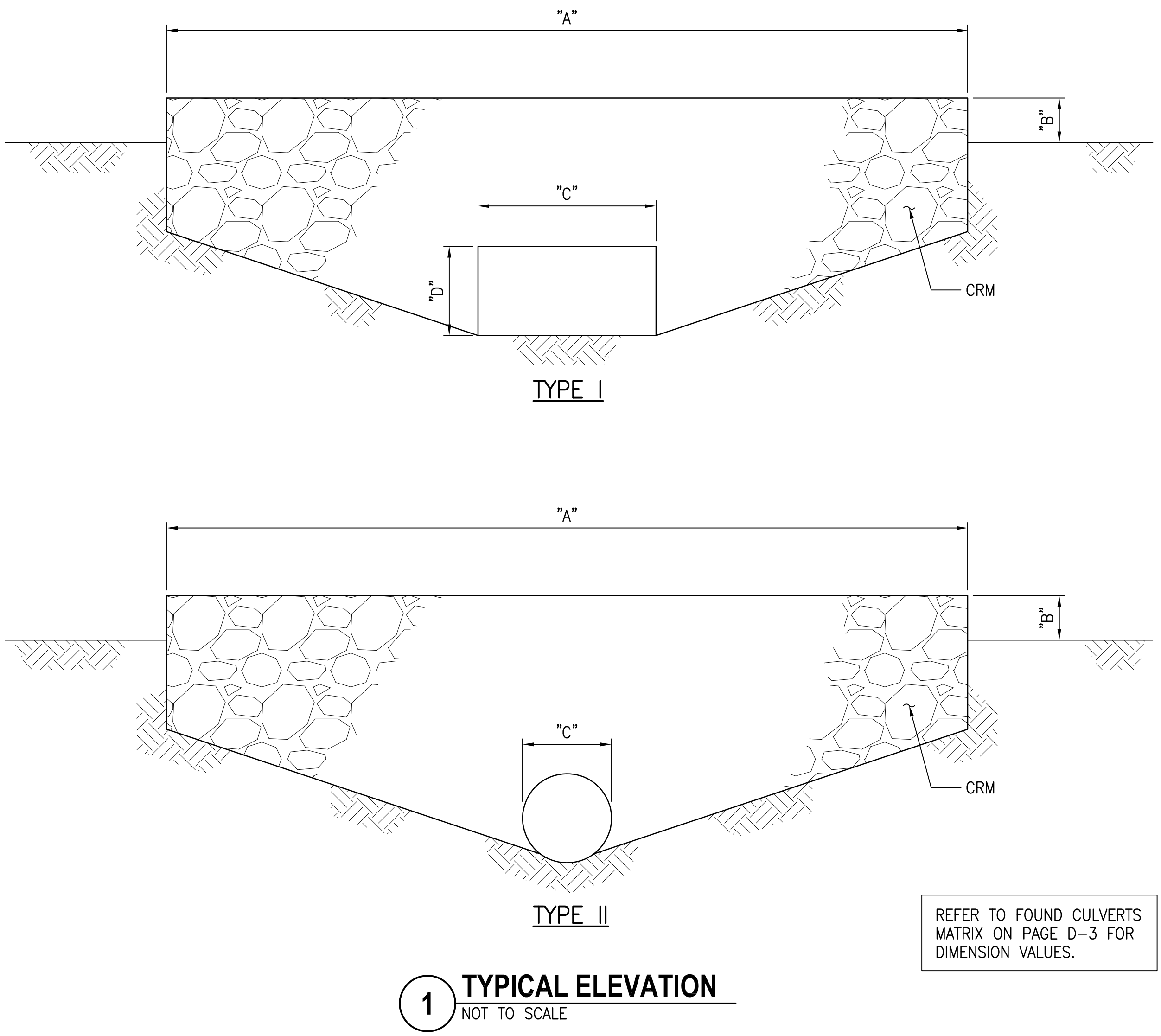


LOCATION MAP
NOT TO SCALE



A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 14.63	Drawing D: 10C-1
	2015



Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

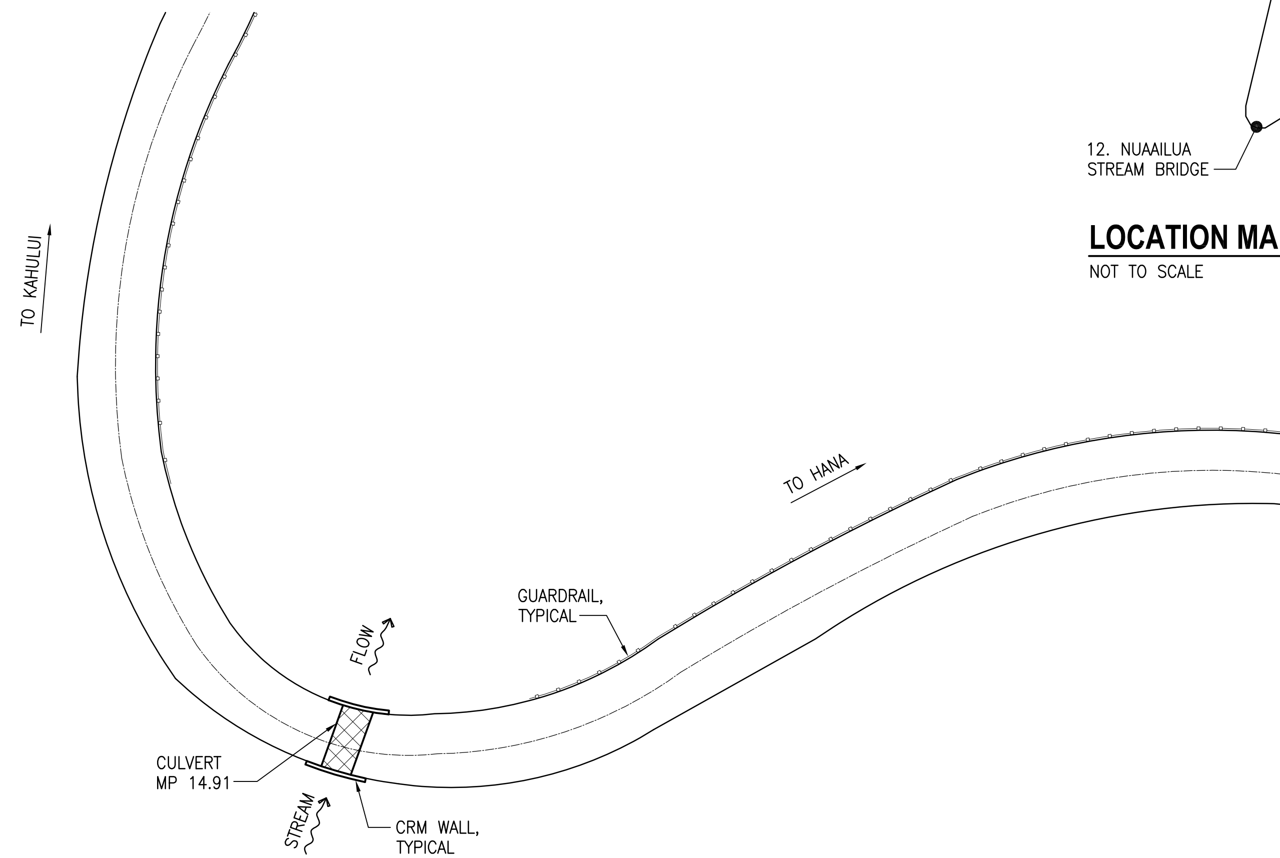
11 C	CULVERT MP 14.91				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

View of upstream CRM parapet.

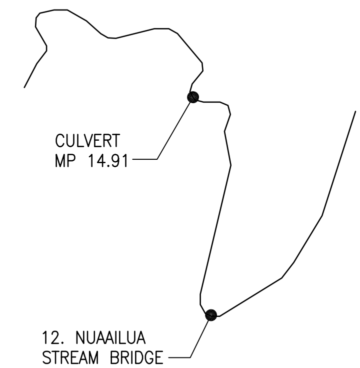
11 C	CULVERT MP 14.91				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

Upstream elevation of CRM parapet. Note: Nothing could be seen per description on as-builts.



A ROADWAY PLAN
NOT TO SCALE

NORTH



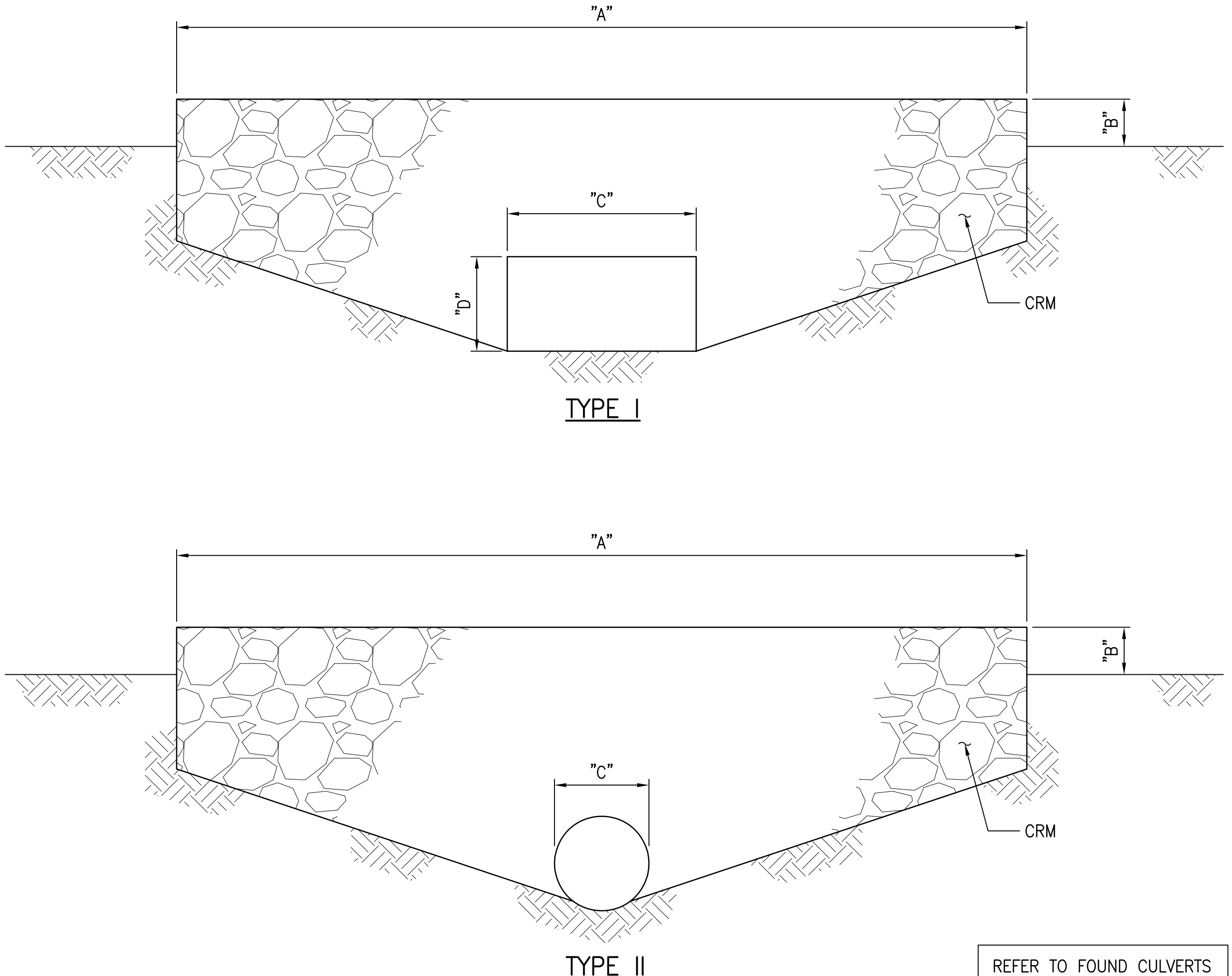
LOCATION MAP
NOT TO SCALE

NORTH

CULVERT MP 14.91

Drawing D: 11C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

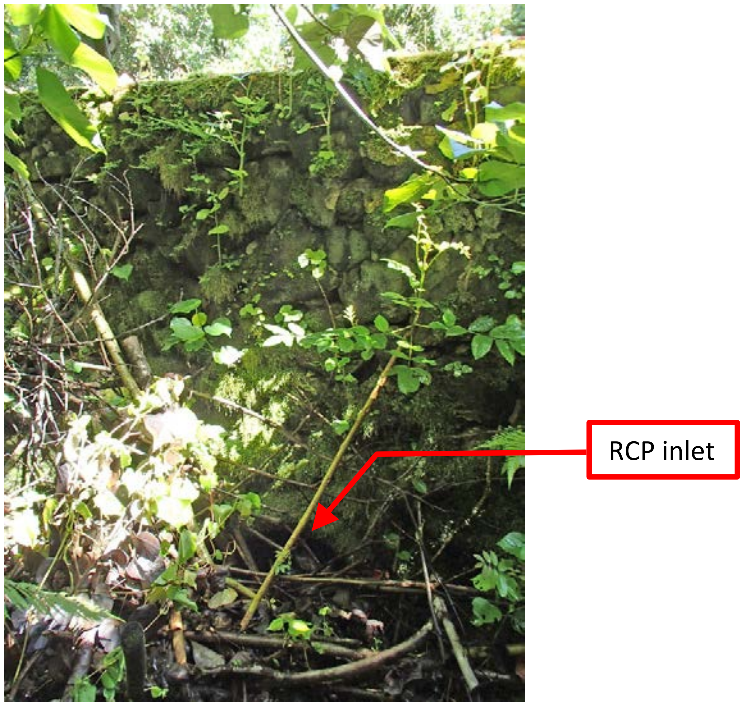
12 C	CULVERT MP 15.40				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

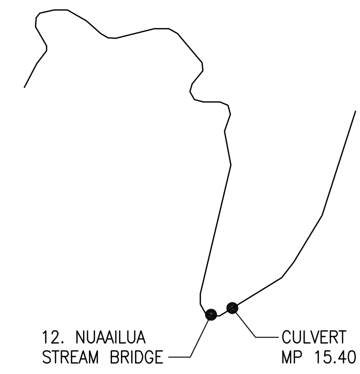
View of upstream CRM parapet.

12 C	CULVERT MP 15.40				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

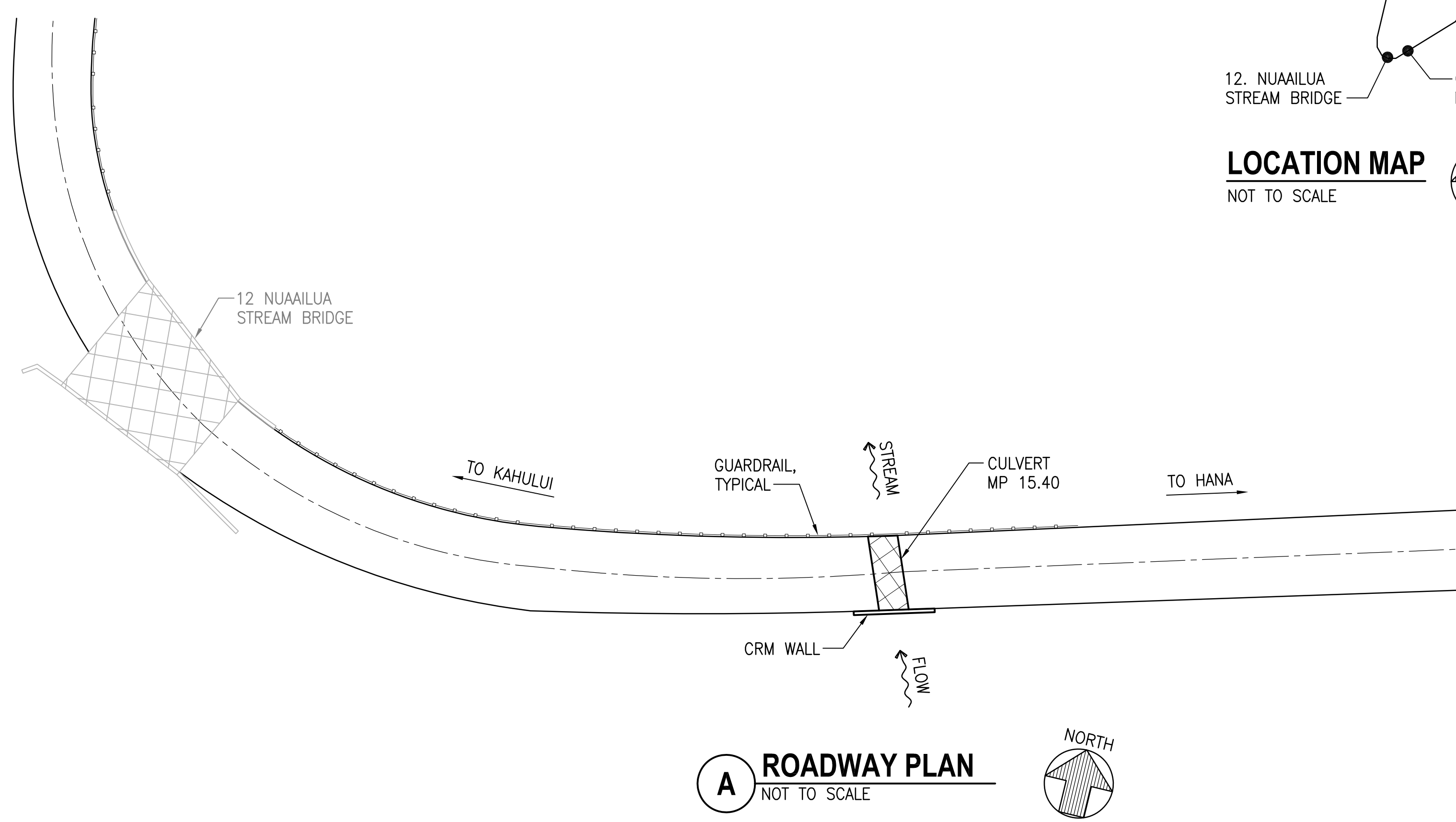
View of downstream metal guardrail.



View of upstream CRM headwall / parapet and 24" diameter RCP inlet.



LOCATION MAP
NOT TO SCALE

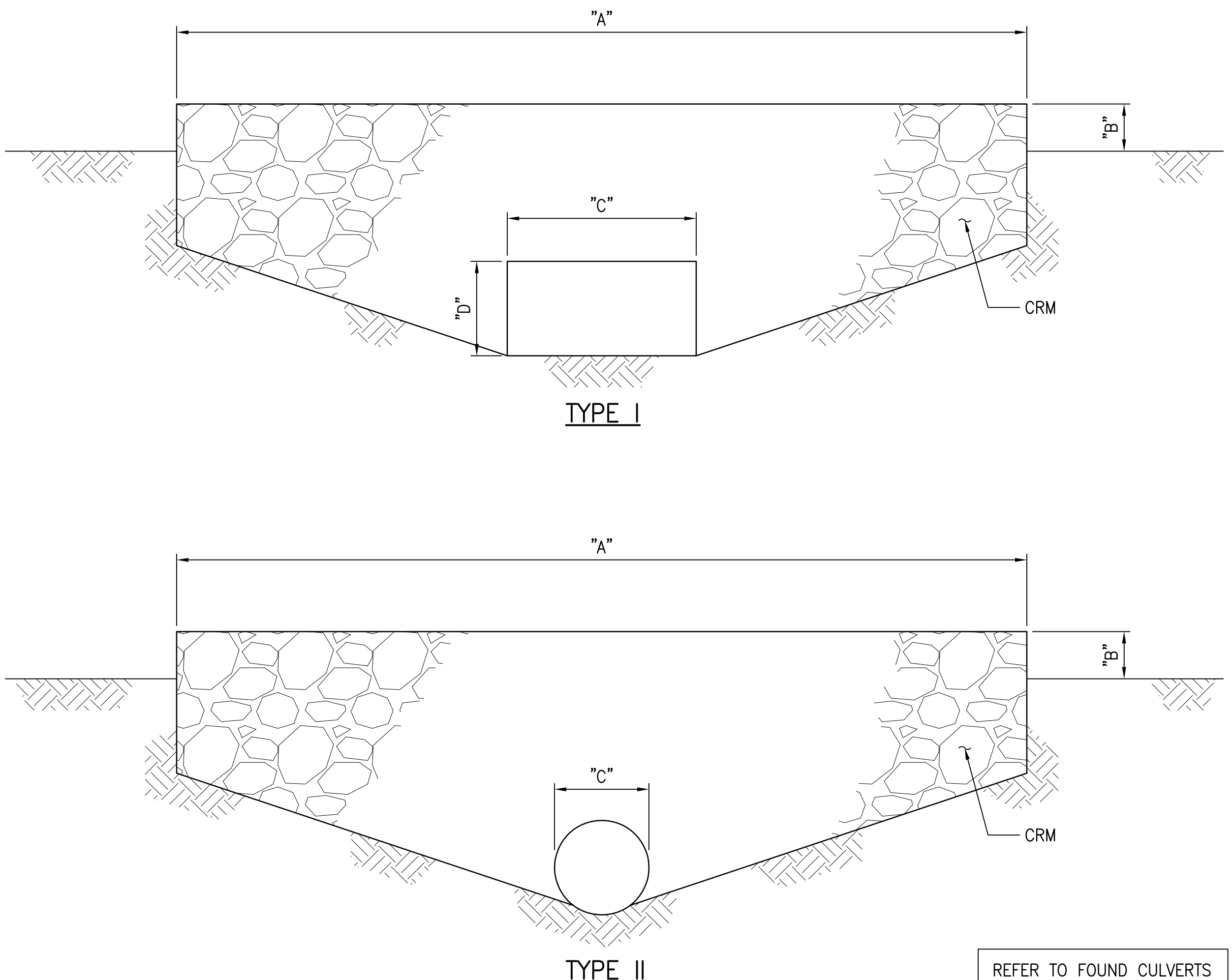


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 15.40

Drawing D: 12C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

13 C	CULVERT MP 16.06				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

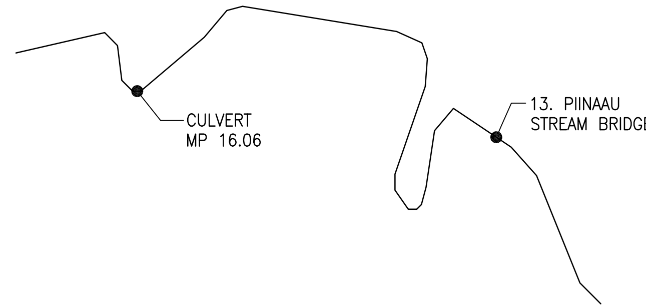
Kahului approach looking toward Hana.

View of upstream CRM parapet.

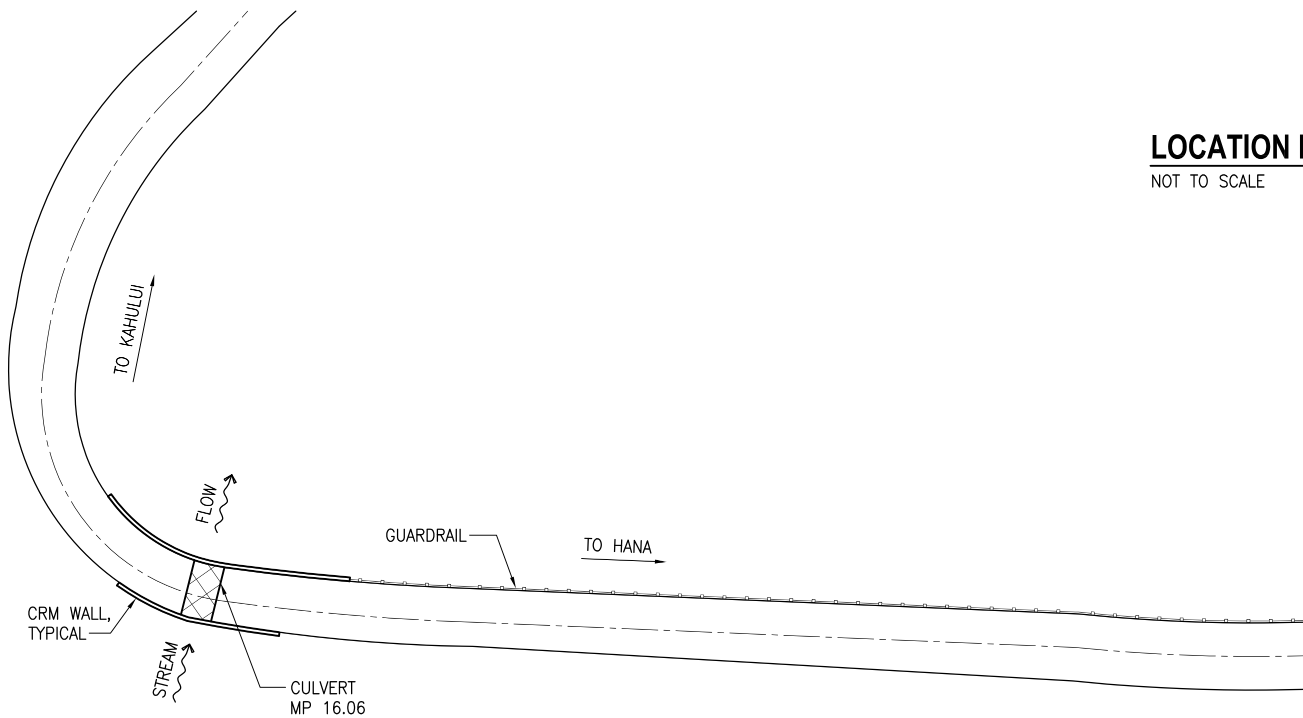
13 C	CULVERT MP 16.06					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream CRM parapet.

View looking downstream through culvert.



LOCATION MAP
NOT TO SCALE

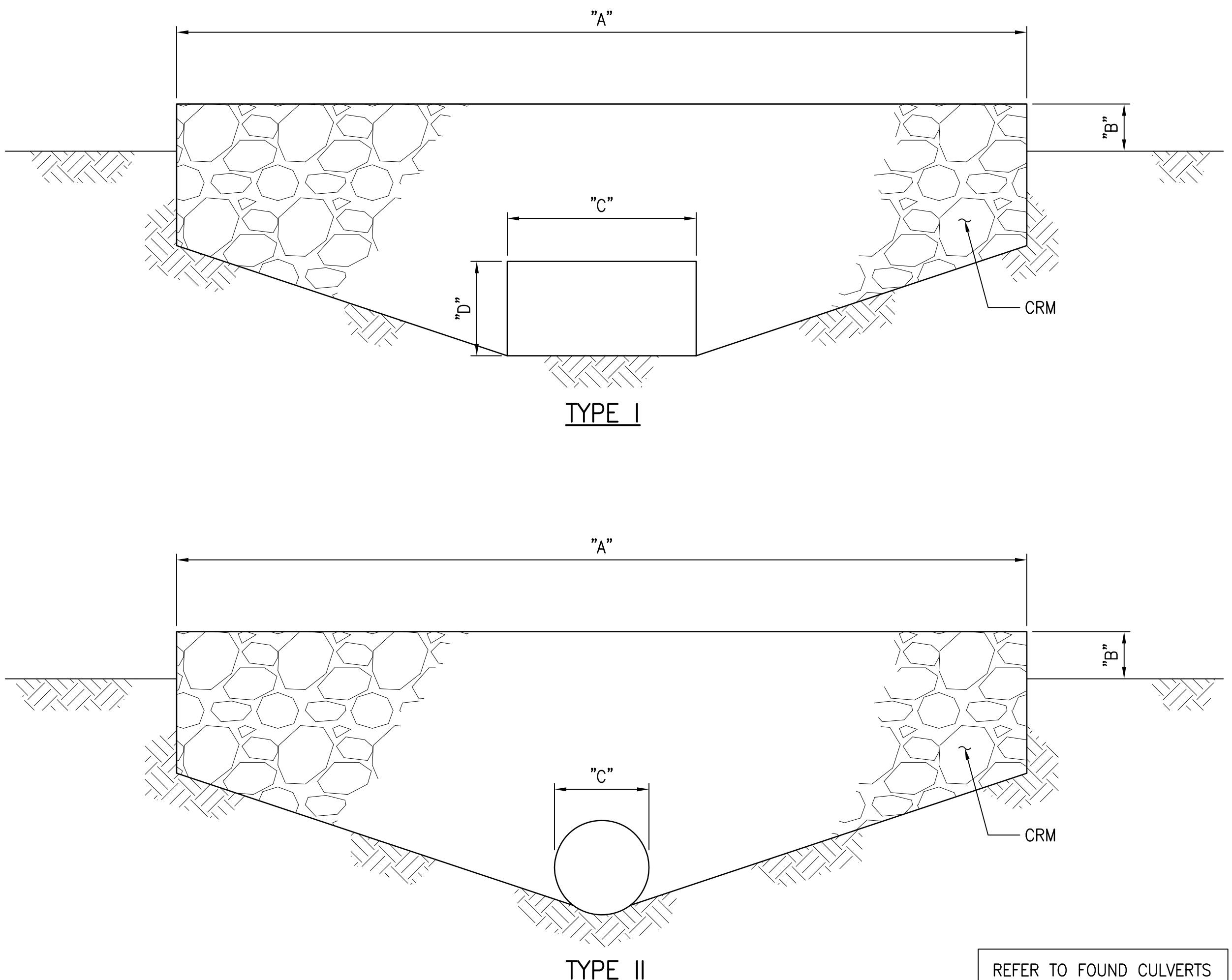


(A) ROADWAY PLAN
NOT TO SCALE

CULVERT MP 16.06

Drawing D: 13C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

14 C	CULVERT MP 17.03					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

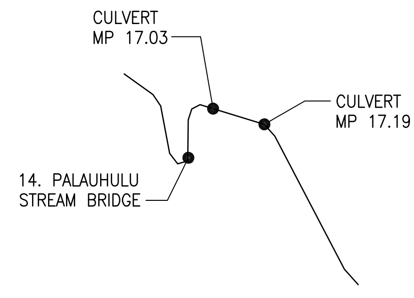
Kahului approach looking toward Hana.

View of upstream CRM parapet.

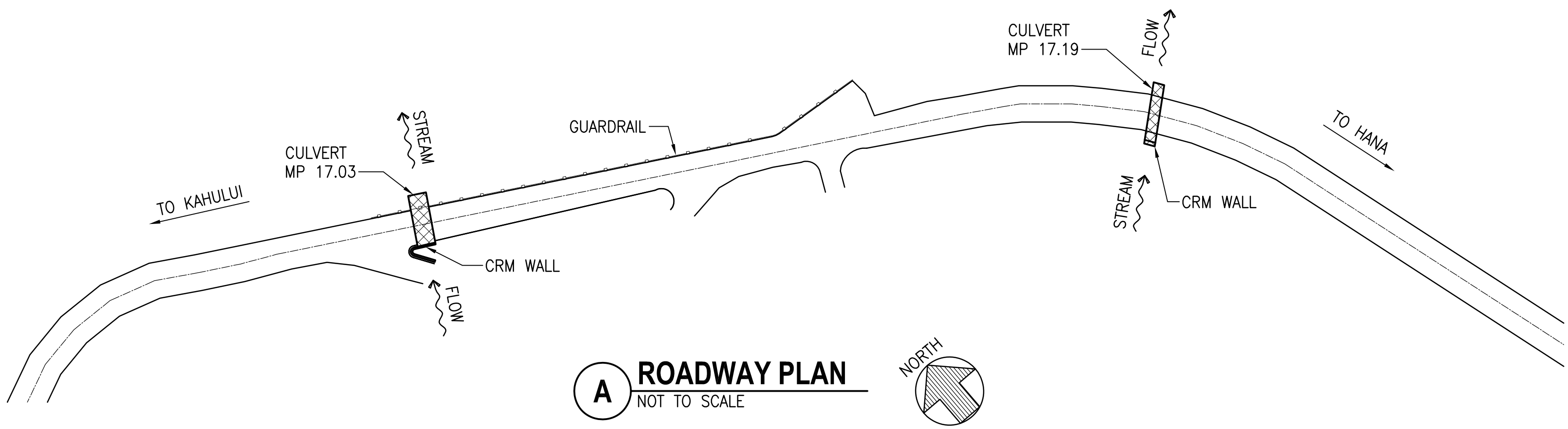
14 C	CULVERT MP 17.03			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream metal guardrail.

24" diameter RCP inlet at upstream side. Upstream / Hana corner of CRM parapet is damaged.



LOCATION MAP
NOT TO SCALE

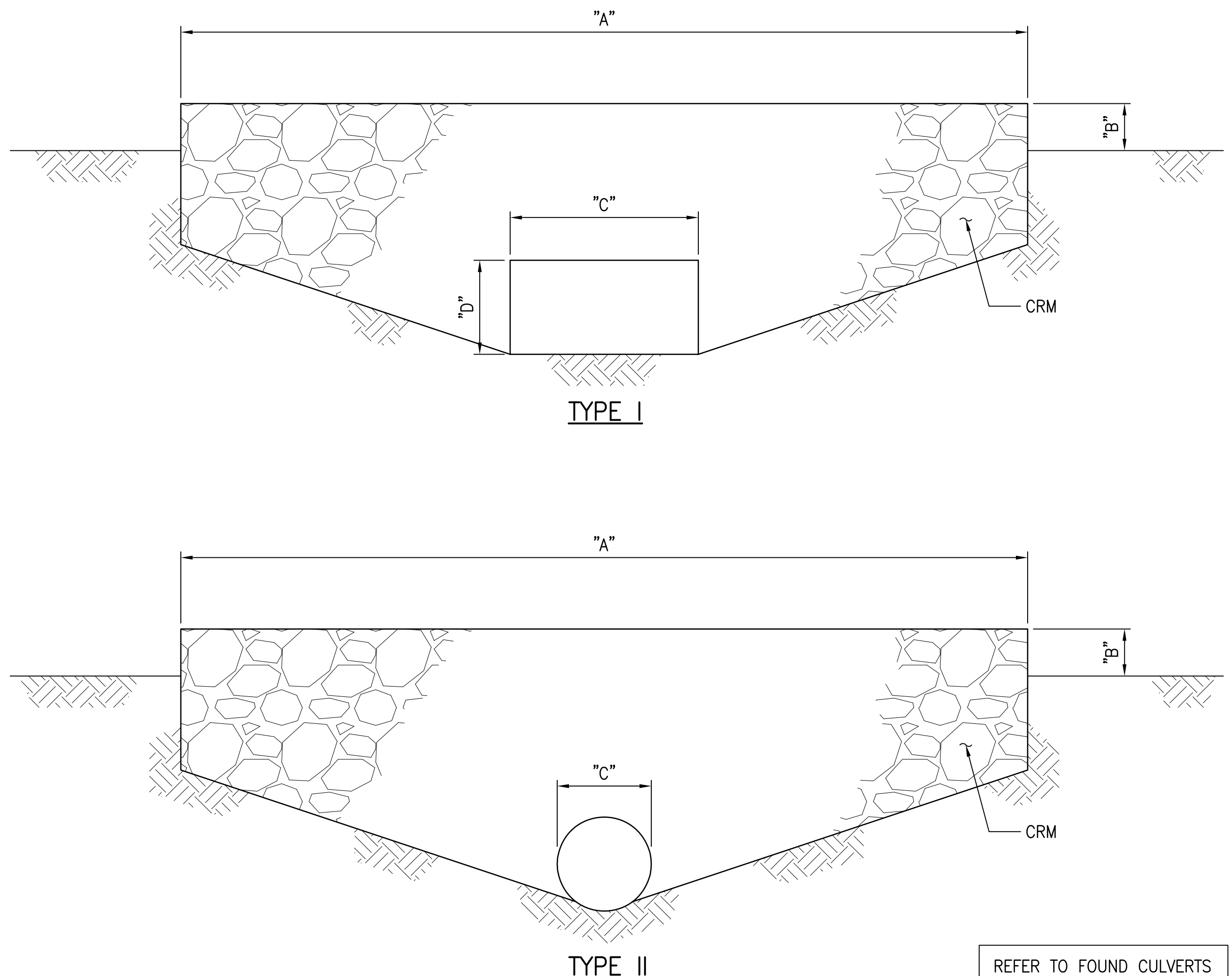


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 17.03 & CULVERT MP 17.19

Drawing D: 14C-1 & 15C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 TYPICAL ELEVATION
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

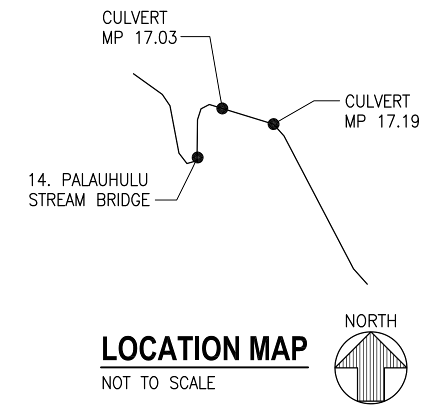
15 C	CULVERT MP 17.19				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

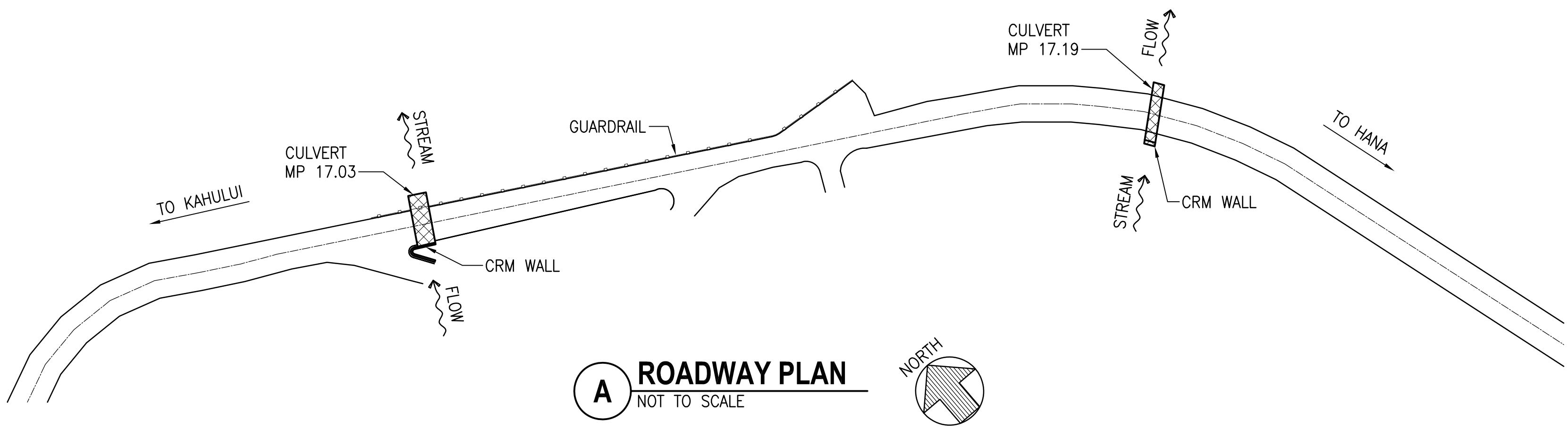
View of upstream CRM parapet.

15 C	CULVERT MP 17.19					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of upstream CRM headwall / parapet and 24" diameter RCP inlet.



LOCATION MAP
NOT TO SCALE

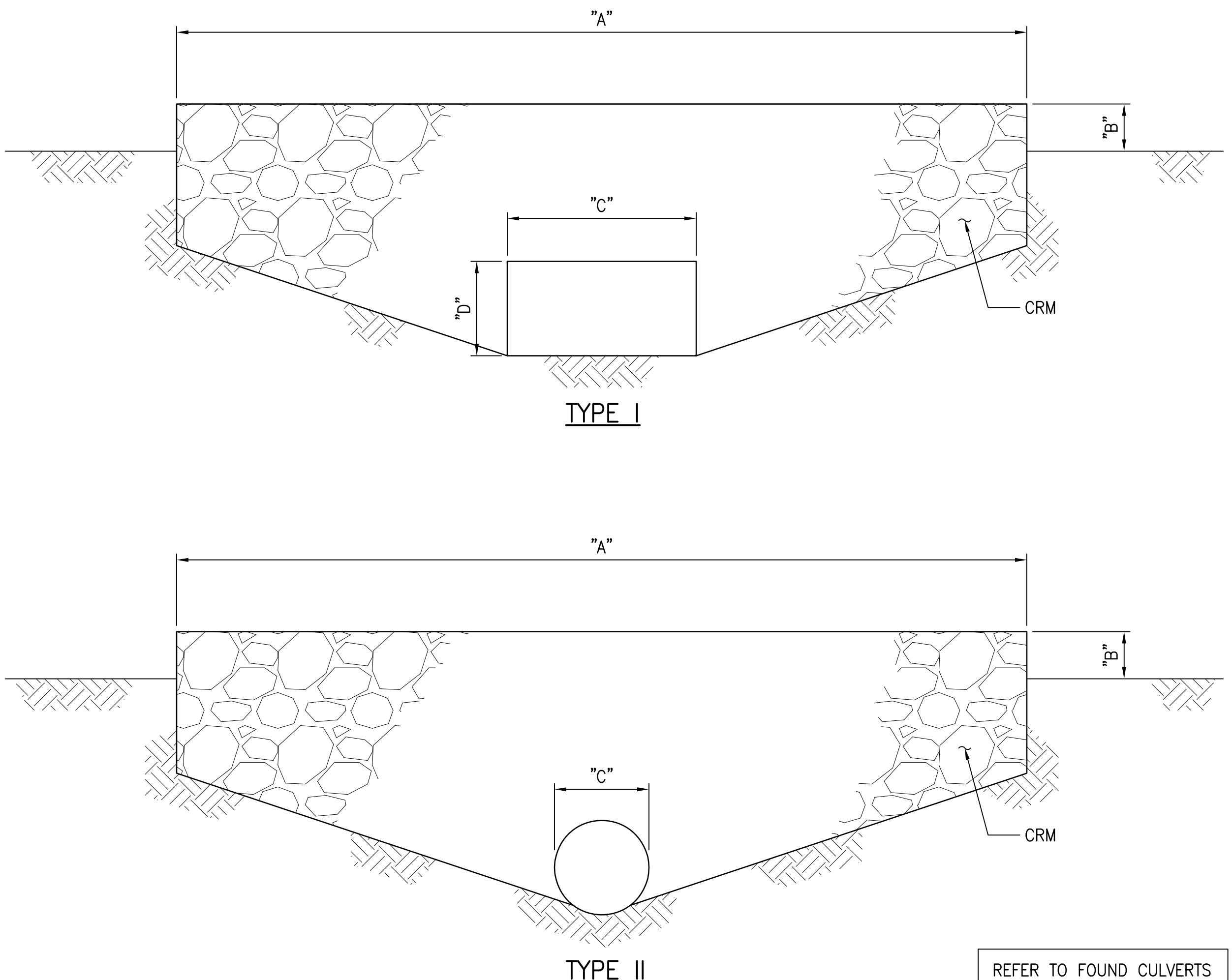


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 17.03 & CULVERT MP 17.19

Drawing D: 14C-1 & 15C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

16 C	CULVERT MP 17.27					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

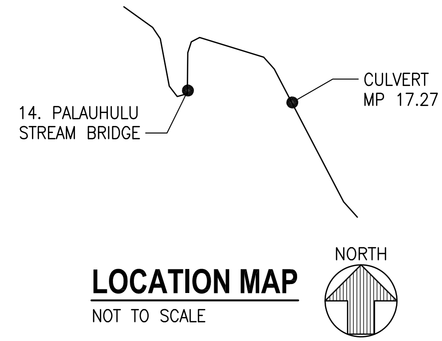
Kahului approach looking toward Hana.

View of chains and posts above upstream culvert.

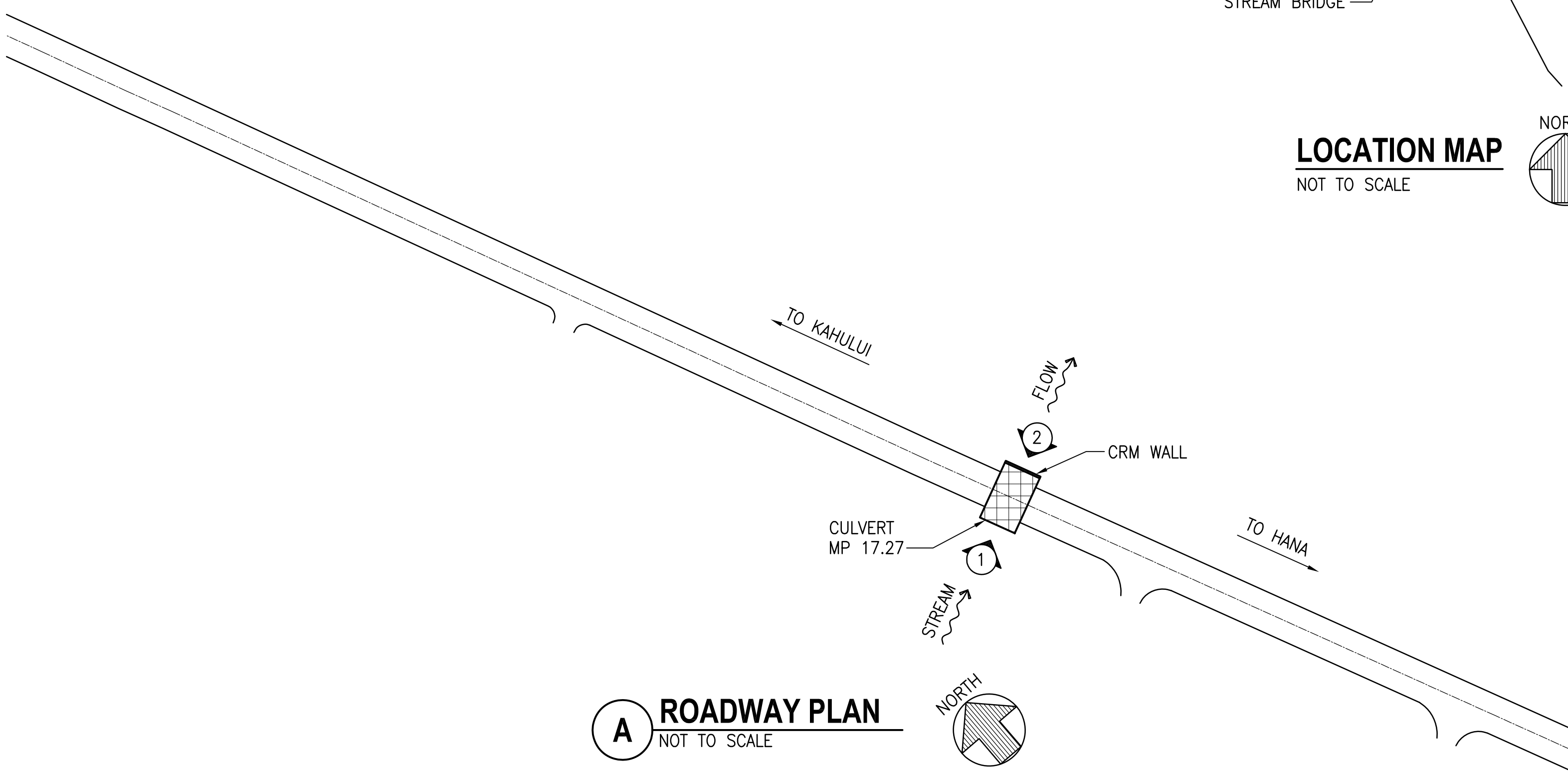
16 C	CULVERT MP 17.27					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream CRM pararpet.

3 - 42" diameter and 1 - 24" diameter RCP inlets at upstream side.



LOCATION MAP
NOT TO SCALE

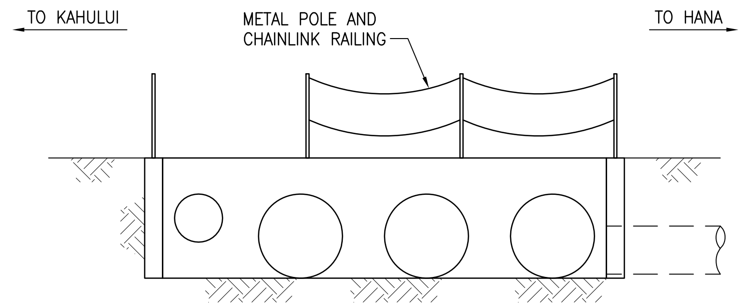


A ROADWAY PLAN
NOT TO SCALE

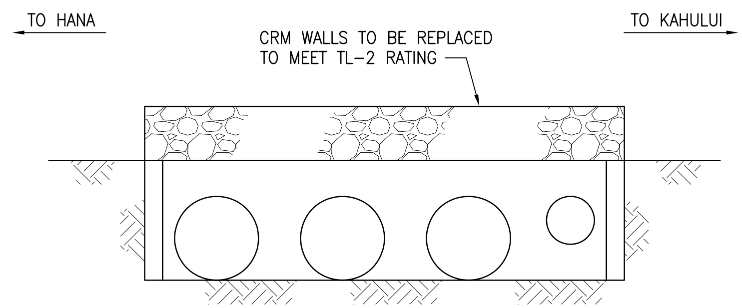
CULVERT MP 17.27

Drawing D: 16C-1

2015



1 **UPSTREAM ELEVATION**
NOT TO SCALE



2 **DOWNSTREAM ELEVATION**
NOT TO SCALE

CULVERT MP 17.27

Drawing D: 16C-2

2015

17 C	CULVERT MP 17.31				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

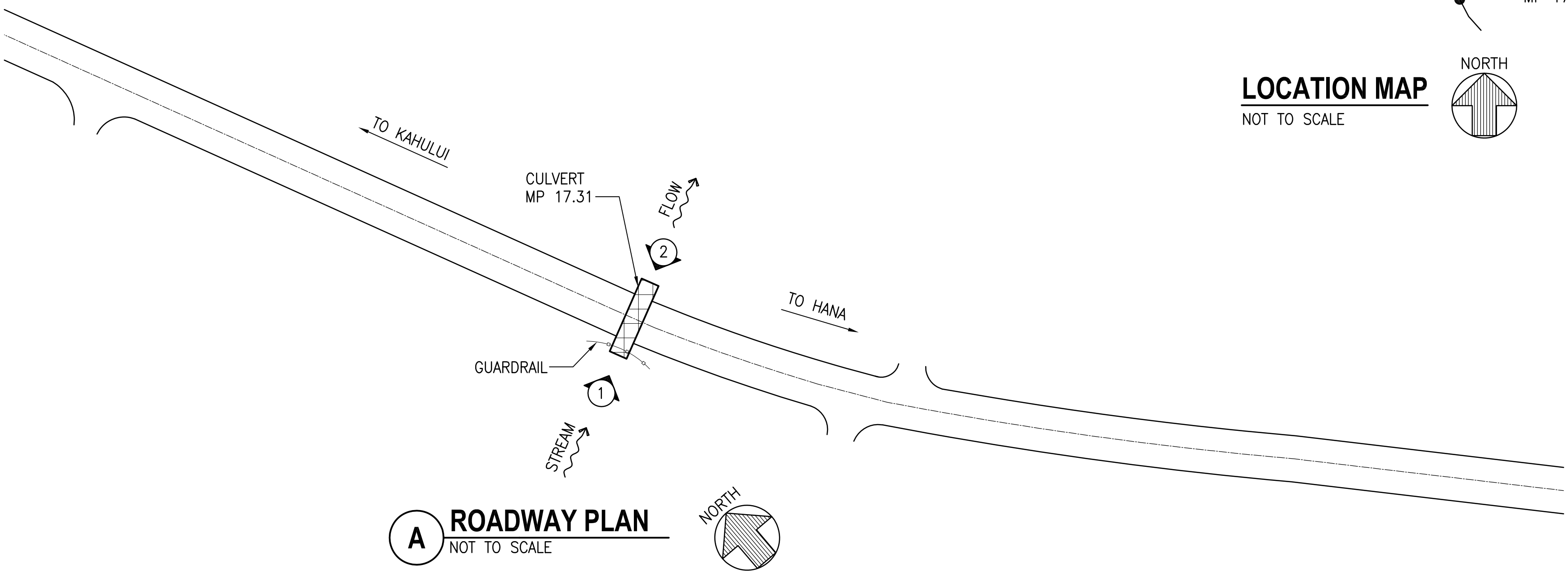
Kahului approach looking toward Hana.

View of upstream metal guardrail.

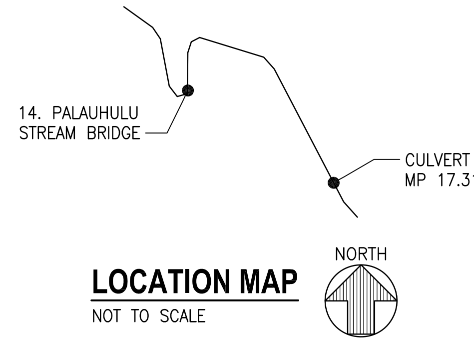
17 C	CULVERT MP 17.31					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

1 - 24" diameter and 1- 36" diameter RCP inlets in upstream CRM headwall.

1 - 36" diameter and 1 - 24" diameter RCP outlets in downstream CRM headwall. 24" outlet is filled with debris.



A ROADWAY PLAN
NOT TO SCALE

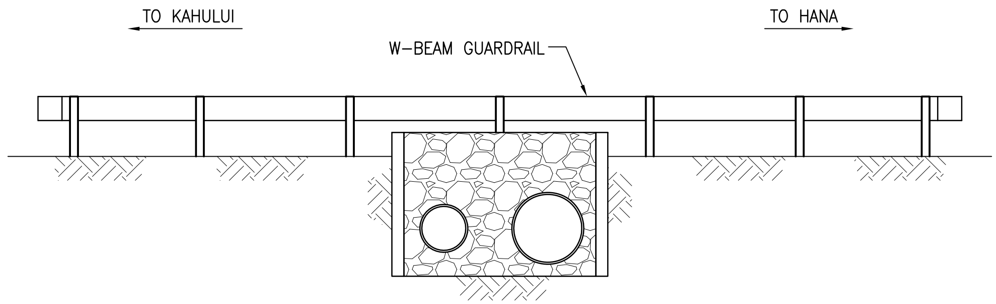


LOCATION MAP
NOT TO SCALE

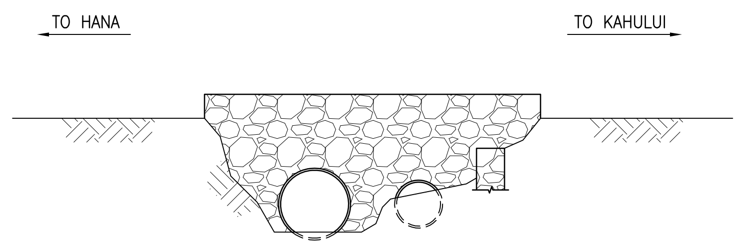
CULVERT MP 17.31

Drawing D: 17C-1

2015



1 **UPSTREAM ELEVATION**
NOT TO SCALE



2 **DOWNSTREAM ELEVATION**
NOT TO SCALE

CULVERT MP 17.31

Drawing D: 17C-2

2015

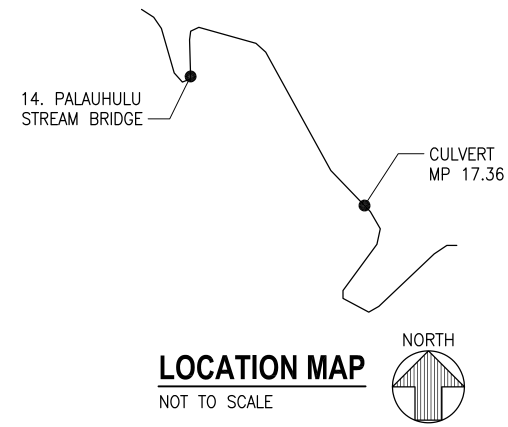
18 C	CULVERT MP 17.36					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

Kahului approach looking toward Hana.

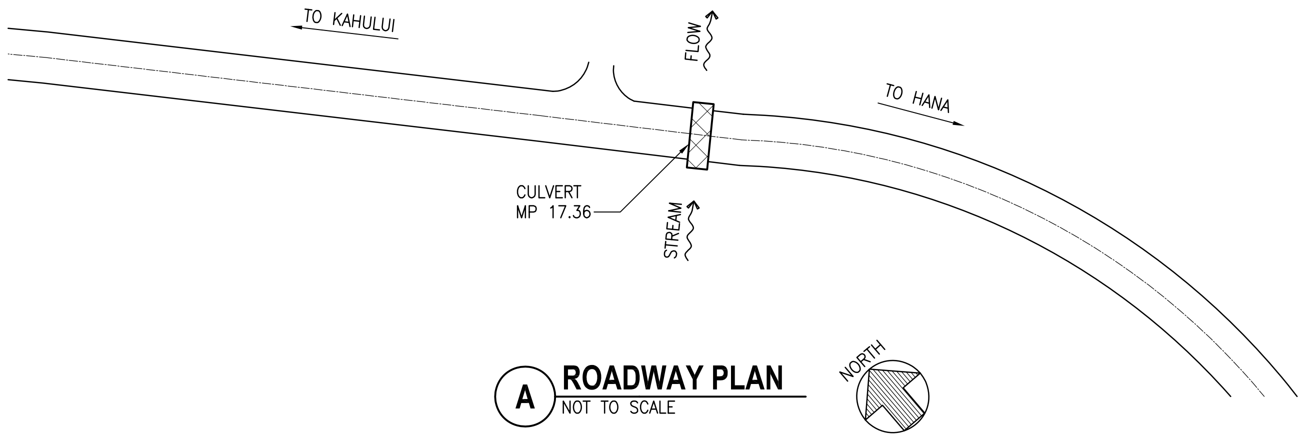
View of downstream fence and top of concrete headwall.

18 C	CULVERT MP 17.36						
	Bridge Number:	N/A		**Island:**	Maui		
	Date of Construction:	Unknown		**Route:**	Hana Highway		
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement	

Looking down at RCP outlet at downstream side.



LOCATION MAP
NOT TO SCALE

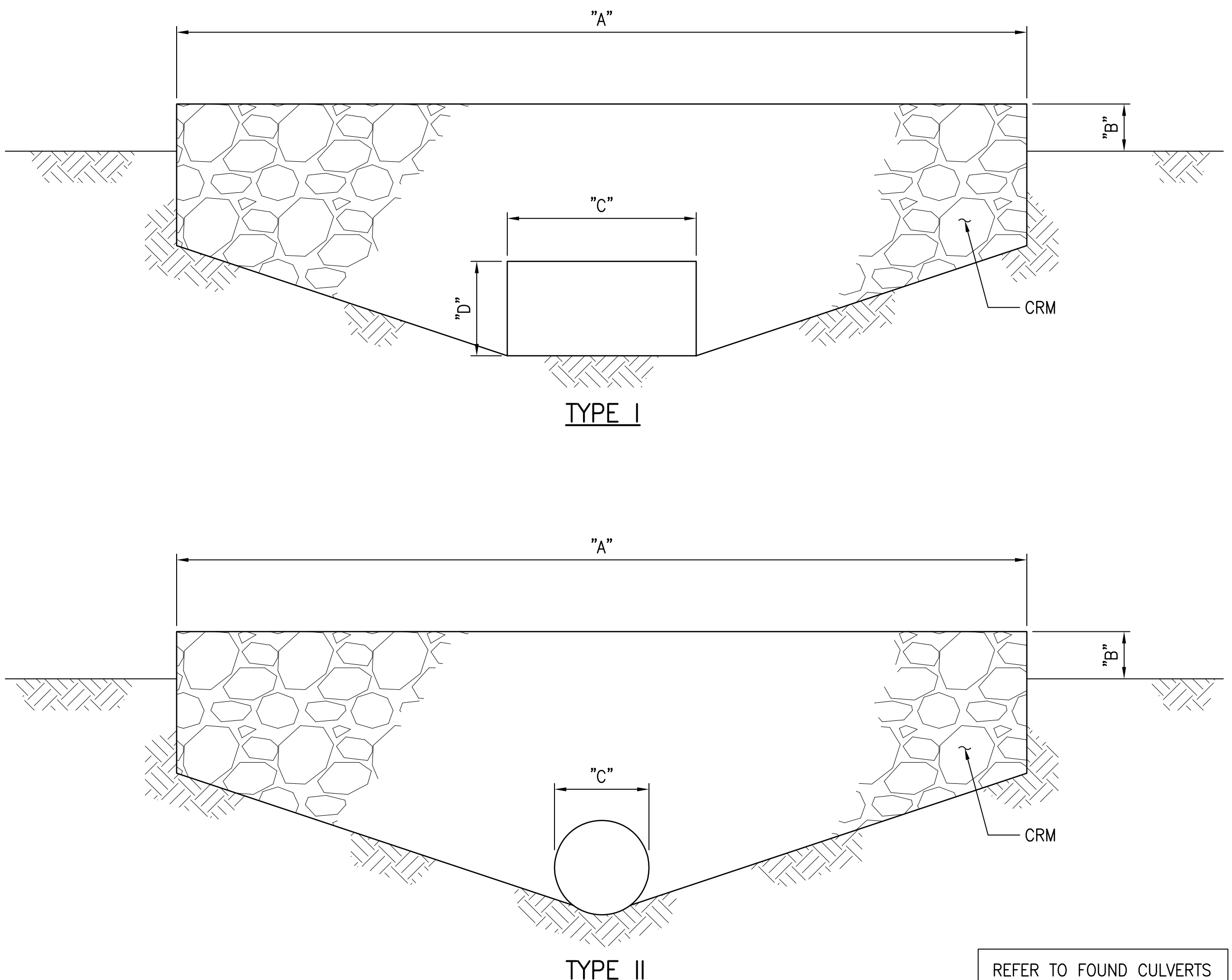


A **ROADWAY PLAN**
NOT TO SCALE

CULVERT MP 17.36

Drawing D: 18C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

22 C CULVERT MP 17.51 (BRIDGE)

Bridge Number:	N/A	**Island:**	Maui
Date of Construction:	Unknown	**Route:**	Hana Highway

Treatment Recommendations: ☑ Preservation ☑ Rehabilitation ☐ Restoration ☐ Replacement

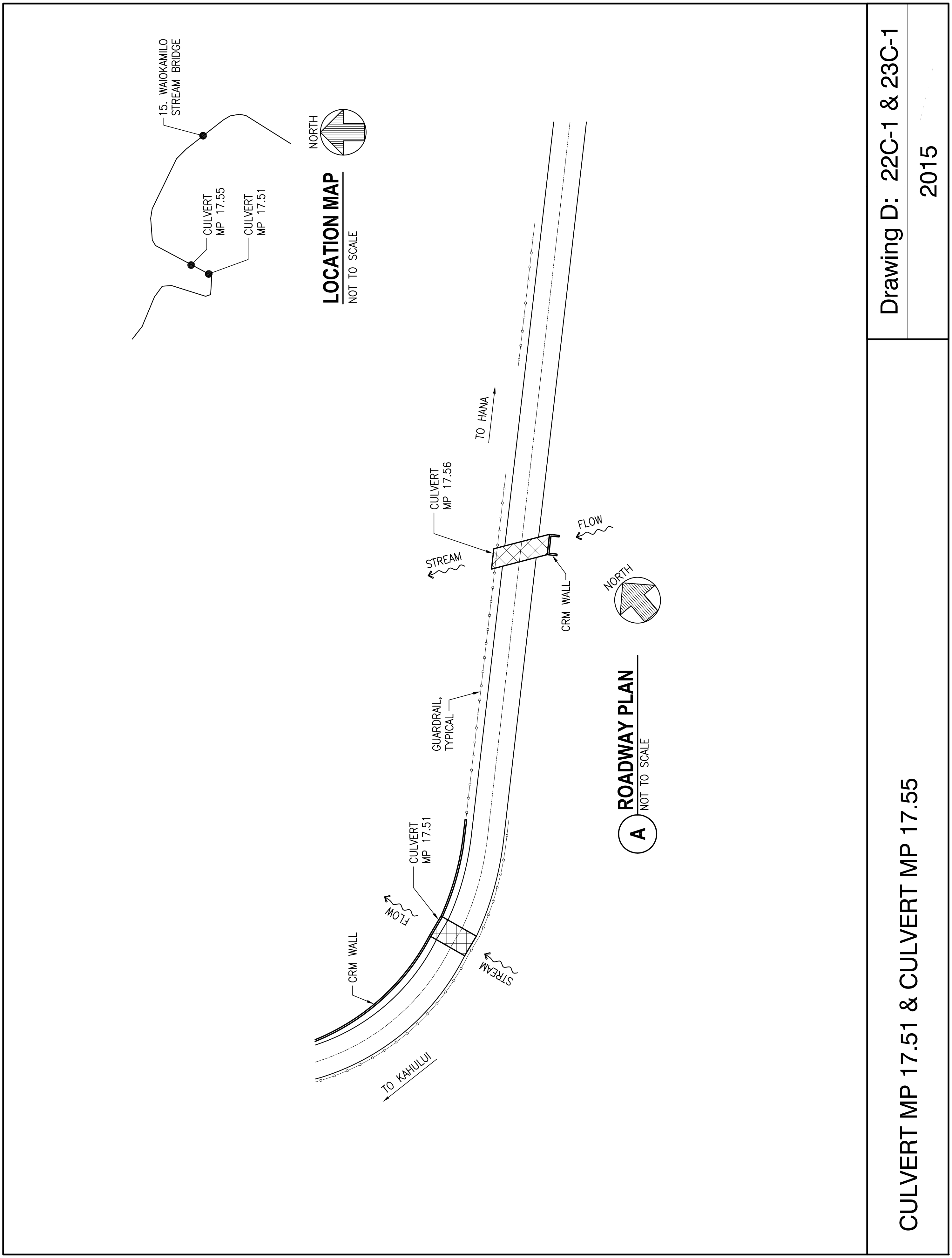
Kahului approach looking toward Hana.

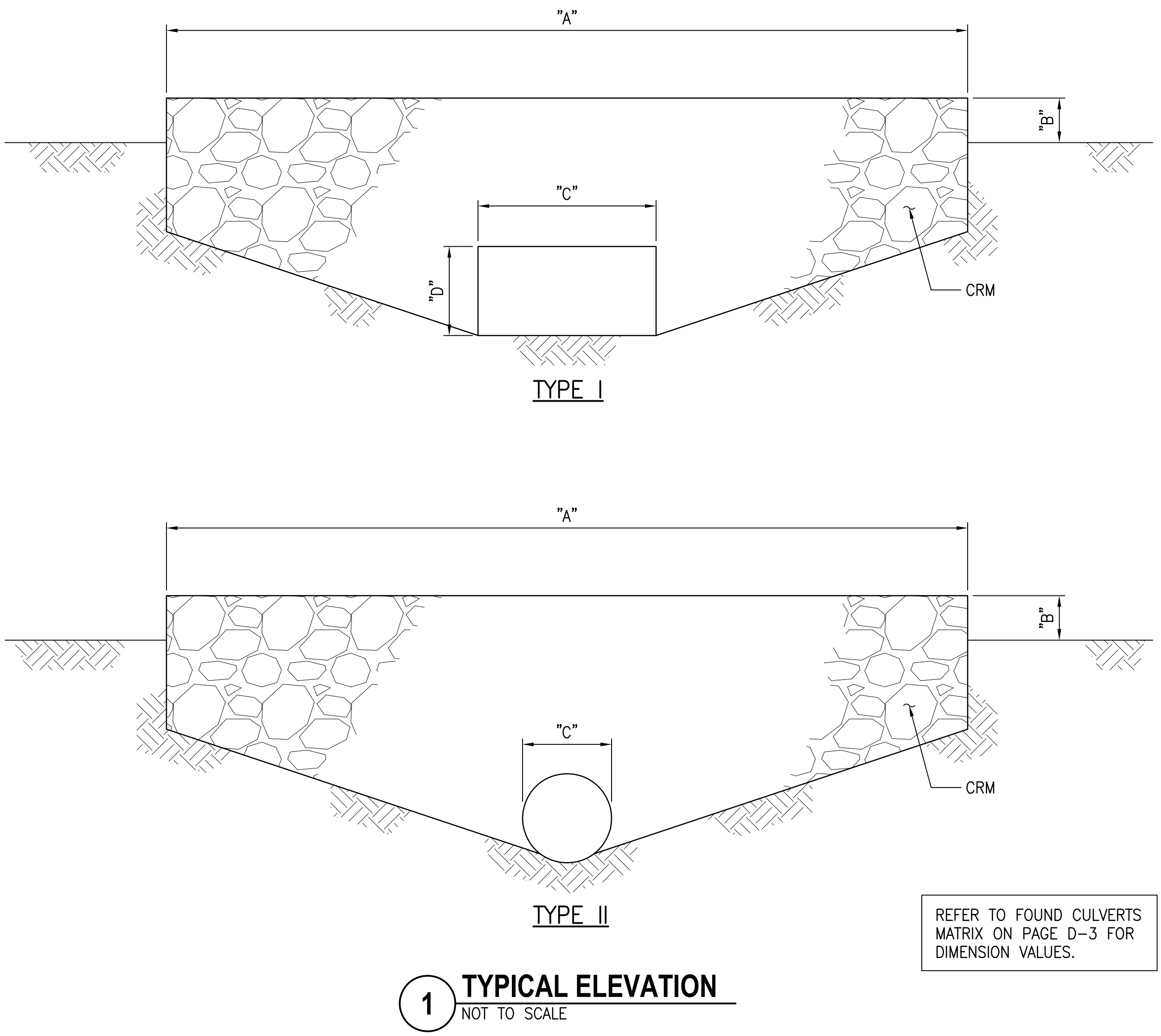
View of upstream metal guardrail.

22 C	CULVERT MP 17.51 (BRIDGE)					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream CRM parapet.

Downstream view through upstream end of bridge.


15. WAIOKAMILO STREAM BRIDGE
CULVERT MP 17.55
CULVERT MP 17.51
NORTH
LOCATION MAP
NOT TO SCALE
TO HANA
CULVERT MP 17.56
FLOW
STREAM
CRM WALL
NORTH
GUARDRAIL, TYPICAL
A ROADWAY PLAN
NOT TO SCALE
CULVERT MP 17.51
FLOW
CRM WALL
STREAM
TO KAHULUI
Drawing D: 22C-1 & 23C-1
2015
CULVERT MP 17.51 & CULVERT MP 17.55



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

23 C	CULVERT MP 17.55			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

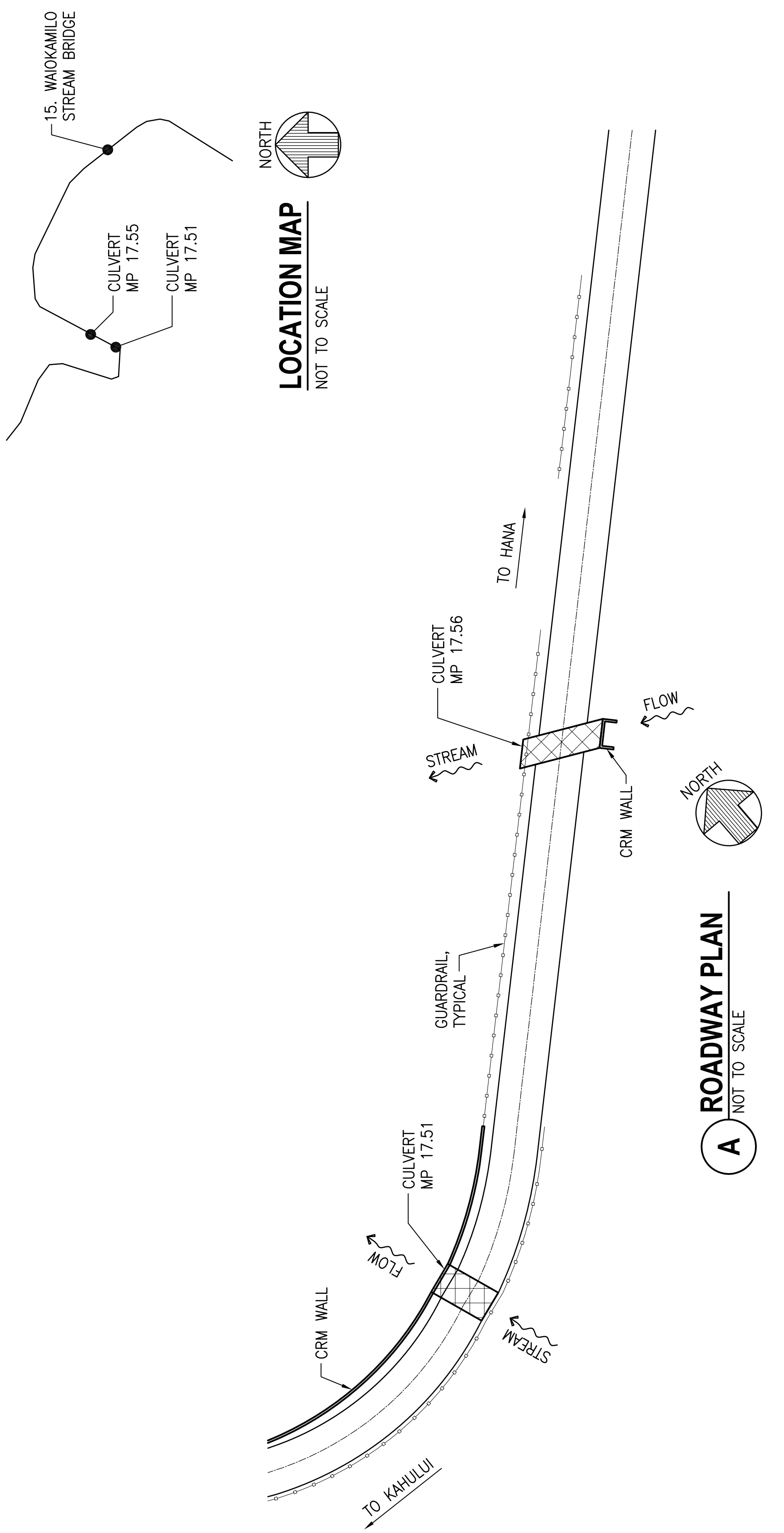
Kahului approach looking toward Hana.

View of upstream CRM parapet.

23 C	CULVERT MP 17.55					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☐ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream metal guardrail.

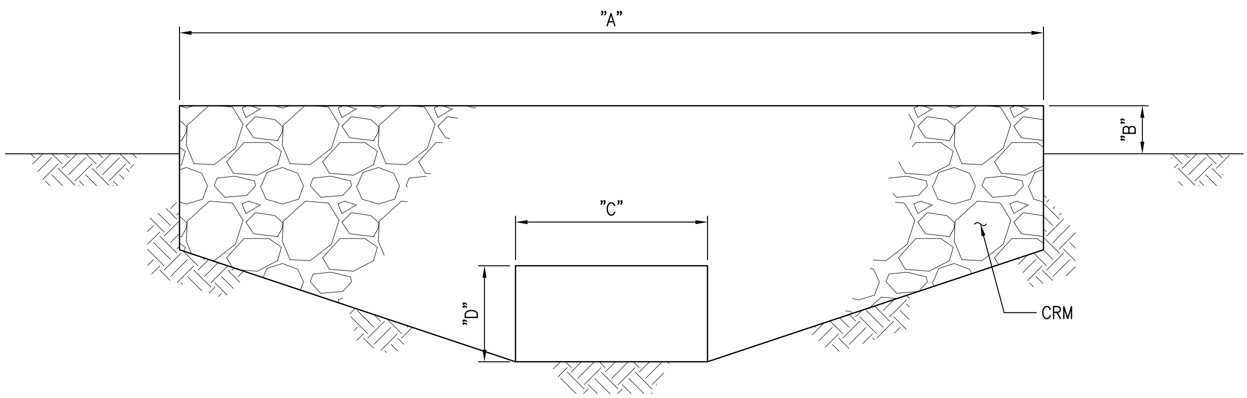
View of upstream CRM headwall / parapet and 24" diameter RCP inlet.

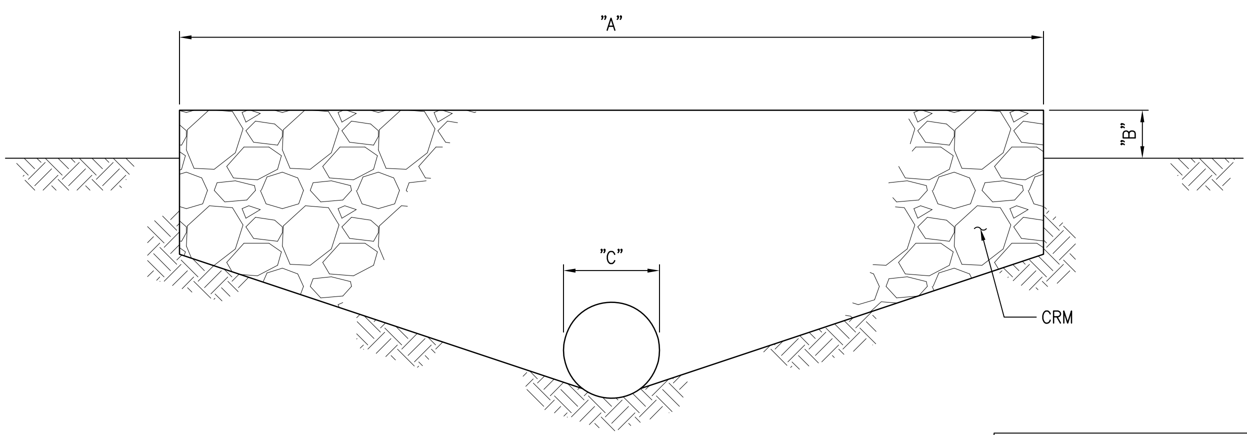


CULVERT MP 17.51 & CULVERT MP 17.55

Drawing D: 22C-1 & 23C-1

2015





REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

24 C	CULVERT MP 17.65				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

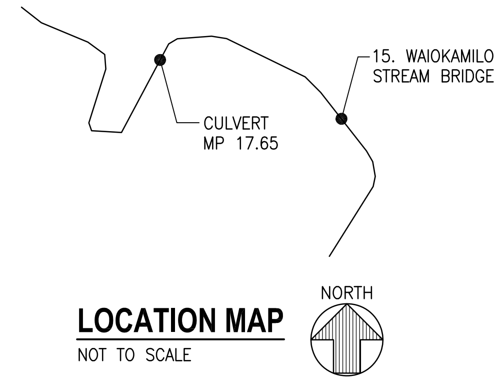
Kahului approach looking toward Hana.

View of upstream CRM parapet.

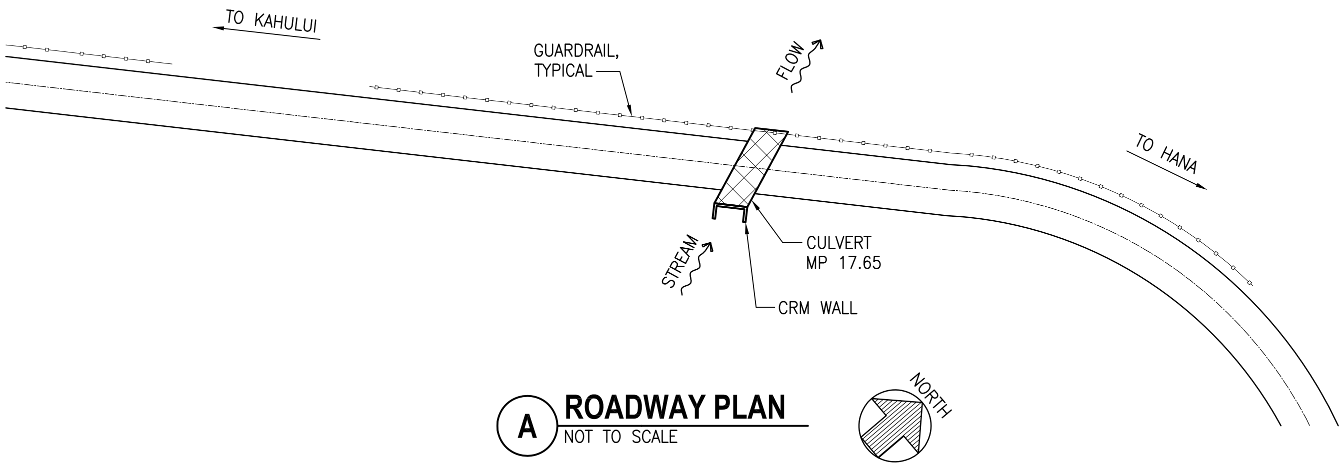
24 C	CULVERT MP 17.65					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream metal guardrail.

View of upstream CRM headwall / parapet and 24" diameter RCP inlet.



LOCATION MAP
NOT TO SCALE

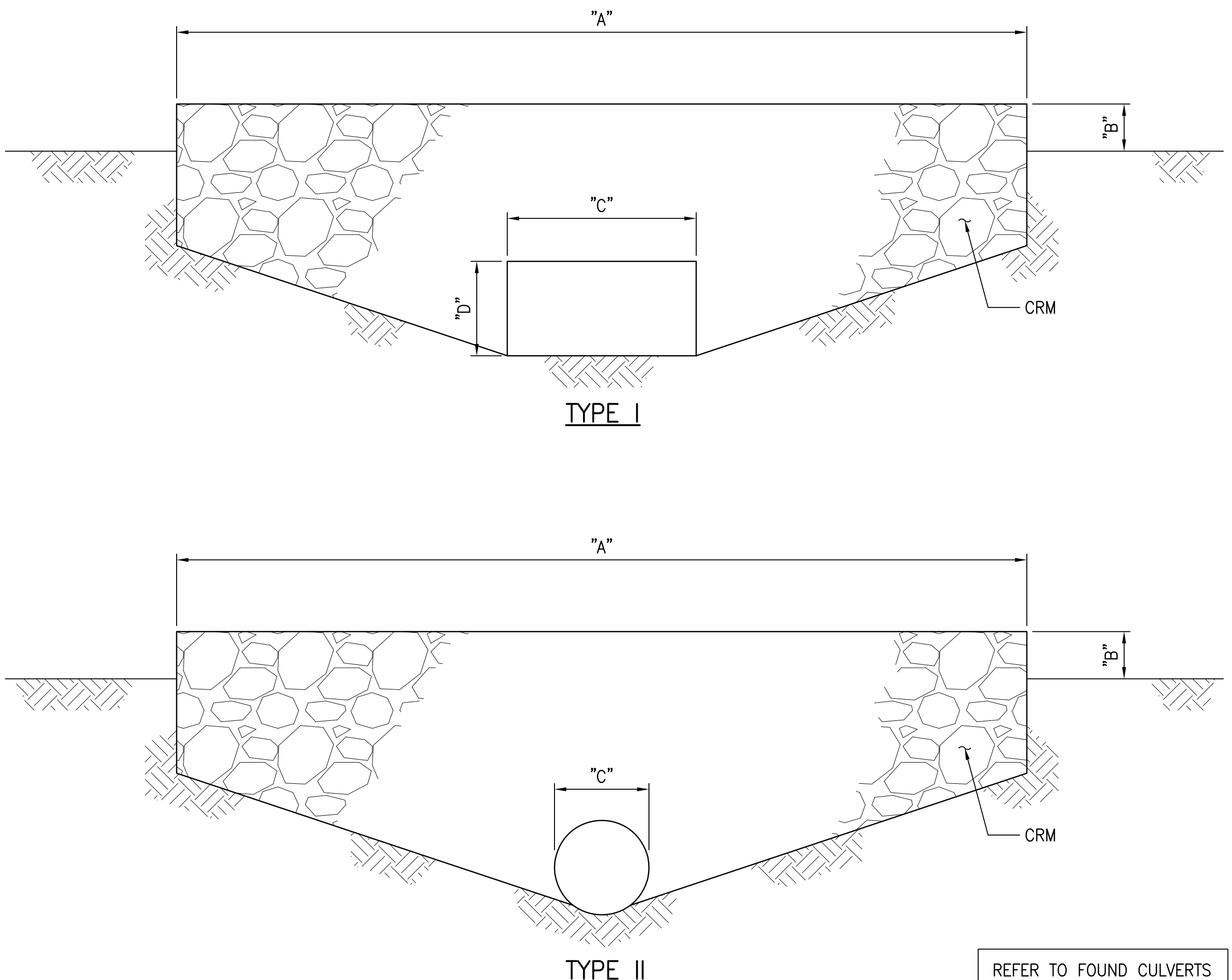


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 17.65

Drawing D: 24C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 TYPICAL ELEVATION
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

26 C	CULVERT MP 20.01				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

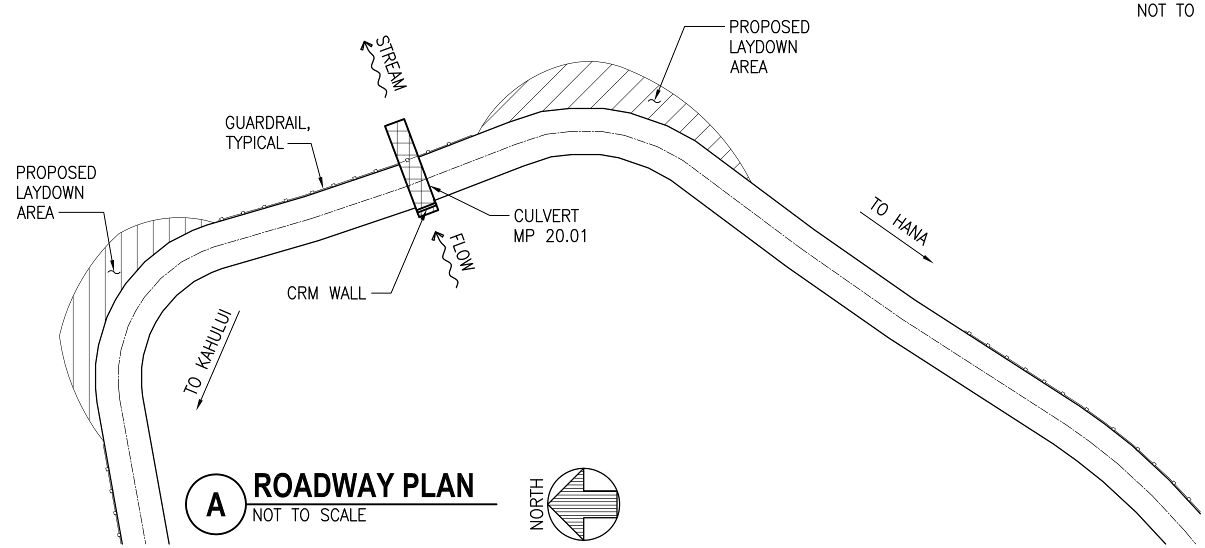
Kahului approach looking toward Hana.

View of upstream CRM parapet.

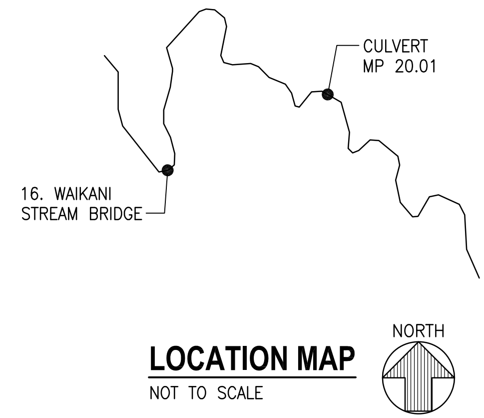
26 C	CULVERT MP 20.01				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream metal guardrail.

View of upstream CRM headwall / parapet and 30" diameter CMP inlet.

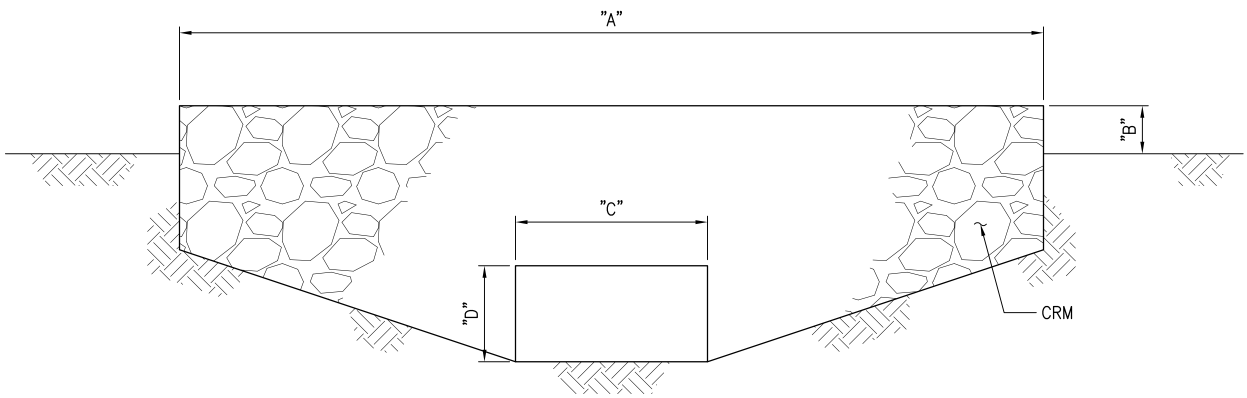


A ROADWAY PLAN
NOT TO SCALE

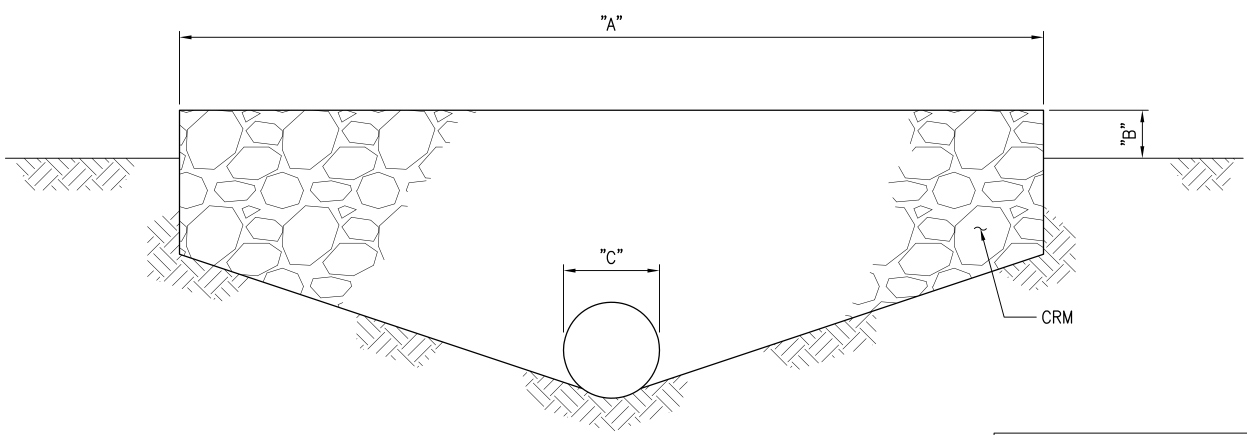


LOCATION MAP
NOT TO SCALE

CULVERT MP 20.01	Drawing D: 26C-1
	2015



TYPE I



TYPE II

REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

27 C	CULVERT MP 20.03						
	Bridge Number:	N/A		**Island:**	Maui		
	Date of Construction:	Unknown		**Route:**	Hana Highway		
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement	

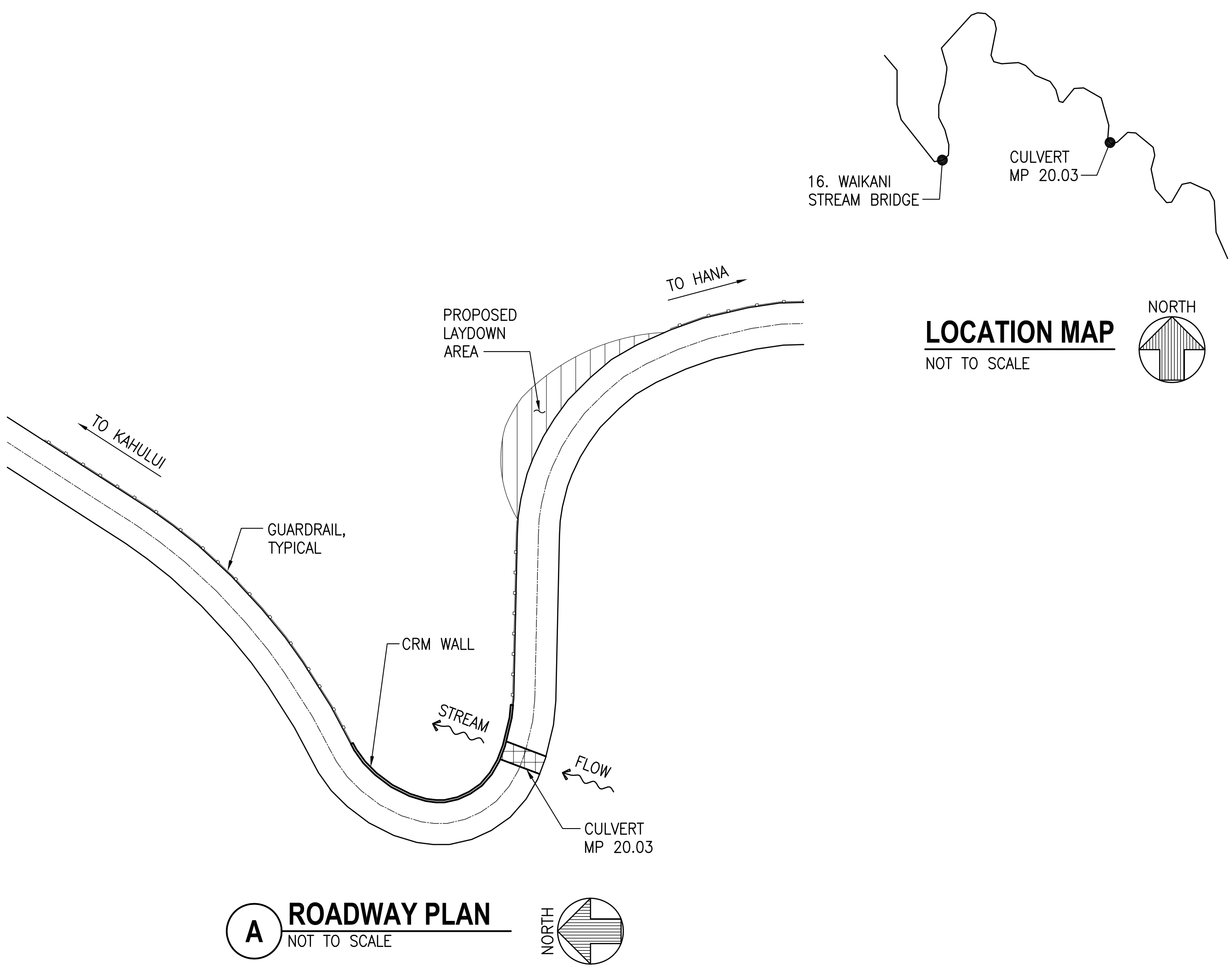
Kahului approach looking toward Hana.

View of upstream CRM parapet.

27 C	CULVERT MP 20.03				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream CRM parapet.

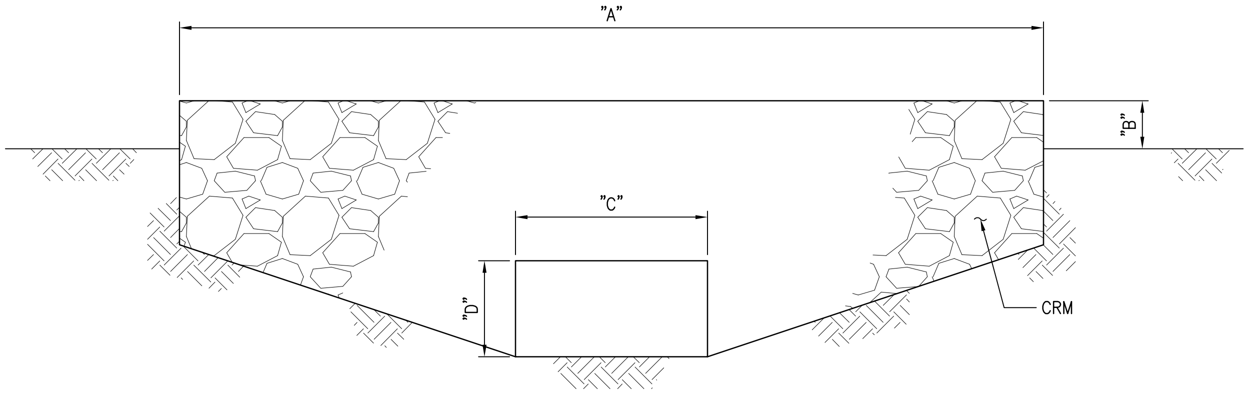
36" diameter CMP inlet at upstream side.



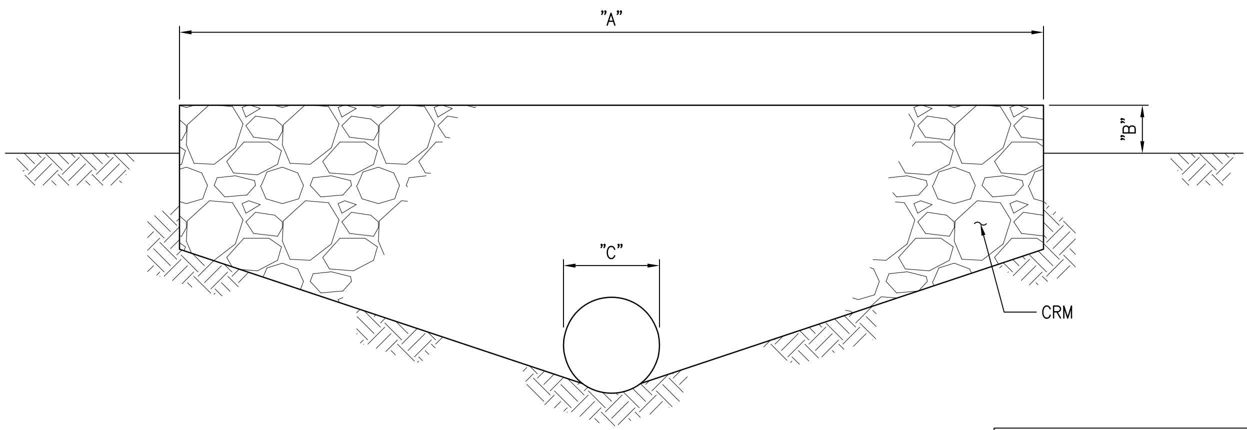
CULVERT MP 20.03

Drawing D: 27C-1

2015



TYPE I



TYPE II

REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 TYPICAL ELEVATION
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

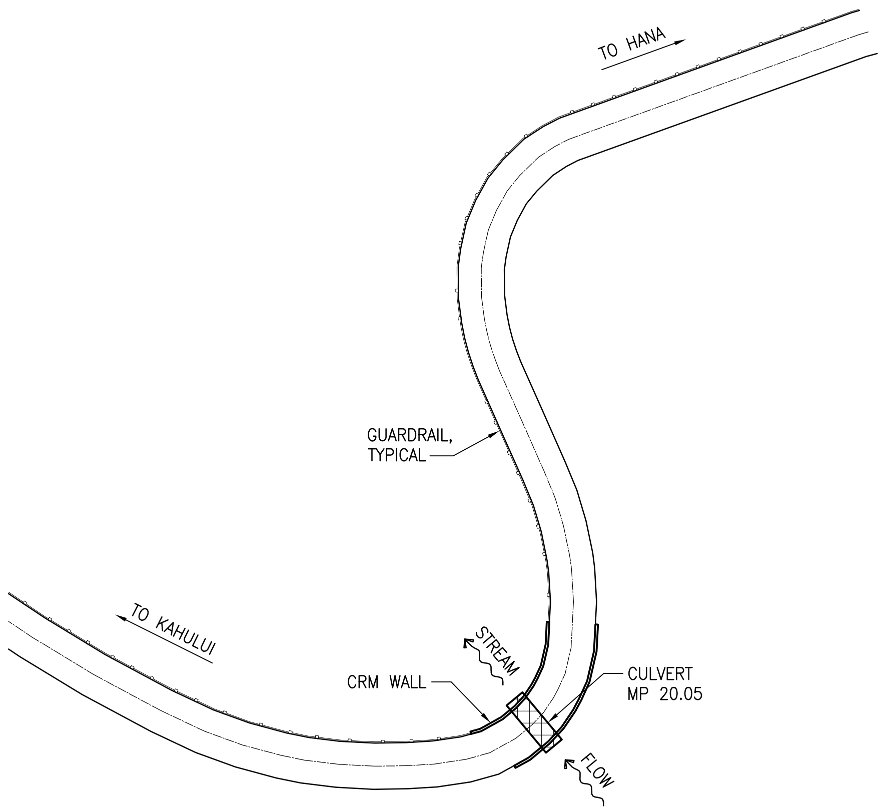
28 C	CULVERT MP 20.05					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

Kahului approach looking toward Hana and upstream CRM parapet.

View of downstream CRM parapet.

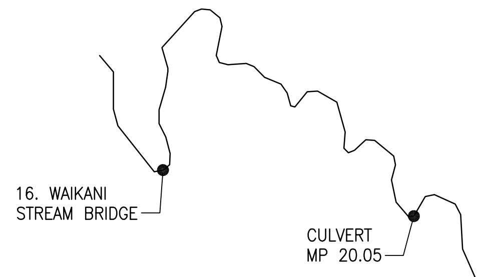
28 C	CULVERT MP 20.05					
	Bridge Number:	N/A		Island:	Maui	
	Date of Construction:	Unknown		Route:	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

48" diameter CMP inlet at upstream side.



A ROADWAY PLAN
NOT TO SCALE

NORTH



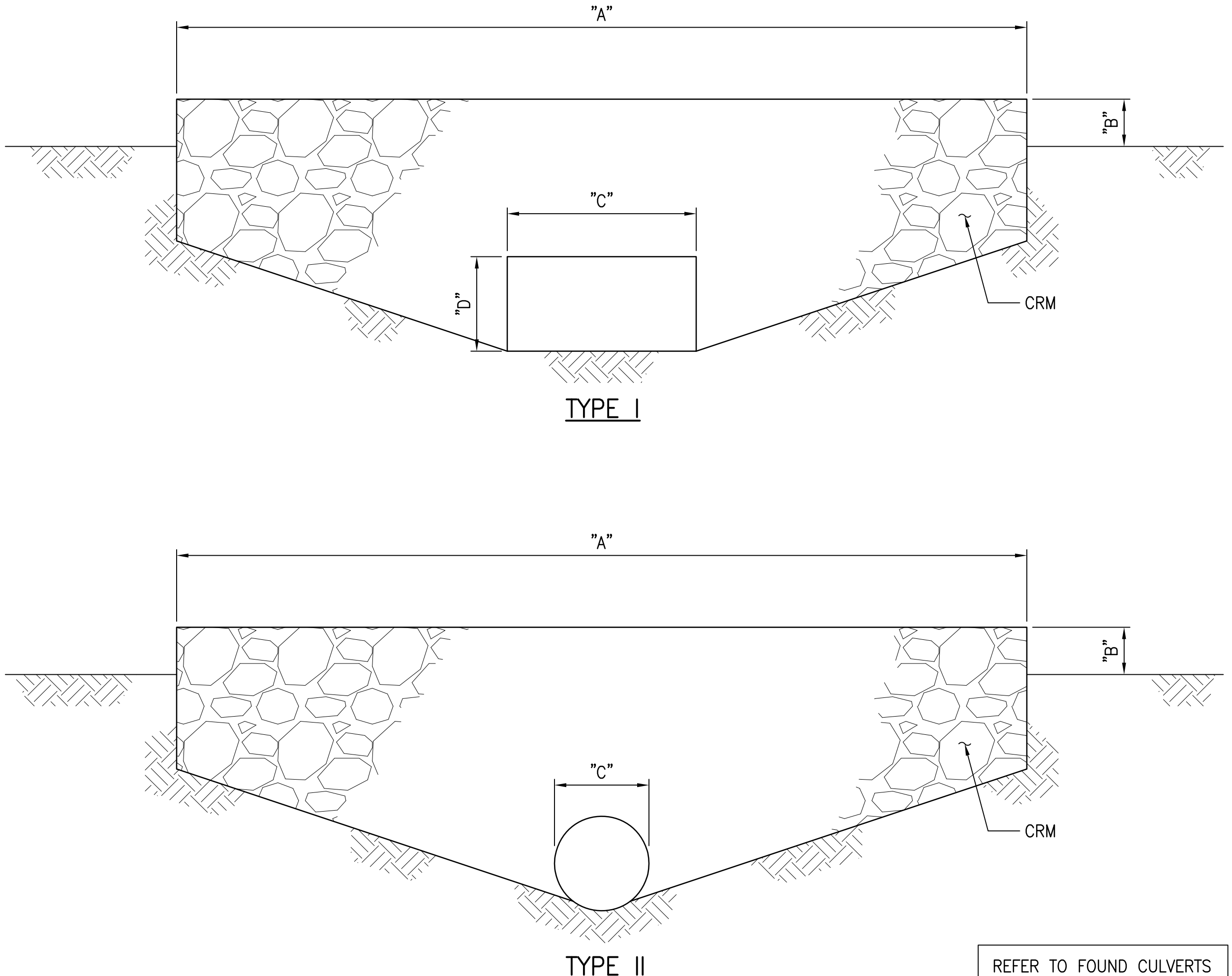
LOCATION MAP
NOT TO SCALE

NORTH

CULVERT MP 20.05

Drawing D: 28C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

29 C CULVERT MP 21.00

Bridge Number:	N/A	**Island:**	Maui
Date of Construction:	Unknown	**Route:**	Hana Highway

Treatment Recommendations: ☑ Preservation ☑ Rehabilitation ☐ Restoration ☐ Replacement

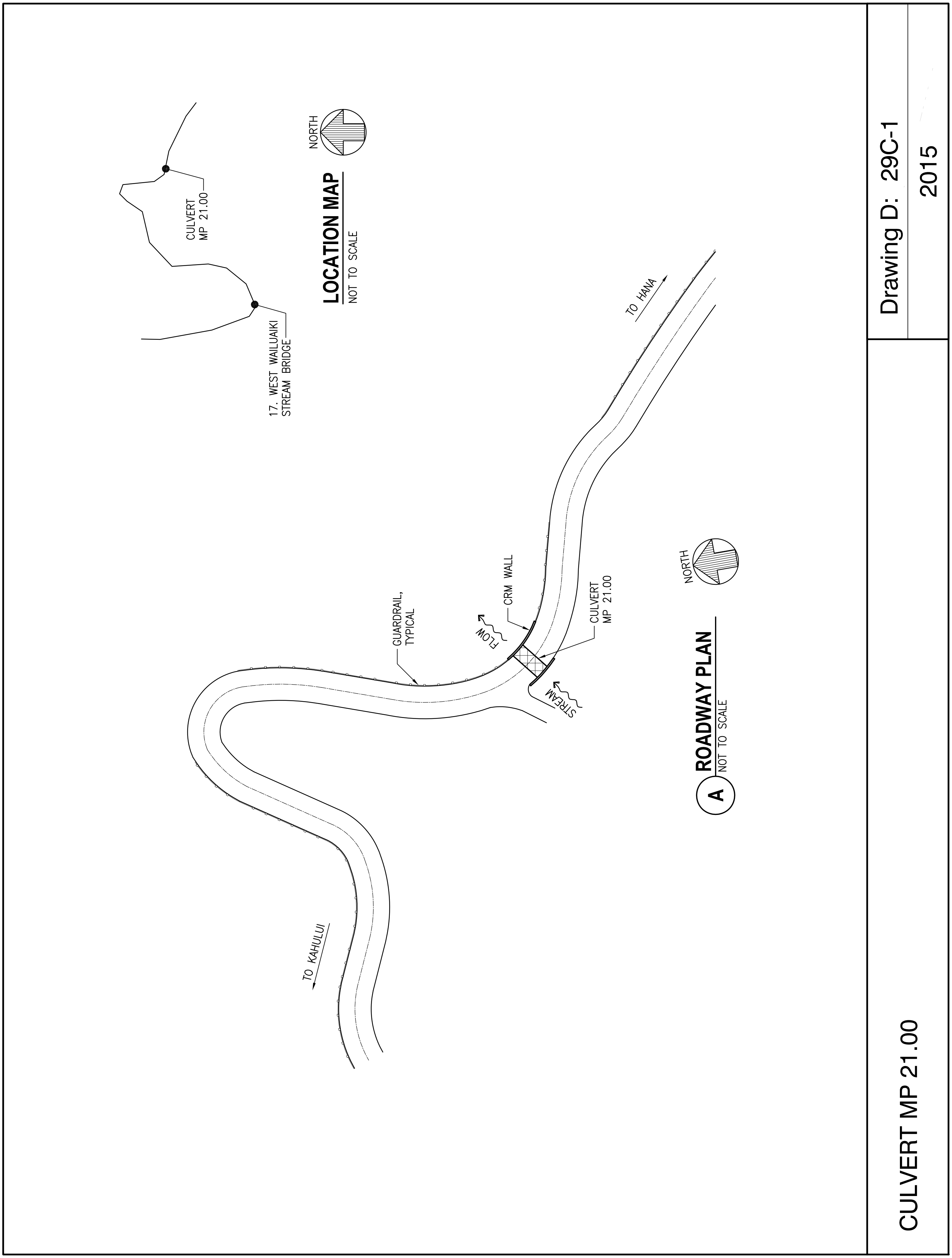
Kahului approach looking toward Hana.

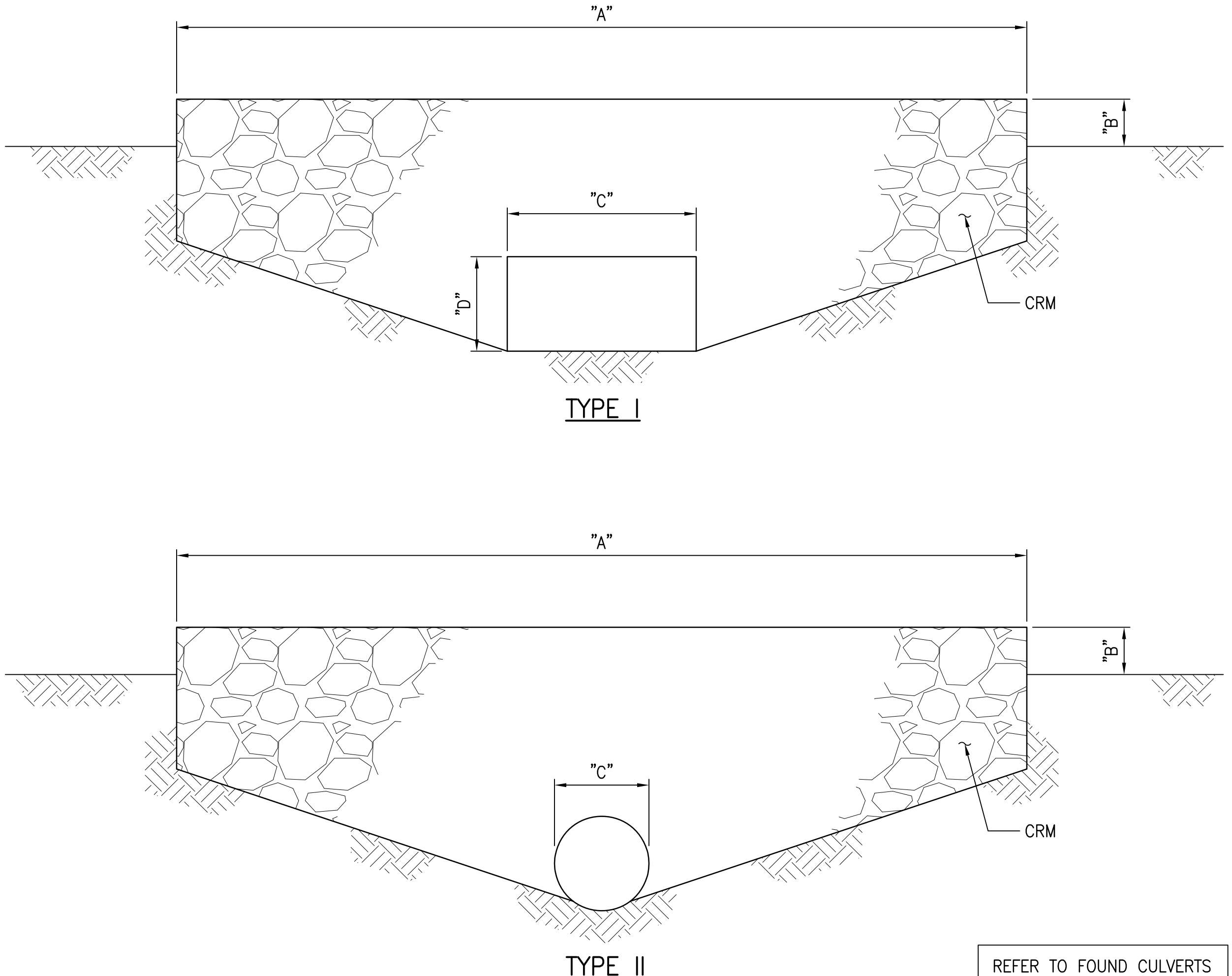
View of upstream CRM parapet.

29 C	**CULVERT MP 21.00**				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream CRM parapet.

View of downstream through culvert.


CULVERT
MP 21.00
17. WEST WAILUAIKI
STREAM BRIDGE
LOCATION MAP
NOT TO SCALE
NORTH
TO HANA
GUARDRAIL,
TYPICAL
CRM WALL
FLOW
CULVERT
MP 21.00
STREAM
NORTH
A
ROADWAY PLAN
NOT TO SCALE
TO KAHULUI
Drawing D: 29C-1
2015
CULVERT MP 21.00



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 TYPICAL ELEVATION
NOT TO SCALE

Various Miscellaneous Culvert Elevations	Drawing D: C-2
	2015

<table>
<tr><td rowspan="4">30
C</td><td colspan="5">CULVERT MP 21.11</td></tr>
<tr><td>Bridge Number:</td><td colspan="2">N/A</td><td>Island:</td><td>Maui</td></tr>
<tr><td>Date of Construction:</td><td colspan="2">Unknown</td><td>Route:</td><td>Hana Highway</td></tr>
<tr><td>Treatment Recommendations:</td><td>☑ Preservation</td><td>☑ Rehabilitation</td><td>☐ Restoration</td><td>☐ Replacement</td></tr>
</table>

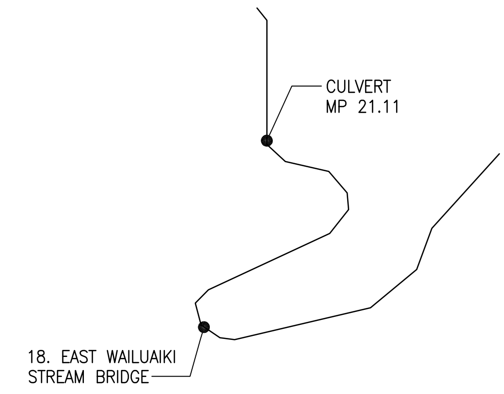
Kahului approach looking toward Hana.

View of upstream CRM parapet.

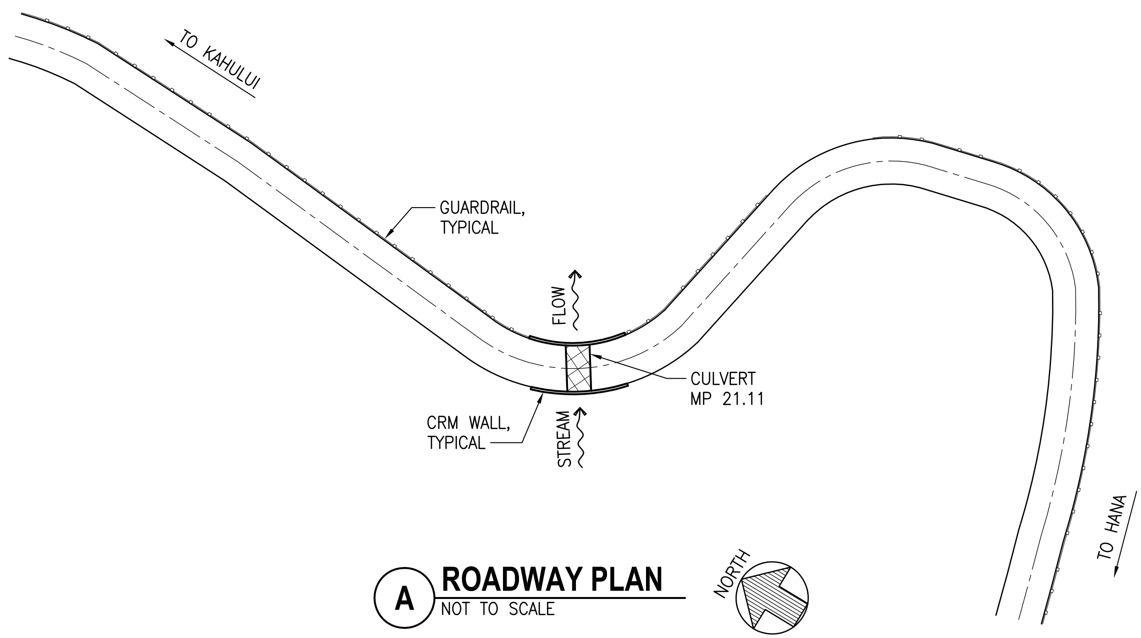
30 C	CULVERT MP 21.11					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream CRM parapet.

View of downstream through culvert.



LOCATION MAP
NOT TO SCALE

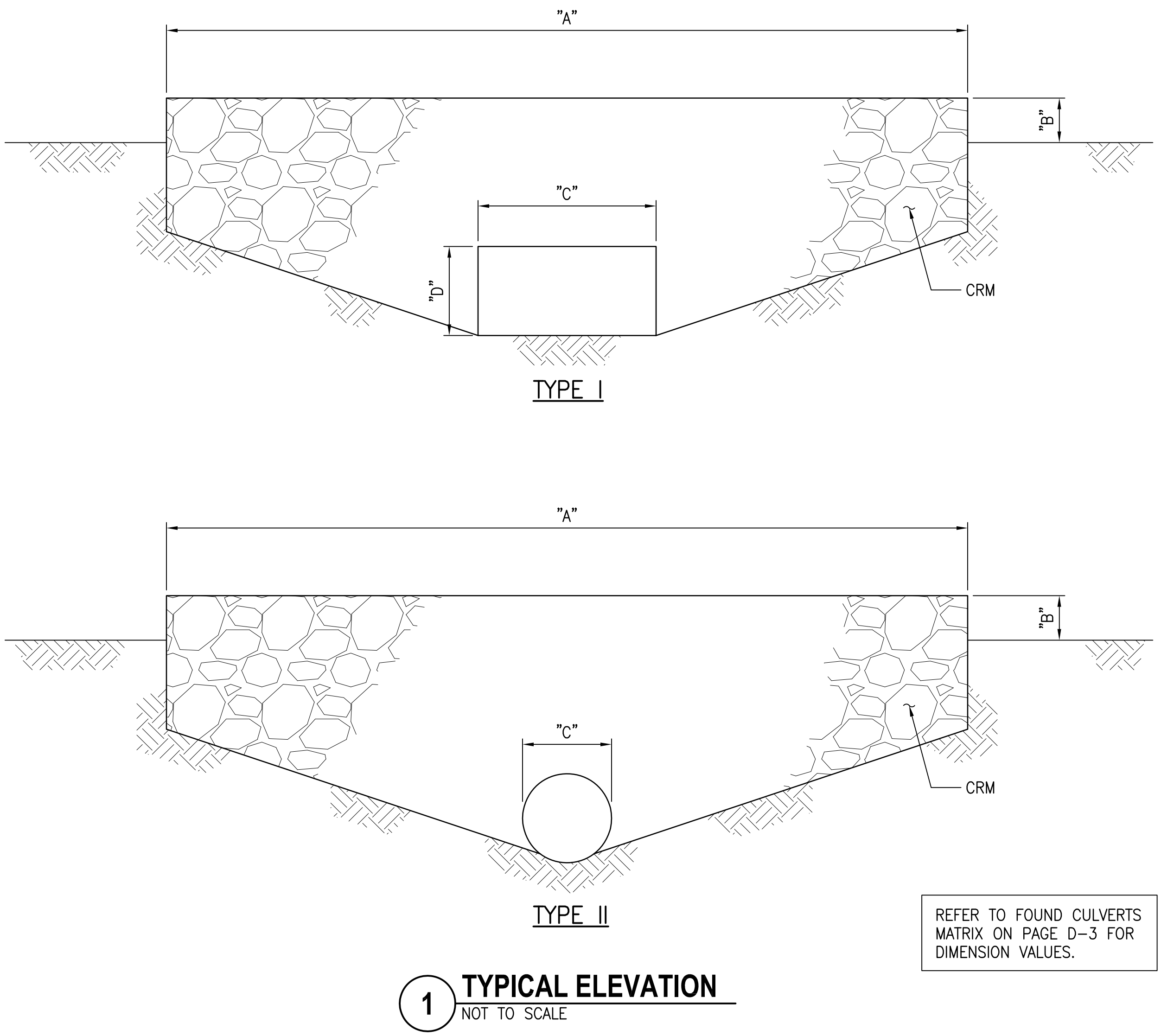


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 21.11

Drawing D: 30C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

31 C	CULVERT MP 21.29					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

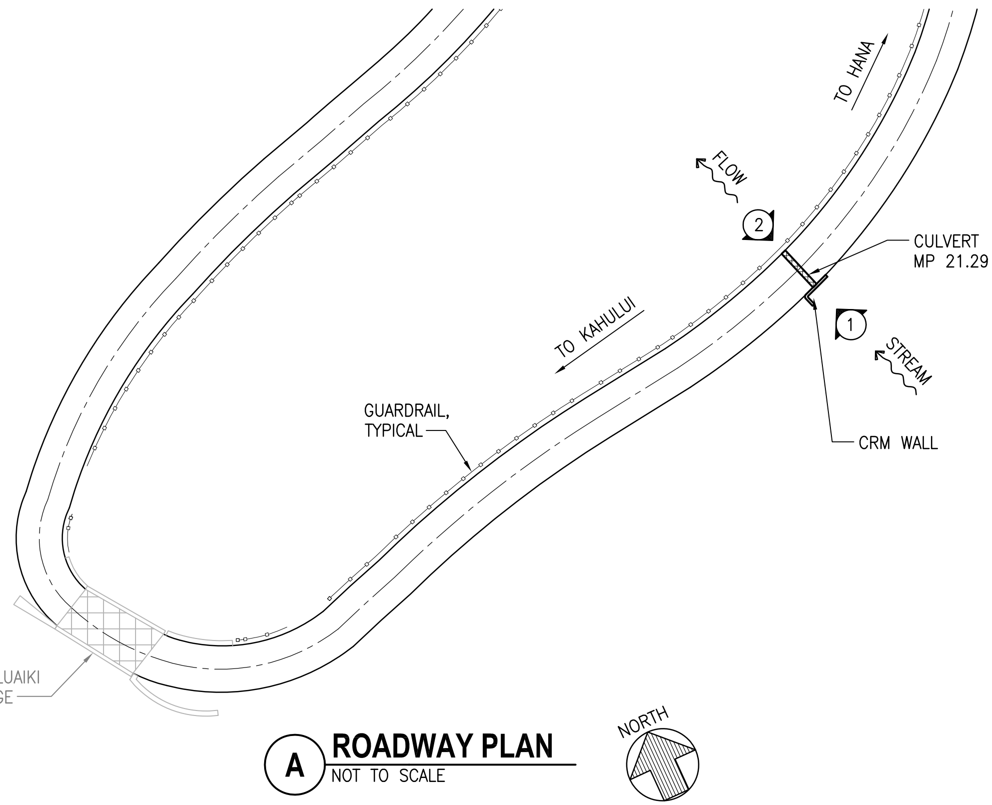
Kahului approach looking toward Hana.

View of upstream CRM parapet.

31 C	CULVERT MP 21.29				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

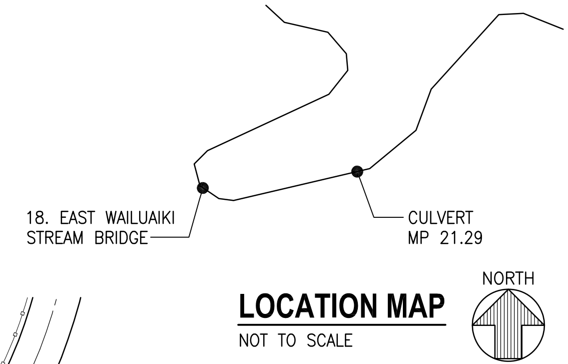
View of downstream metal guardrail.

24" diameter RCP inlet at the upstream side.



ROADWAY PLAN
NOT TO SCALE

A

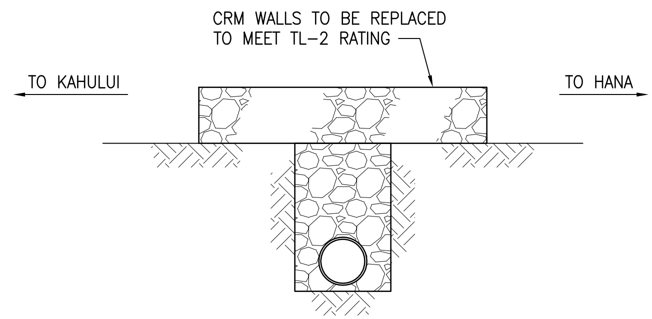


LOCATION MAP
NOT TO SCALE

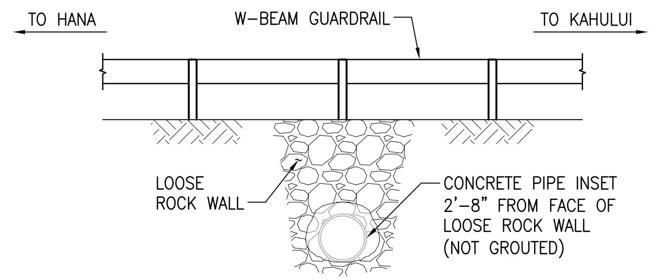
CULVERT MP 21.29

Drawing D: 31C-1

2015



1 **UPSTREAM ELEVATION**
NOT TO SCALE



2 **DOWNSTREAM ELEVATION**
NOT TO SCALE

CULVERT MP 21.29

Drawing D: 31C-2

2015

32 C	CULVERT MP 21.92				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

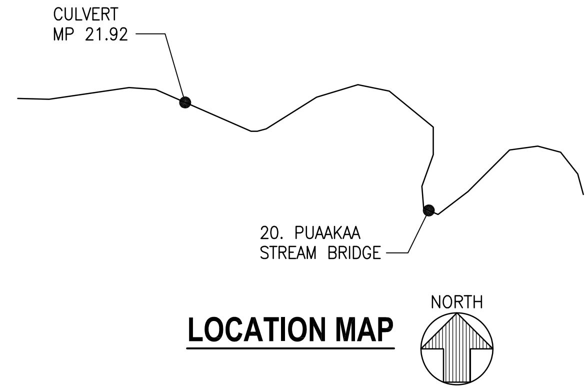
Kahului approach looking toward Hana.

View of upstream concrete parapet.

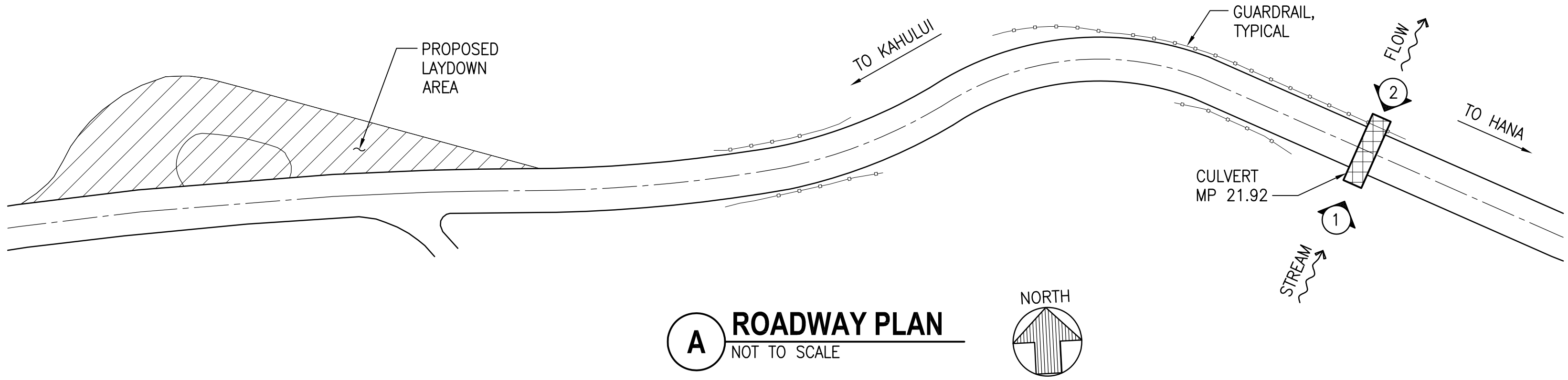
32 C	CULVERT MP 21.92					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream metal guardrail.

2 - 24" diameter RCP inlets at upstream side.



LOCATION MAP

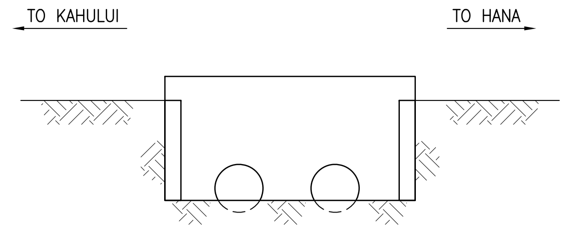


A ROADWAY PLAN
NOT TO SCALE

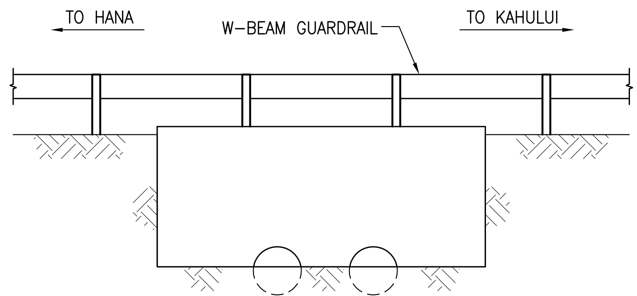
CULVERT MP 21.92

Drawing D: 32C-1

2015



1 UPSTREAM ELEVATION
NOT TO SCALE



2 DOWNSTREAM ELEVATION
NOT TO SCALE

CULVERT MP 21.92

Drawing D: 32C-2

2015

33 C	CULVERT MP 22.10				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

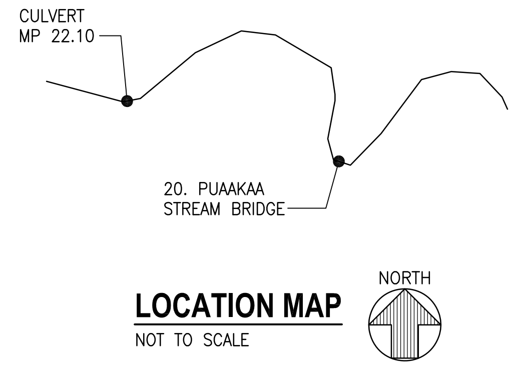
Kahului approach looking toward Hana.

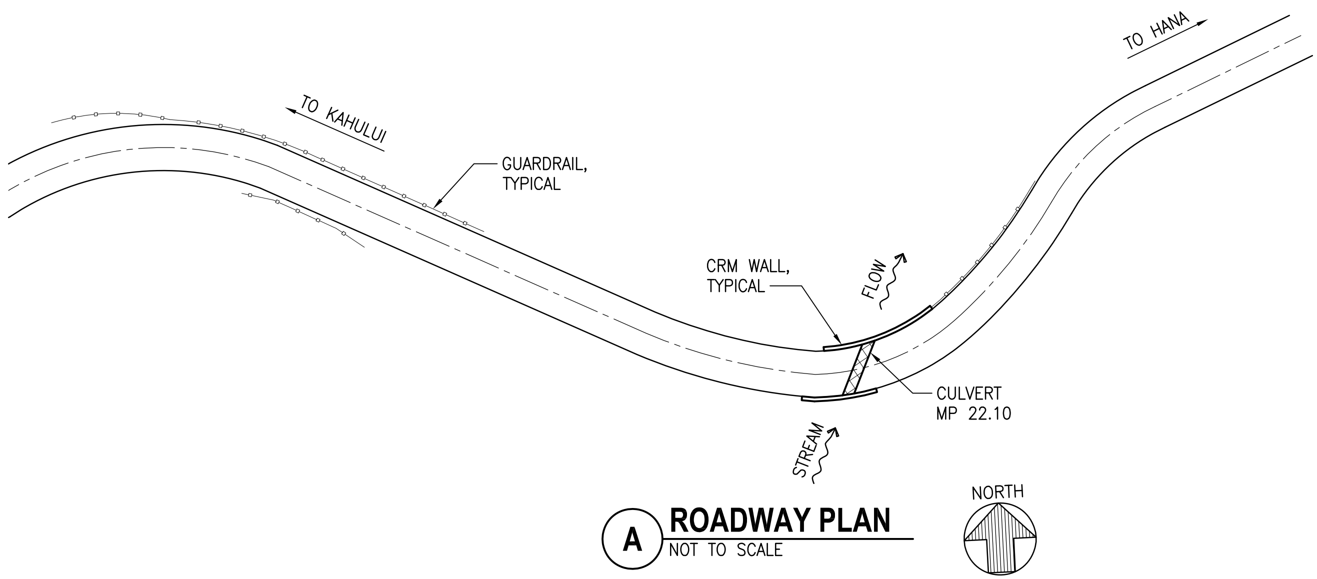
View of upstream CRM parapet.

33 C	CULVERT MP 22.10					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream CRM parapet.

View of CRM parapet and concrete headwall at upstream side.

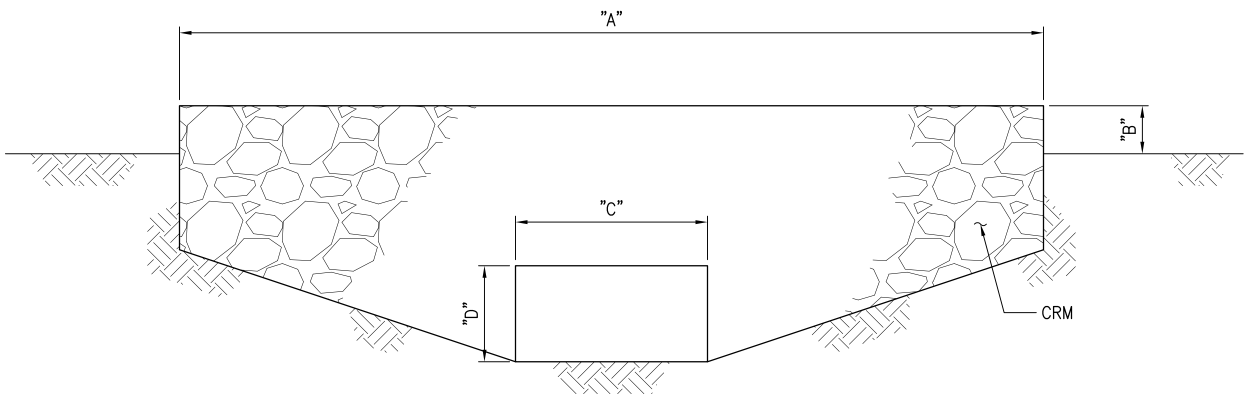


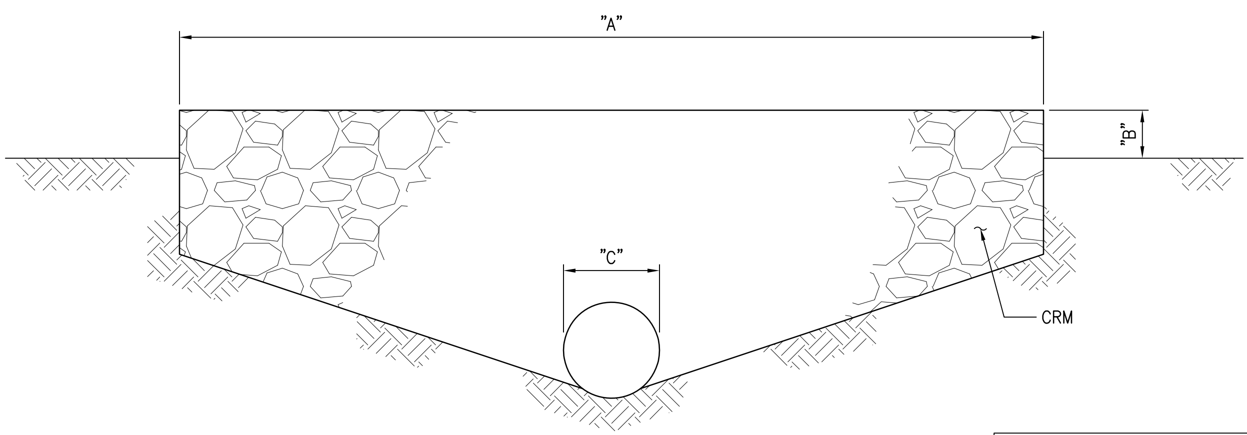


CULVERT MP 22.10

Drawing D: 33C-1

2015





REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

34 C	CULVERT MP 22.52					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

Kahului approach looking toward Hana.

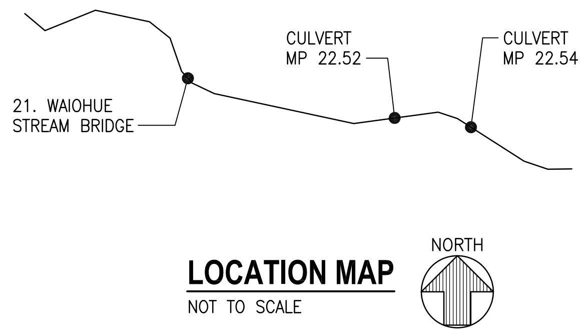
View of upstream CRM parapet.

34 C CULVERT MP 22.52

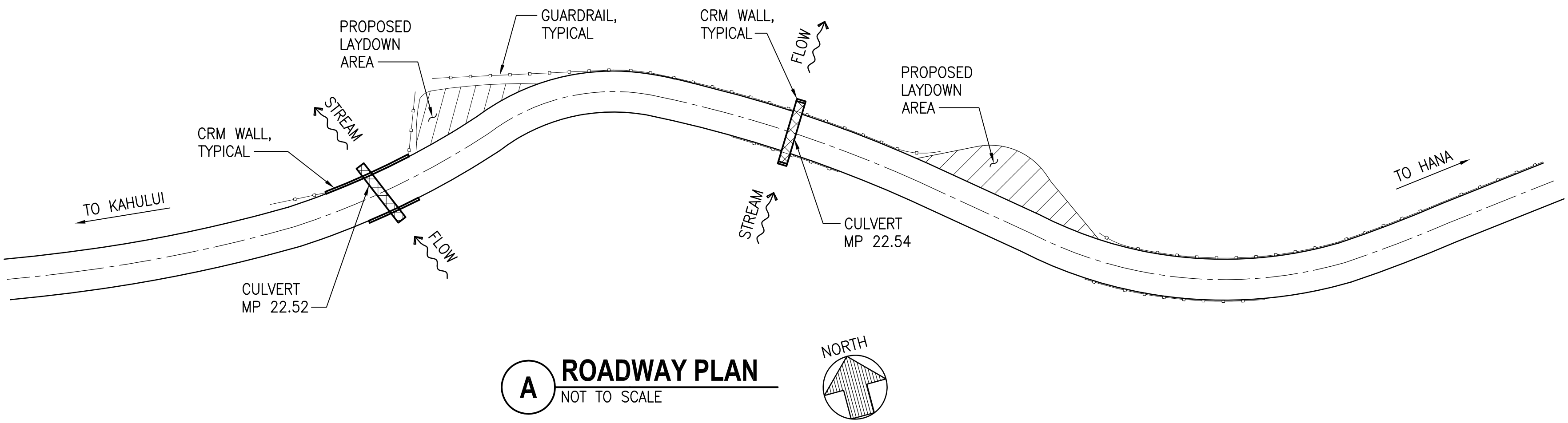
Bridge Number:	N/A			**Island:**	Maui		
Date of Construction:	Unknown			**Route:**	Hana Highway		
Treatment Recommendations:	☑	Preservation	☑ Rehabilitation	☐	Restoration	☐	Replacement

View of downstream CRM parapet.

View of upstream CRM headwall / parapet.



LOCATION MAP
NOT TO SCALE

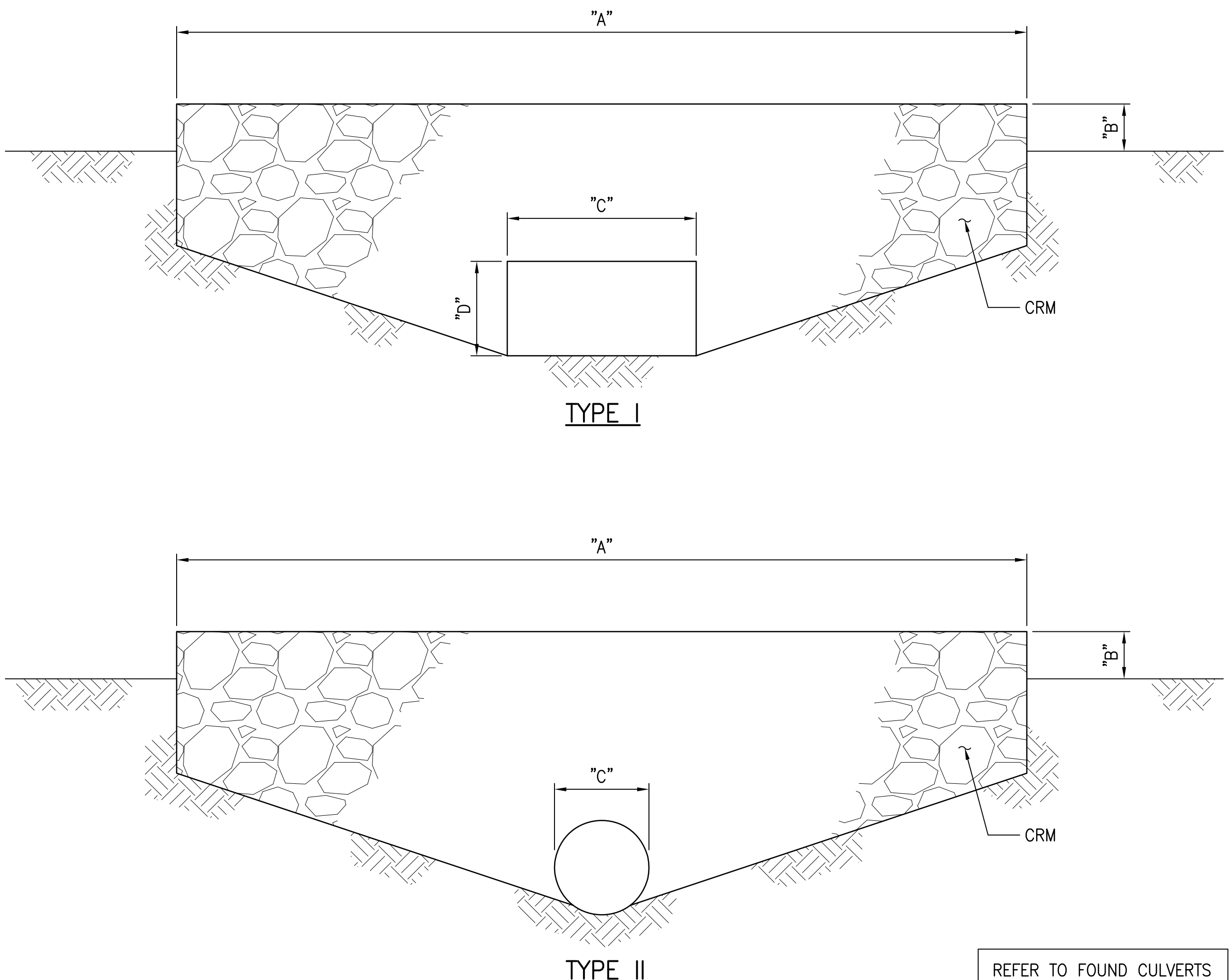


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 22.52 & CULVERT MP 22.54

Drawing D: 34C-1 & 35C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

35 C	CULVERT MP 22.54					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

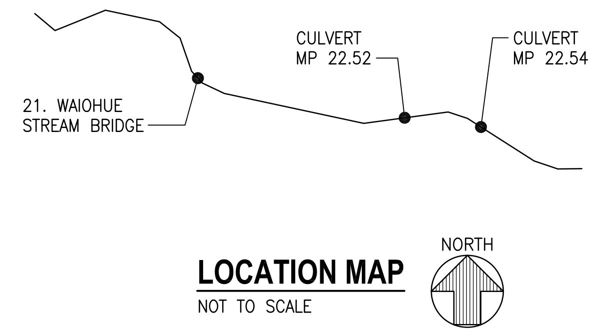
Kahului approach looking toward Hana.

View of upstream CRM parapet with continuous metal guardrail in-front.

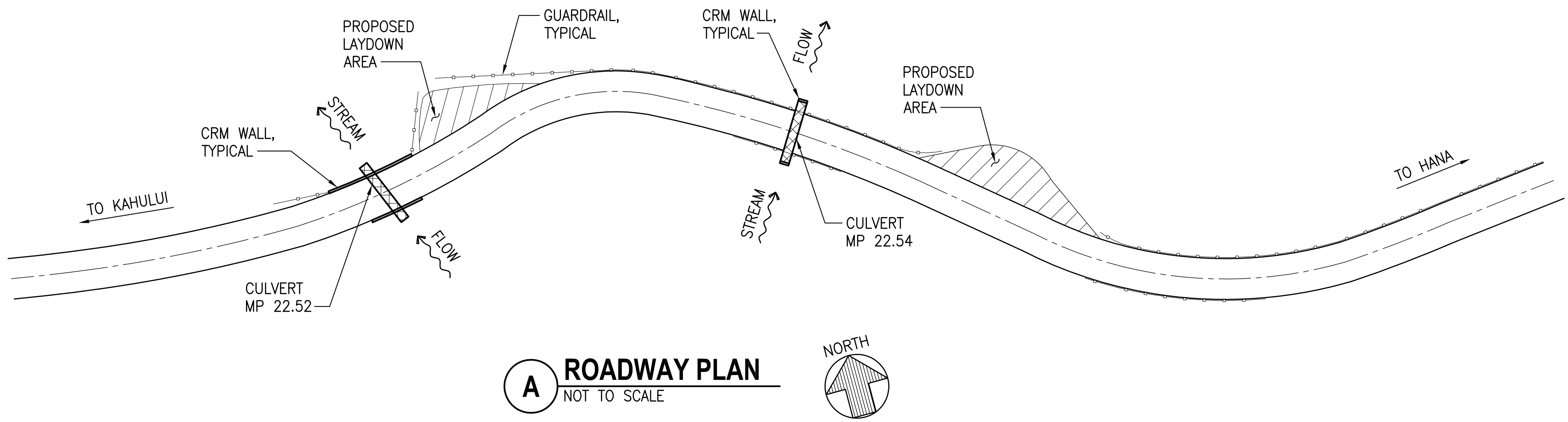
35 C	CULVERT MP 22.54				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream CRM parapet with continuous metal guardrail in-front.

18" diameter RCP inlet at the upstream side.



LOCATION MAP
NOT TO SCALE

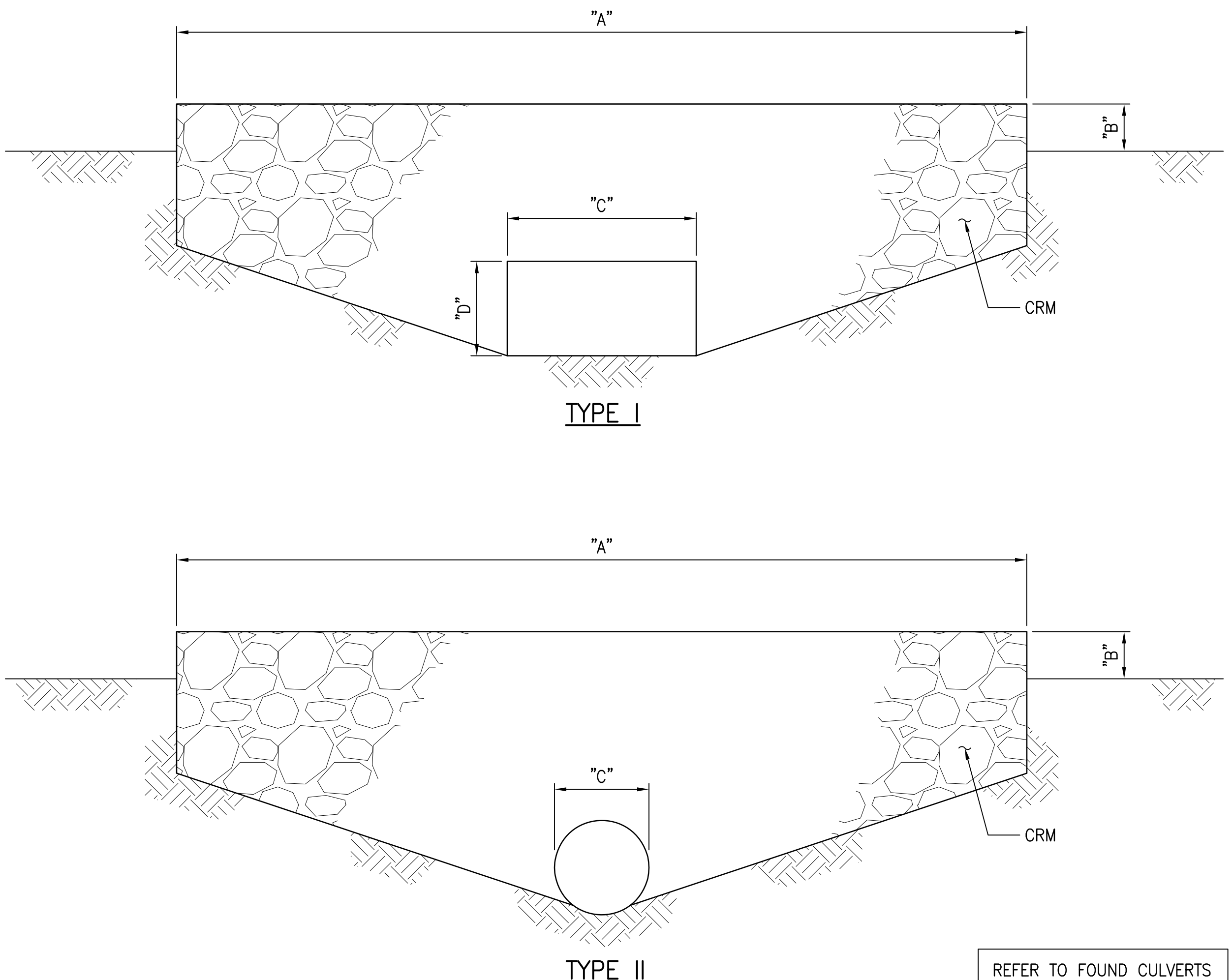


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 22.52 & CULVERT MP 22.54

Drawing D: 34C-1 & 35C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

36 C	CULVERT MP 22.79						
	Bridge Number:	N/A		**Island:**	Maui		
	Date of Construction:	Unknown		**Route:**	Hana Highway		
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement	

Kahului approach looking toward Hana.

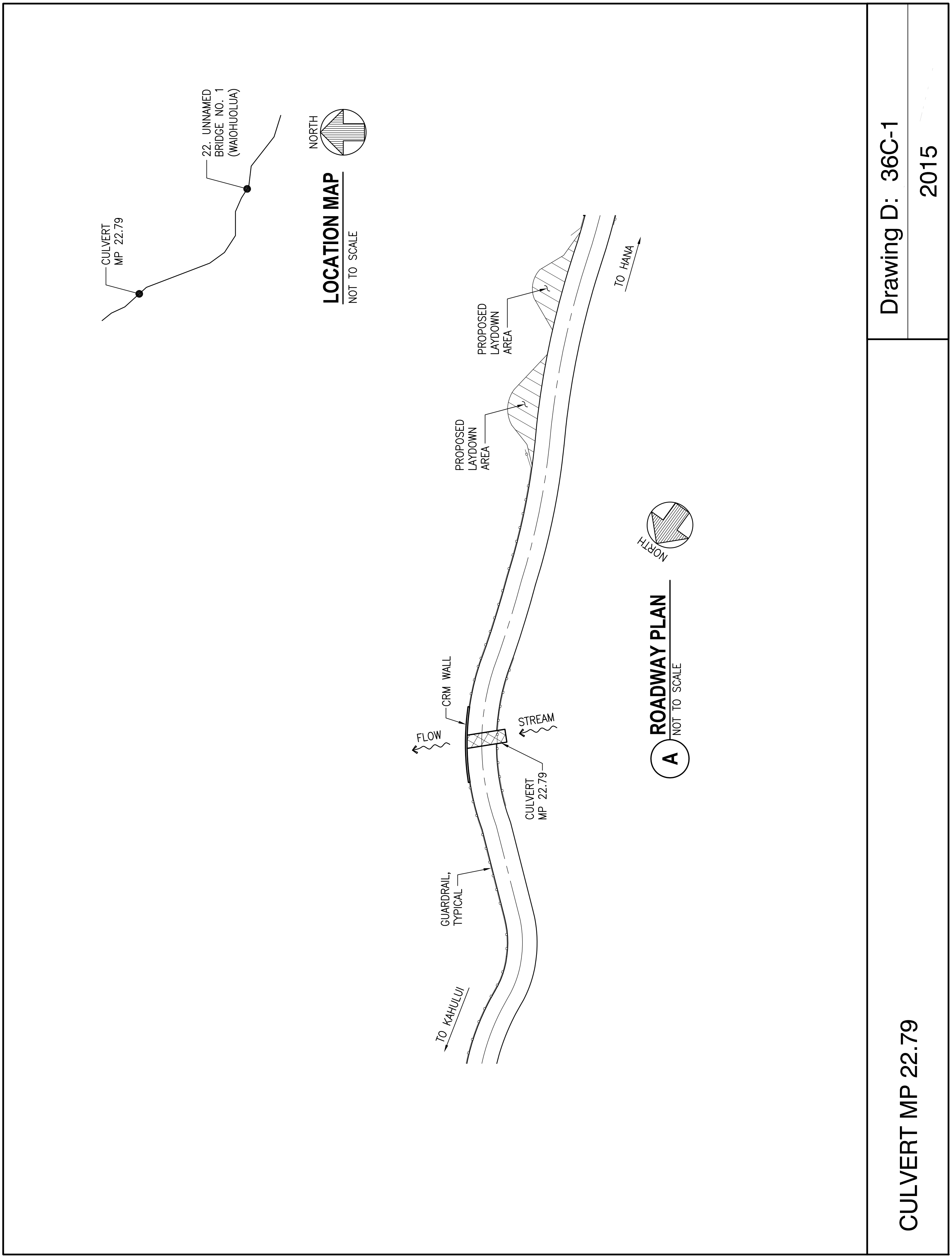
View of upstream metal guardrail.

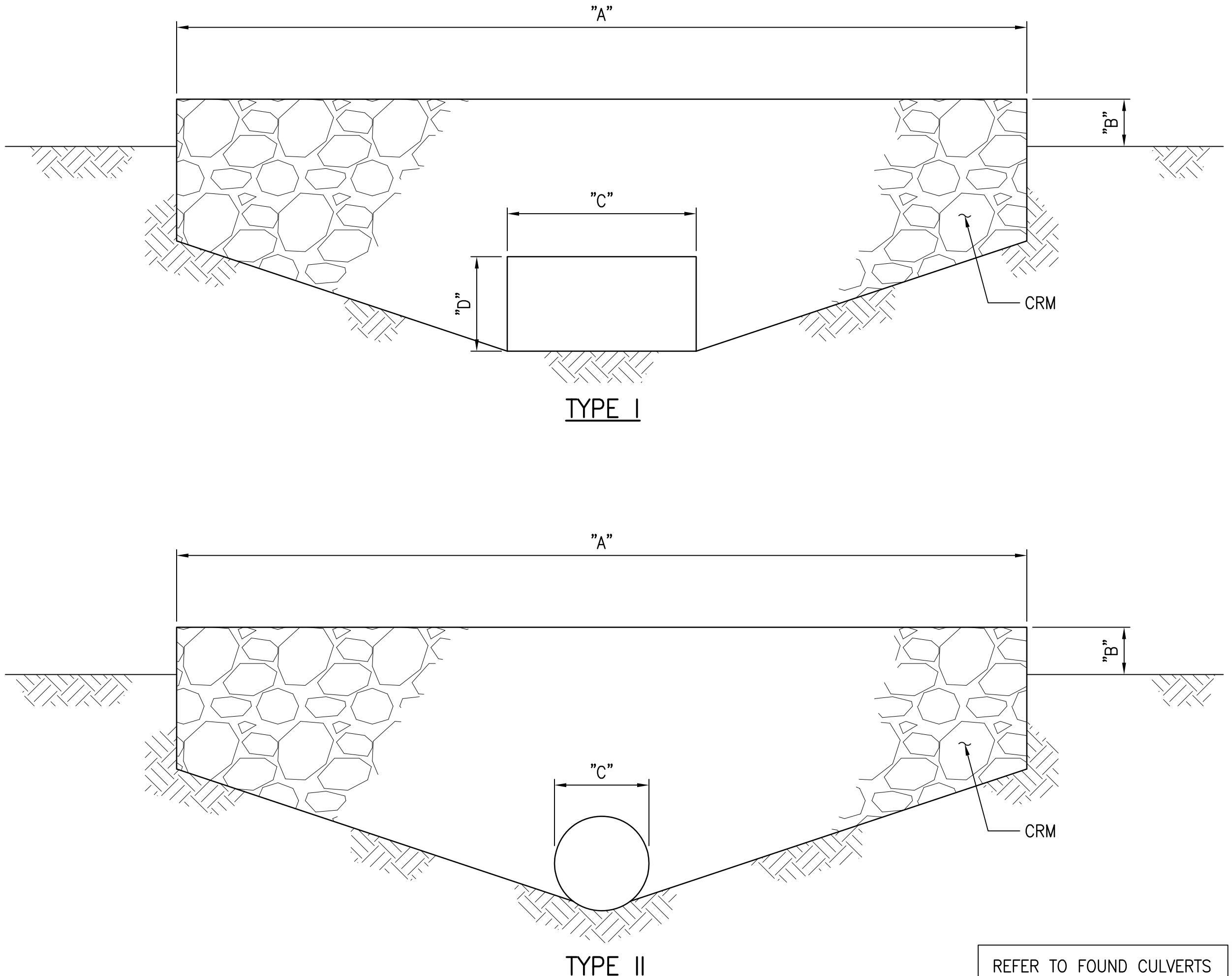
36 C CULVERT MP 22.79

Bridge Number:	N/A		**Island:**	Maui
Date of Construction:	Unknown		**Route:**	Hana Highway
Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream CRM parapet.

View of upstream concrete culvert headwall and CRM wingwalls.


CULVERT
MP 22.79
22. UNNAMED
BRIDGE NO. 1
(WAIOHUOLUA)
NORTH
LOCATION MAP
NOT TO SCALE
PROPOSED
LAYDOWN
AREA
PROPOSED
LAYDOWN
AREA
TO HANA
NORTH
A
ROADWAY PLAN
NOT TO SCALE
CRM WALL
FLOW
STREAM
CULVERT
MP 22.79
GUARDRAIL,
TYPICAL
TO KAHULUI
Drawing D: 36C-1
2015
CULVERT MP 22.79



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

37 C CULVERT MP 22.90

Bridge Number:	N/A	**Island:**	Maui
Date of Construction:	Unknown	**Route:**	Hana Highway

Treatment Recommendations: ☑ Preservation ☑ Rehabilitation ☐ Restoration ☐ Replacement

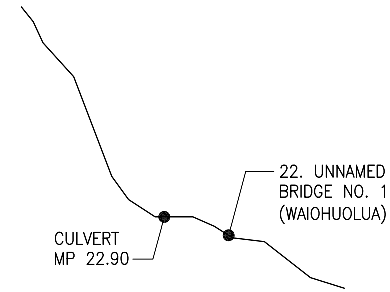
Kahului approach looking toward Hana.

View of upstream CRM parapet.

37 C	CULVERT MP 22.90				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

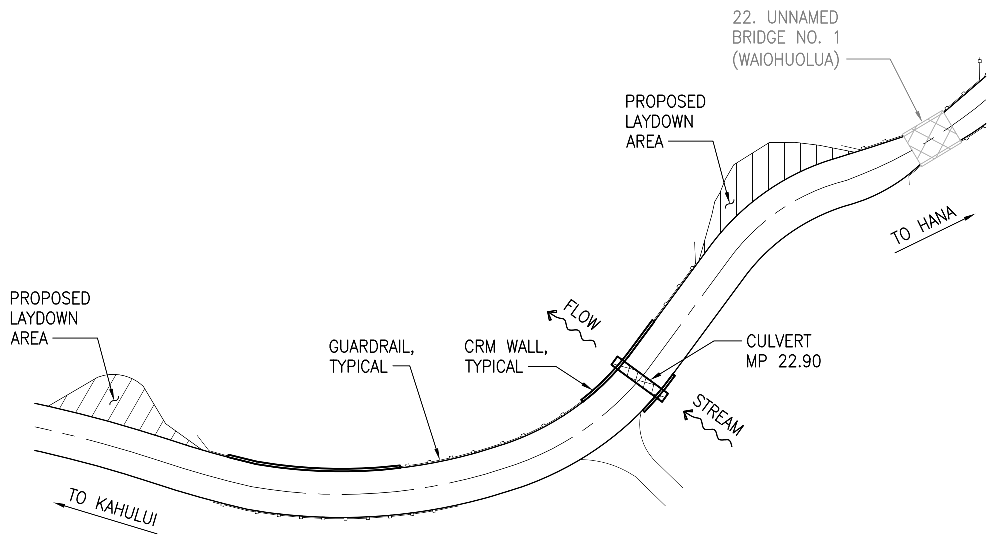
View of downstream CRM parapet.

24" diameter RCP inlet at upstream side.



LOCATION MAP
NOT TO SCALE

NORTH



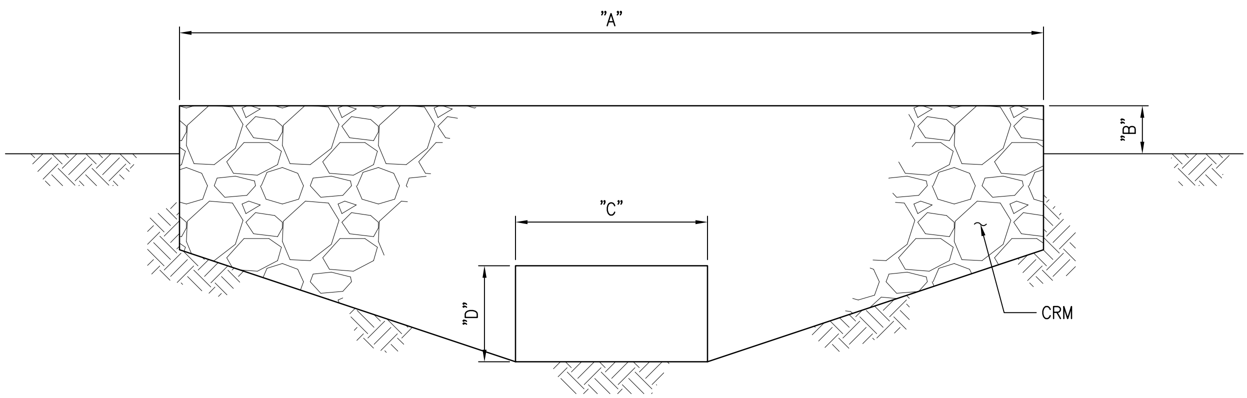
(A) ROADWAY PLAN
NOT TO SCALE

NORTH

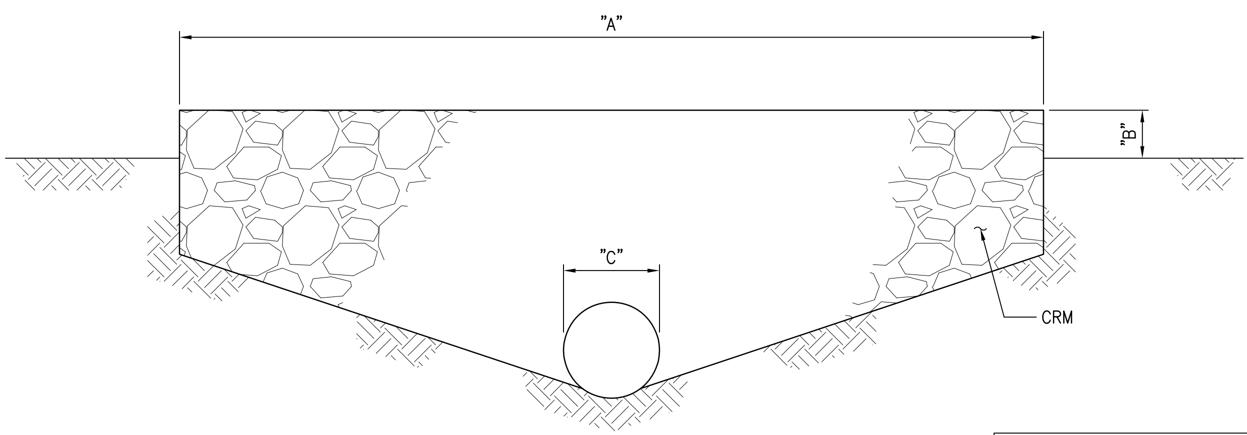
CULVERT MP 22.90

Drawing D: 37C-1

2015



TYPE I



TYPE II

REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 TYPICAL ELEVATION
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

38 C	CULVERT MP 23.04					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

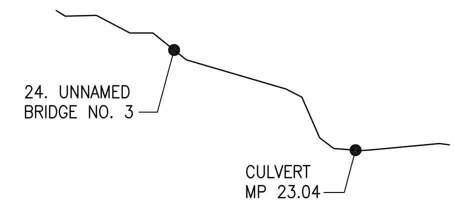
Kahului approach looking toward Hana.

View of upstream CRM parapet.

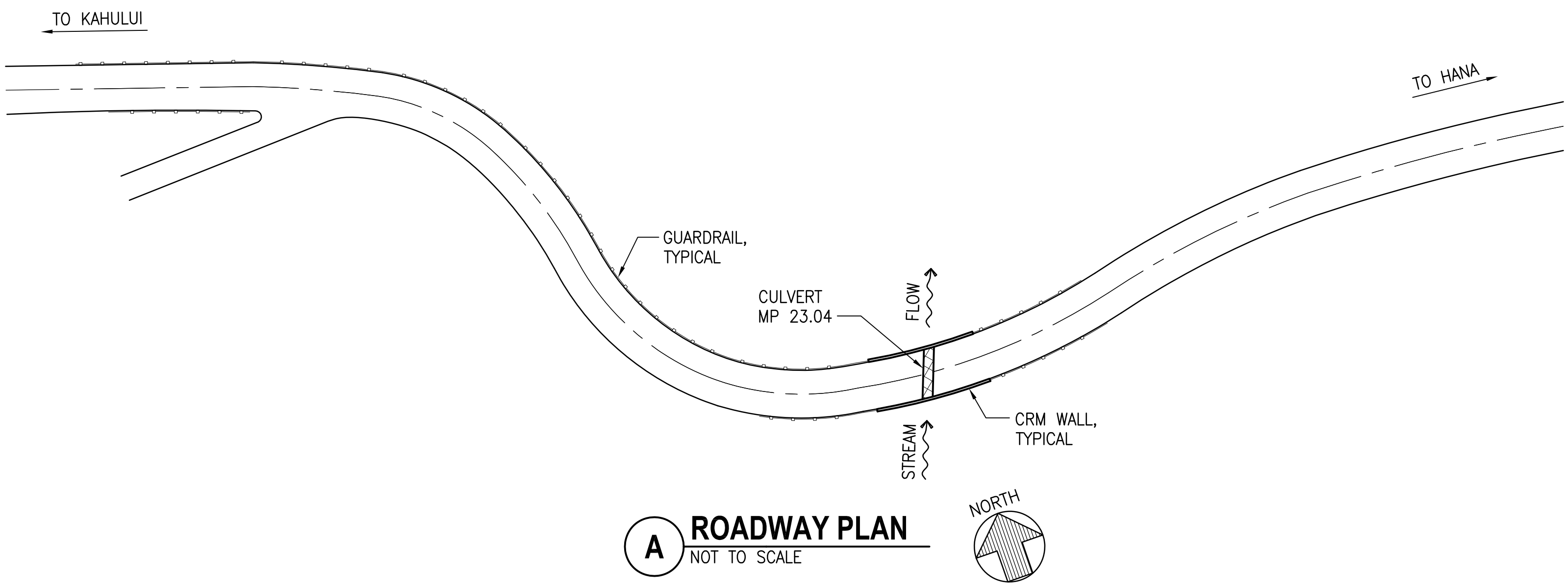
38 C	CULVERT MP 23.04					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement

View of downstream CRM parapet.

48" diameter CMP inlet at upstream side.



LOCATION MAP
NOT TO SCALE

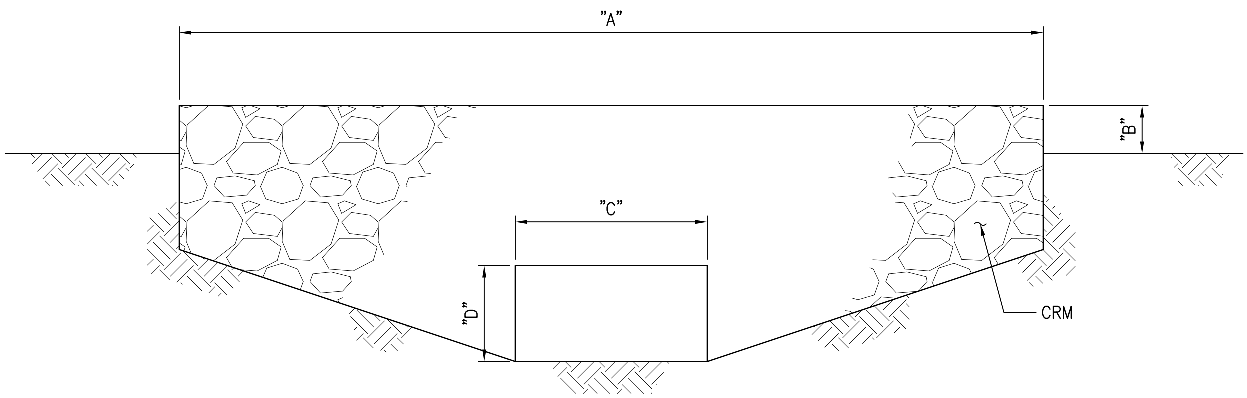


A ROADWAY PLAN
NOT TO SCALE

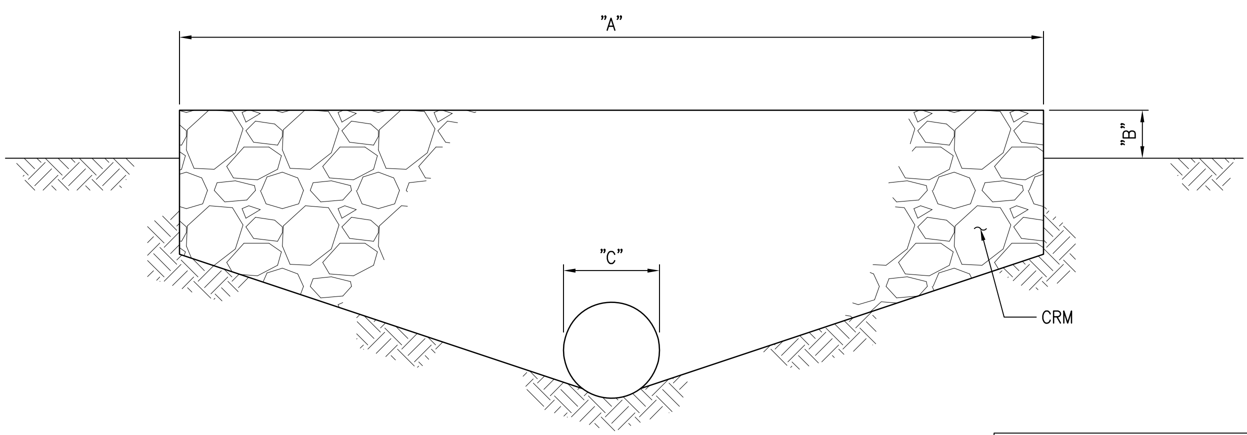
CULVERT MP 23.04

Drawing D: 38C-1

2015



TYPE I



TYPE II

REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 TYPICAL ELEVATION
NOT TO SCALE

Various Miscellaneous Culvert Elevations	Drawing D: C-2
	2015

39 C	CULVERT MP 23.21					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

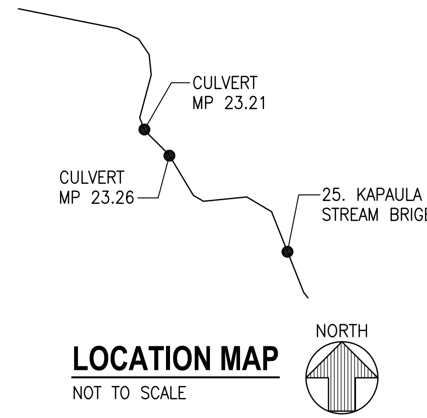
Kahului approach looking toward Hana.

View of upstream CRM parapet.

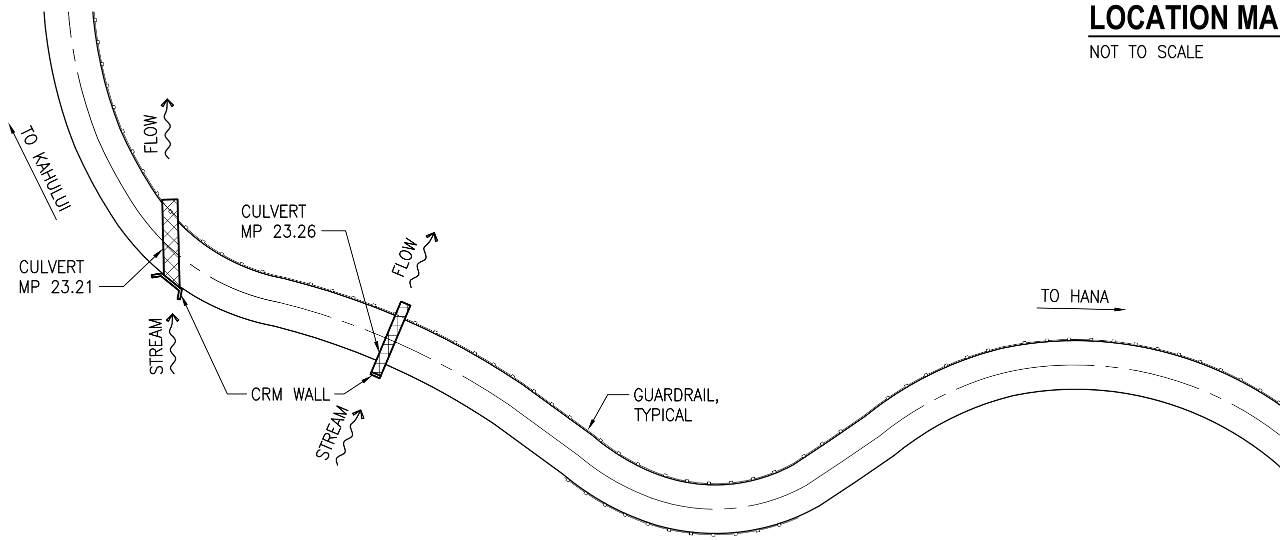
39 C	CULVERT MP 23.21					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement

View of downstream metal guardrail.

View of upstream CRM headwall / parapet and wingwalls.



LOCATION MAP
NOT TO SCALE

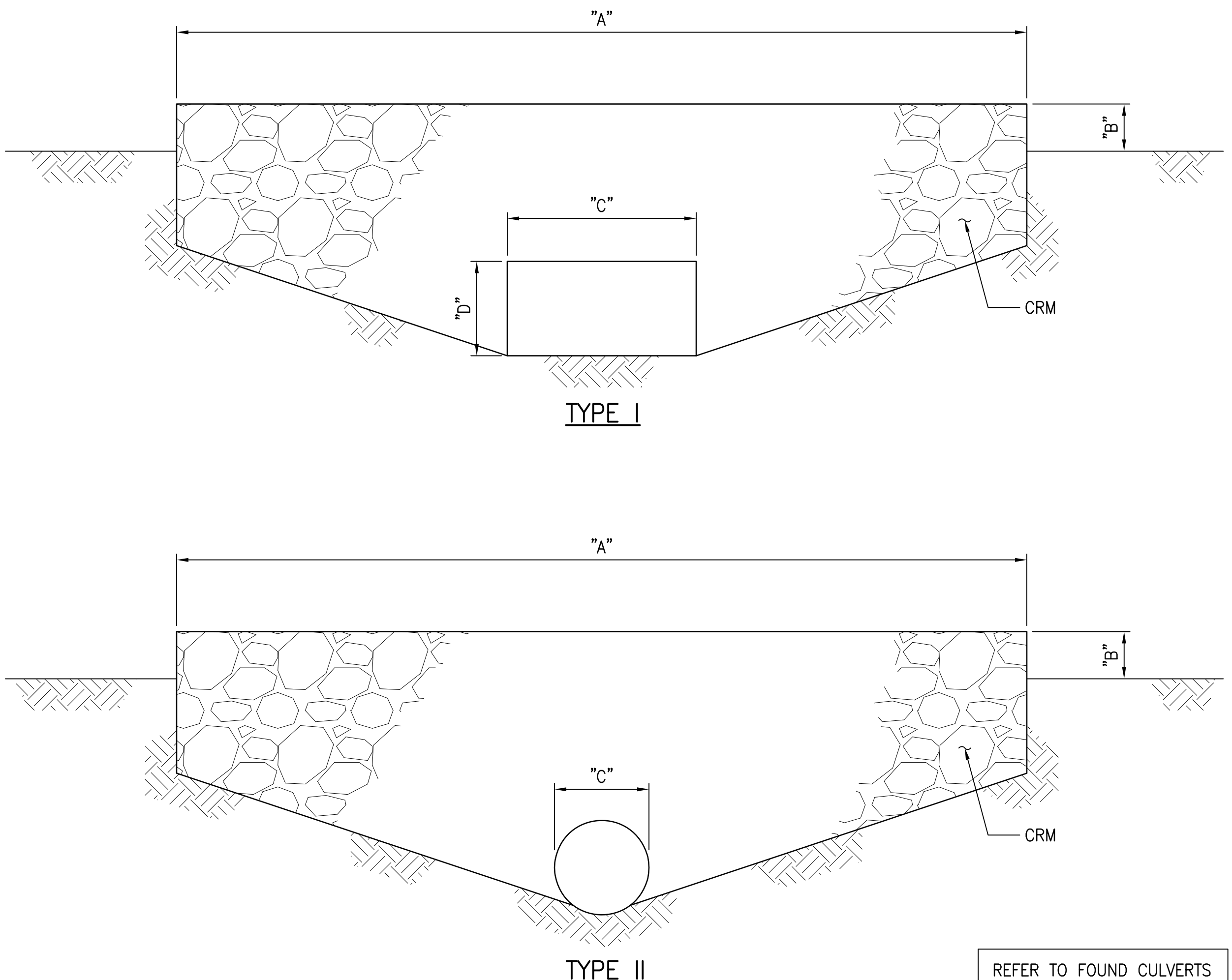


A **ROADWAY PLAN**
NOT TO SCALE

CULVERT MP 23.21 & CULVERT MP 23.26

Drawing D: 39C-1 & 40C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations	Drawing D: C-2
	2015

40C	CULVERT MP 23.26					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

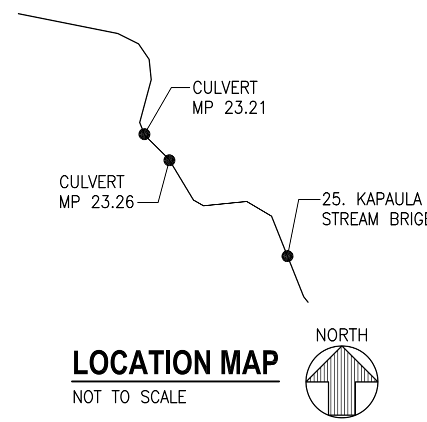
Kahului approach looking toward Hana.

View of upstream concrete parapet.

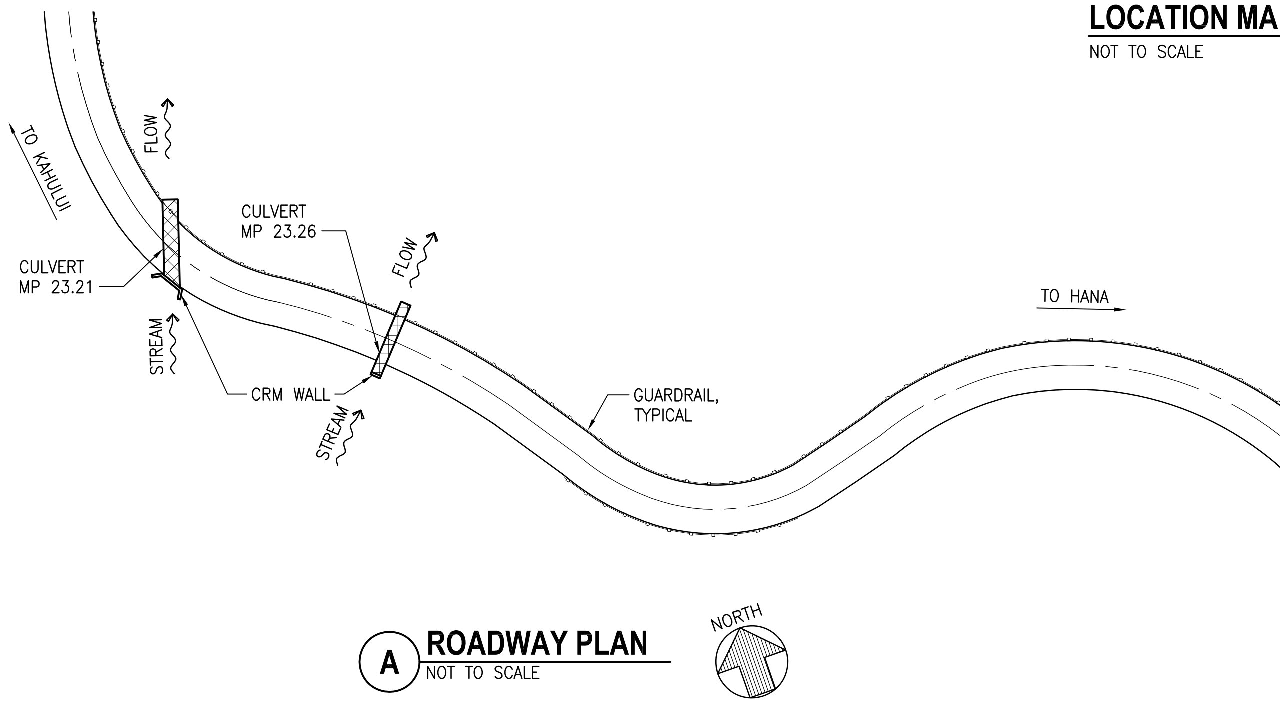
40 C	CULVERT MP 23.26					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement

View of downstream metal guardrail.

36" diameter RCP inlet at upstream side.



LOCATION MAP
NOT TO SCALE

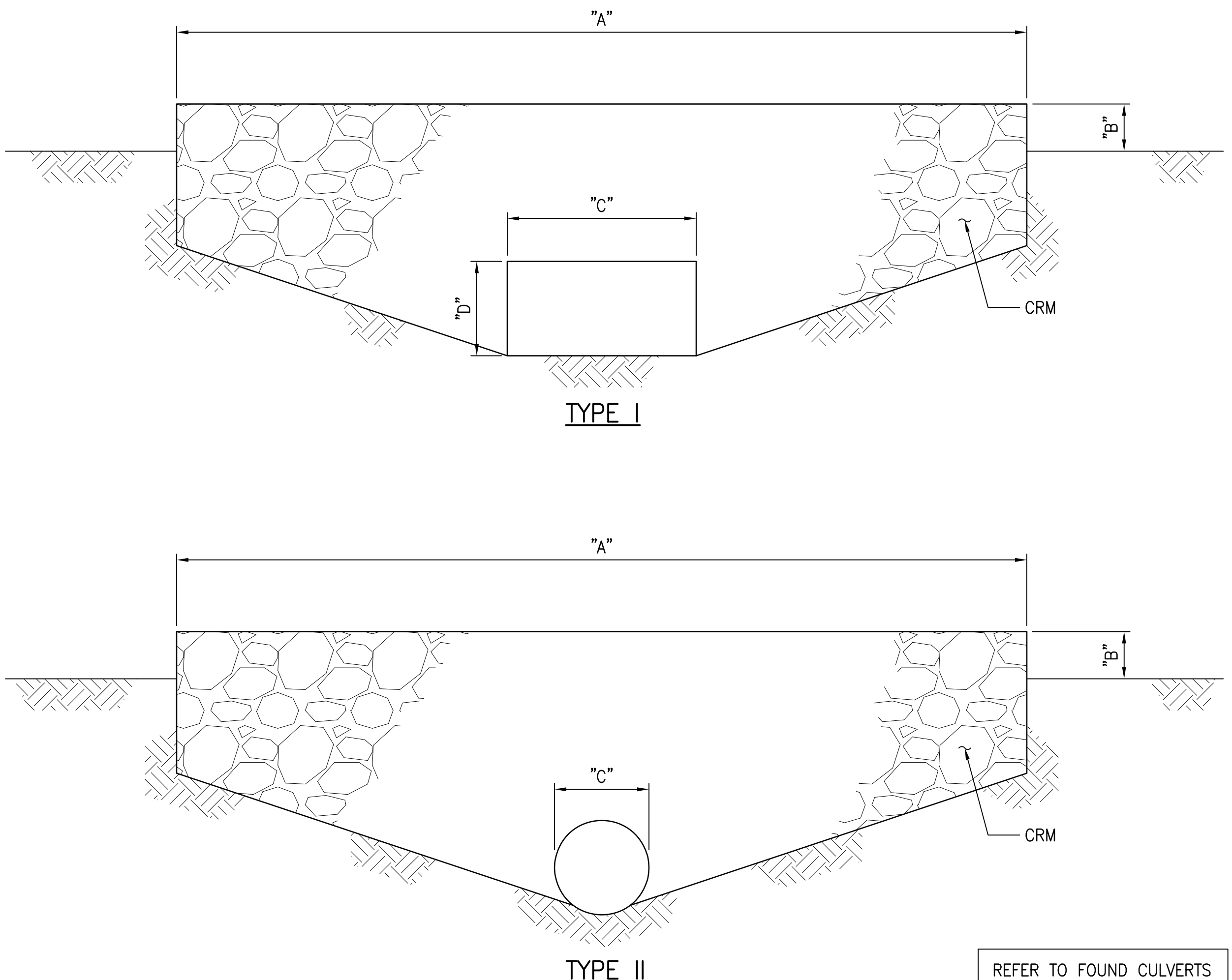


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 23.21 & CULVERT MP 23.26

Drawing D: 39C-1 & 40C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

41 C	CULVERT MP 23.70					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

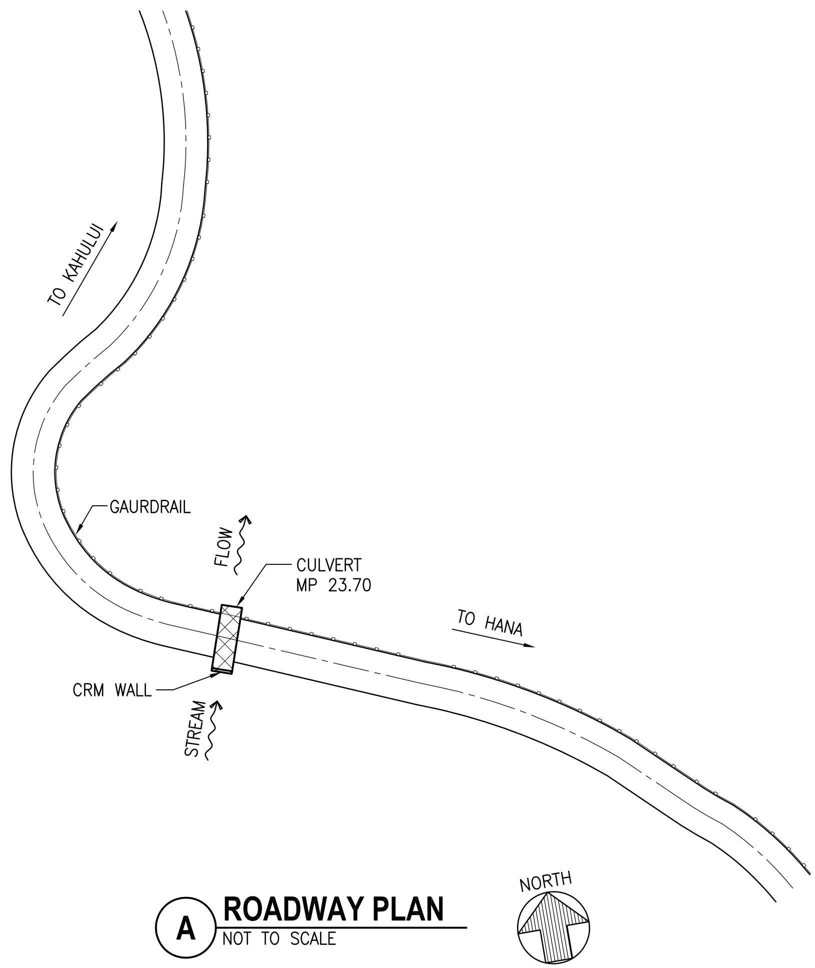
Kahului approach looking toward Hana on upstream side.

View of upstream CRM parapet.

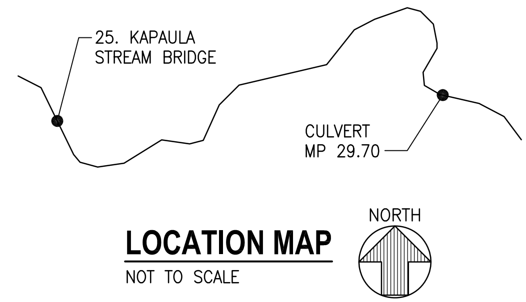
41 C	CULVERT MP 23.70					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream metal guardrail.

48" diameter RCP inlet at upstream side.



A ROADWAY PLAN
NOT TO SCALE

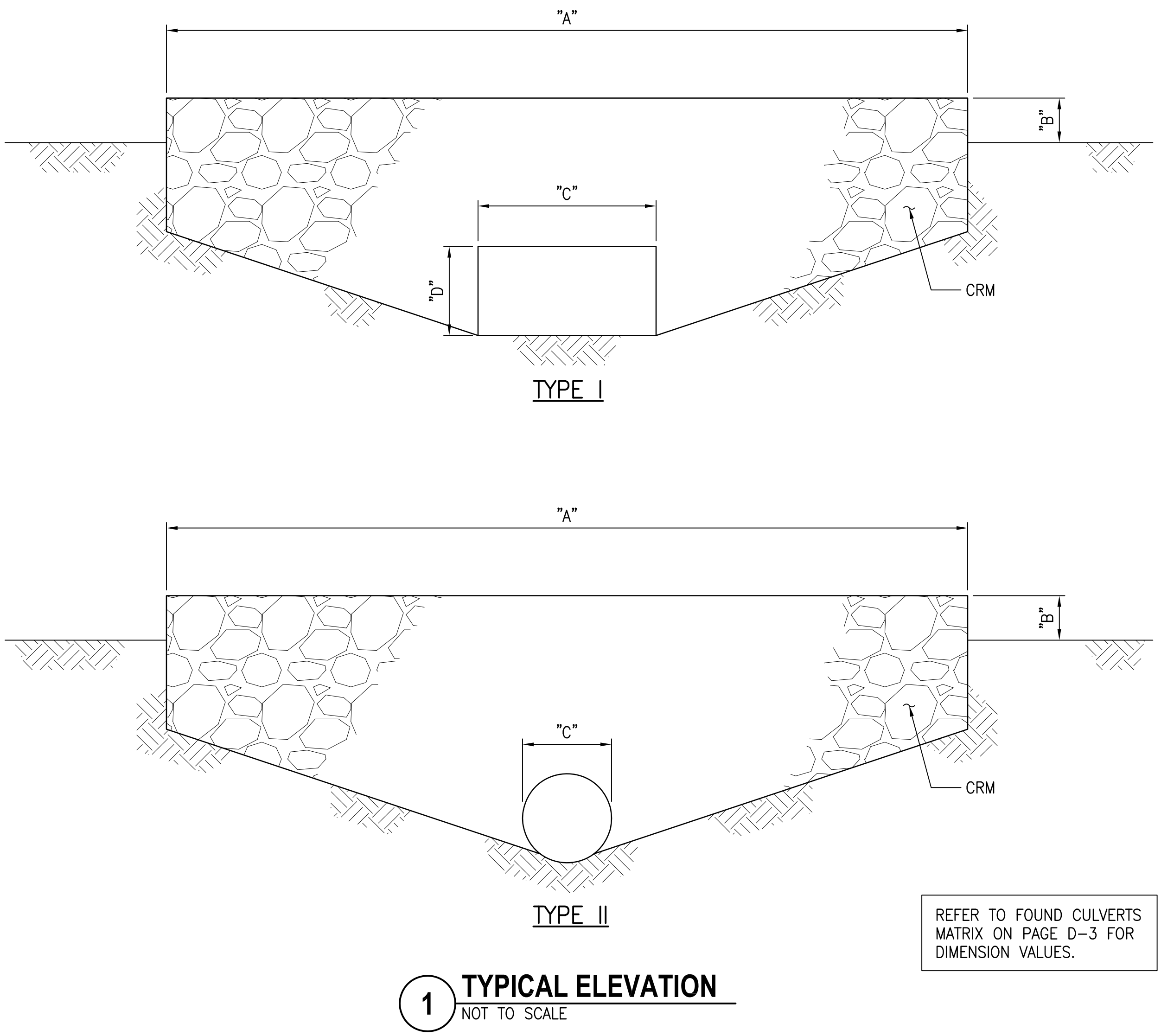


LOCATION MAP
NOT TO SCALE

CULVERT MP 23.70

Drawing D: 41C-1

2015



Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

43 C	CULVERT MP 24.38					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

Kahului approach looking toward Hana on upstream side.

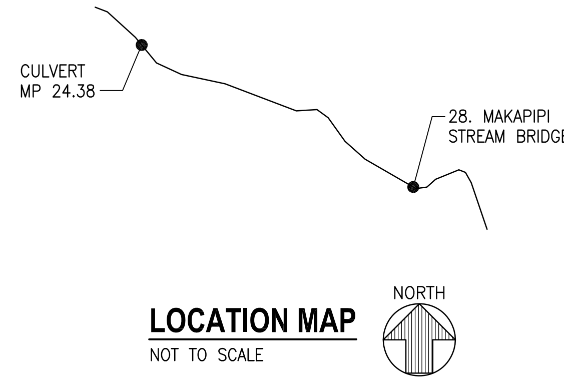
View of downstream CRM parapet.

43 C CULVERT MP 24.38

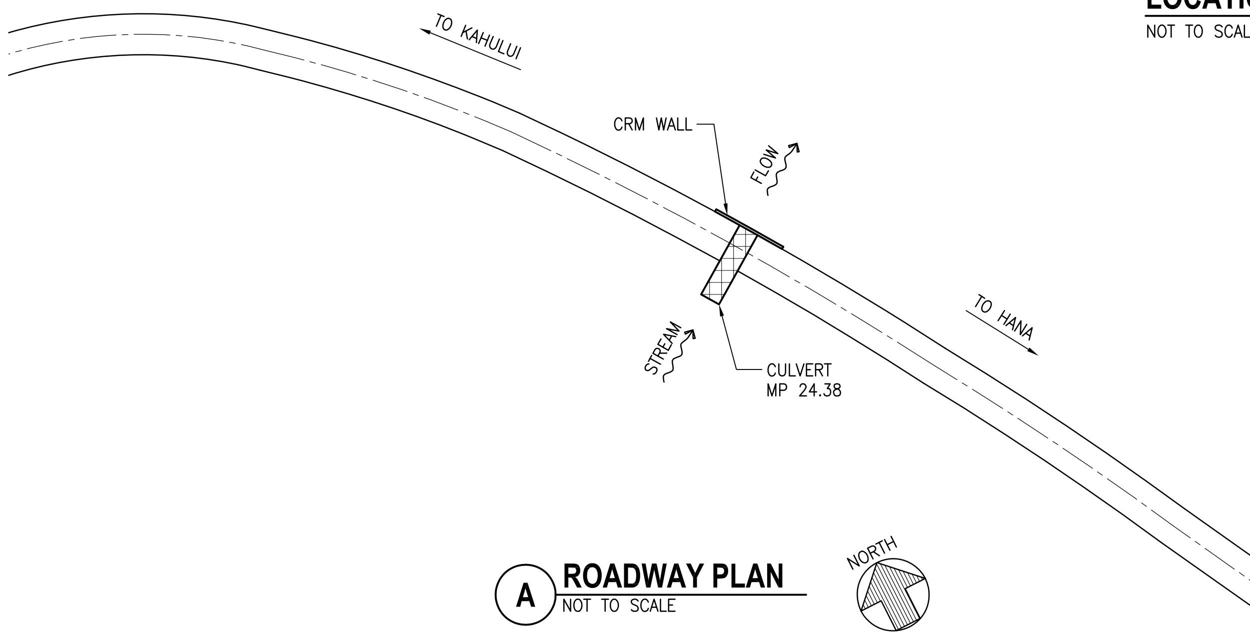
Bridge Number:	N/A	**Island:**	Maui
Date of Construction:	Unknown	**Route:**	Hana Highway

Treatment Recommendations: ☑ Preservation ☑ Rehabilitation ☐ Restoration ☐ Replacement

24" diameter RCP outlet at downstream side.



LOCATION MAP
NOT TO SCALE

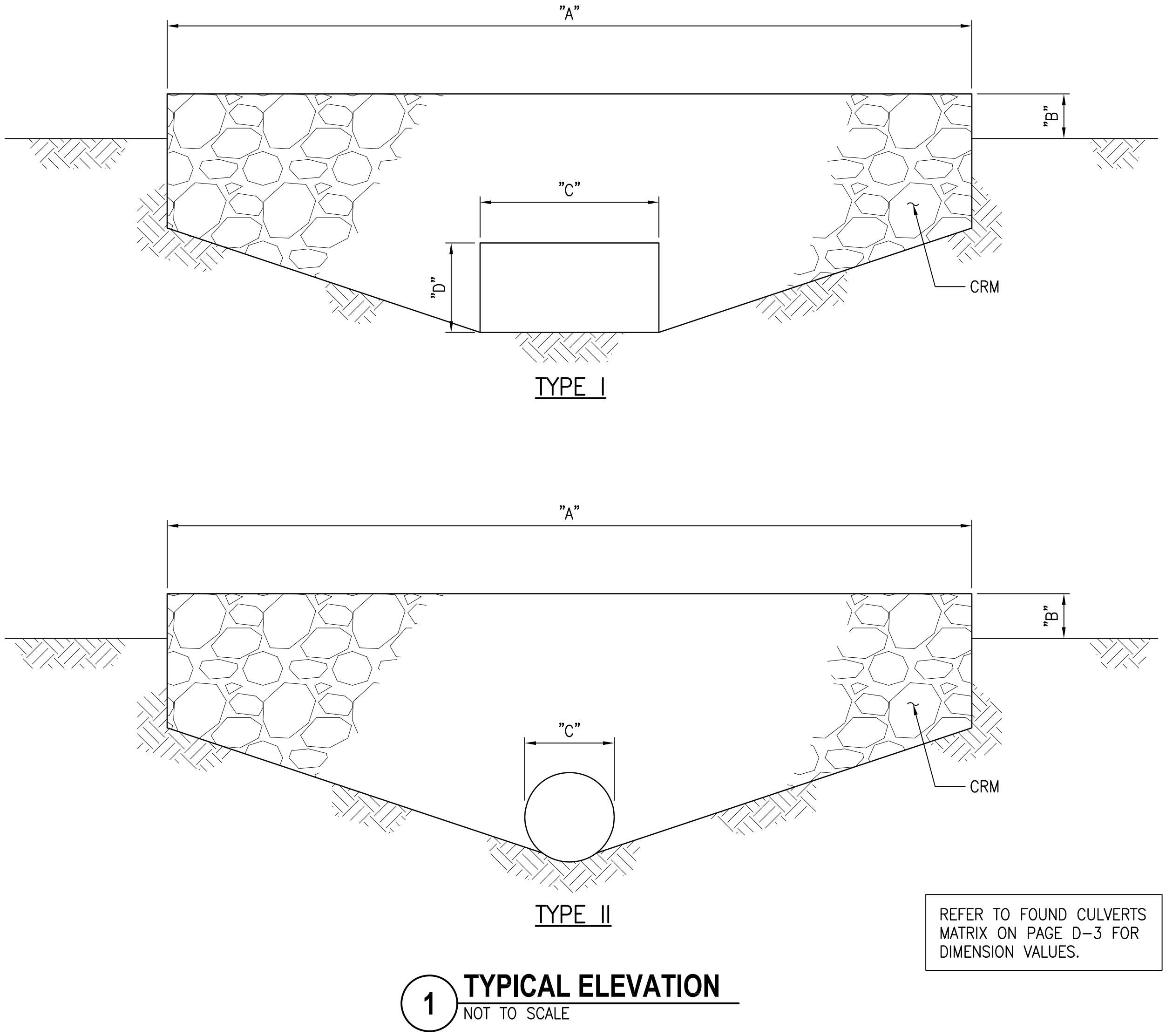


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 24.38

Drawing D: 43C-1

2015



Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

44 C	CULVERT MP 24.71				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

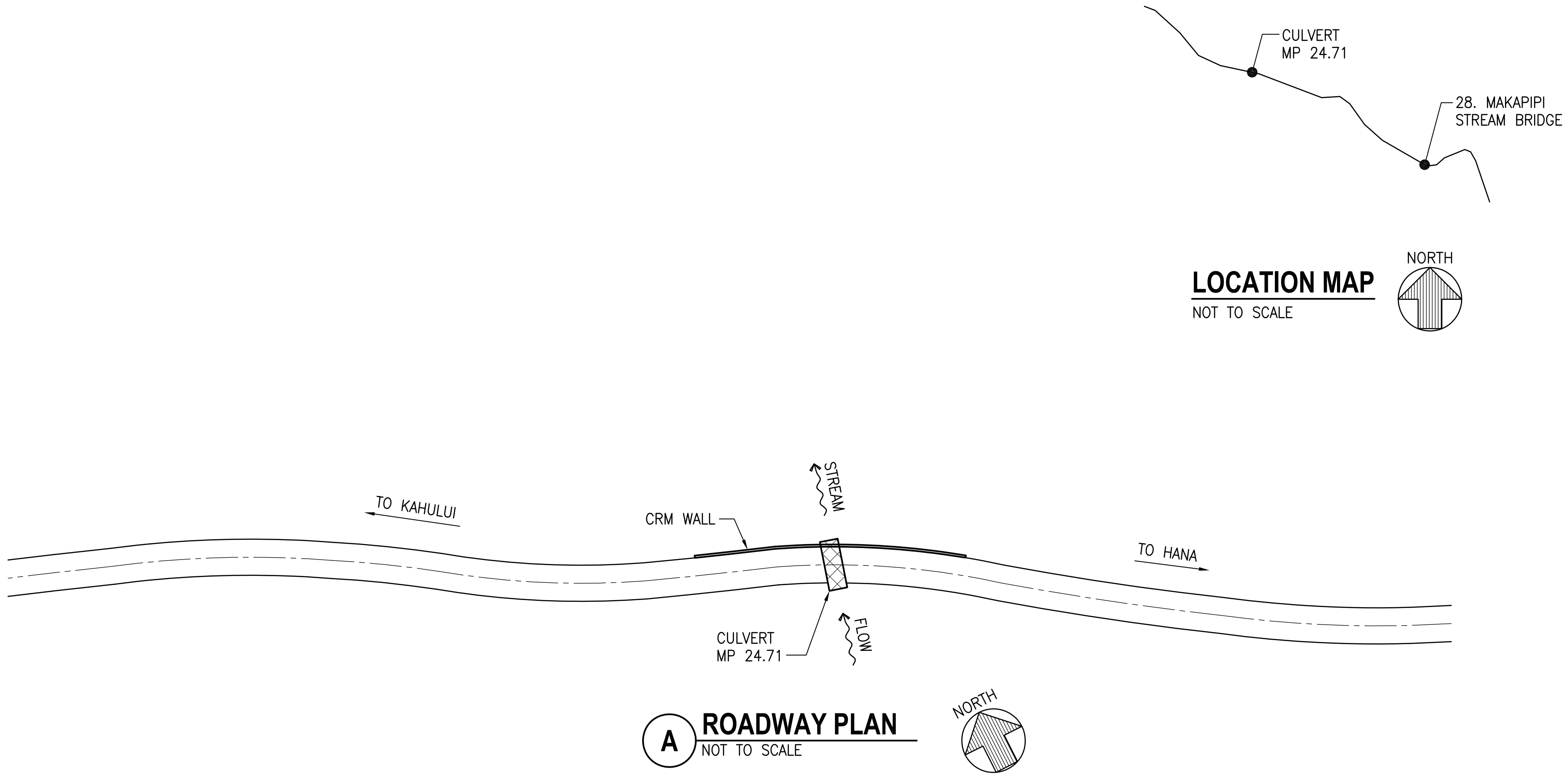
Kahului approach looking toward Hana on upstream side.

View of downstream CRM parapet.

44 C	CULVERT MP 24.71				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

2 - 4" diameter pipe outlets at downstream side.

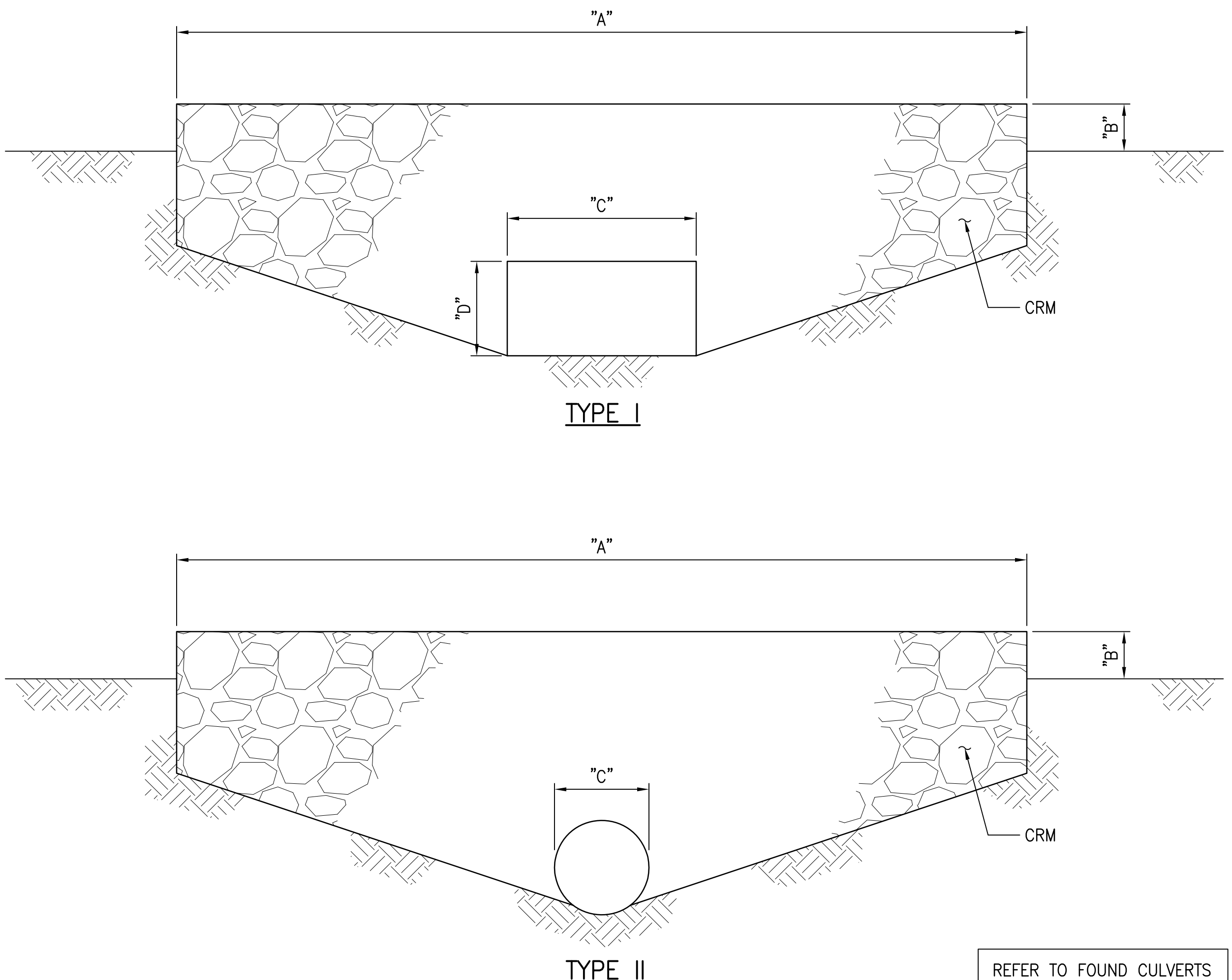
View of CRM headwall / parapet at downstream side.



CULVERT MP 24.71

Drawing D: 44C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

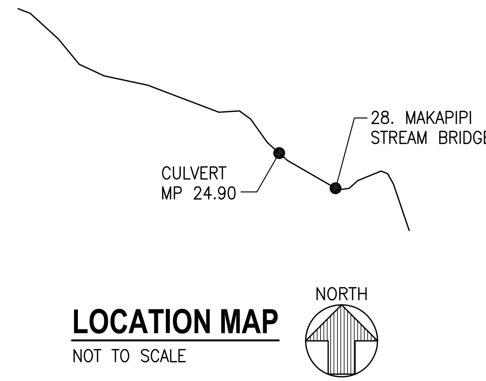
45 C	CULVERT MP 24.90					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☑ Replacement	

Kahului approach looking toward Hana on upstream side.

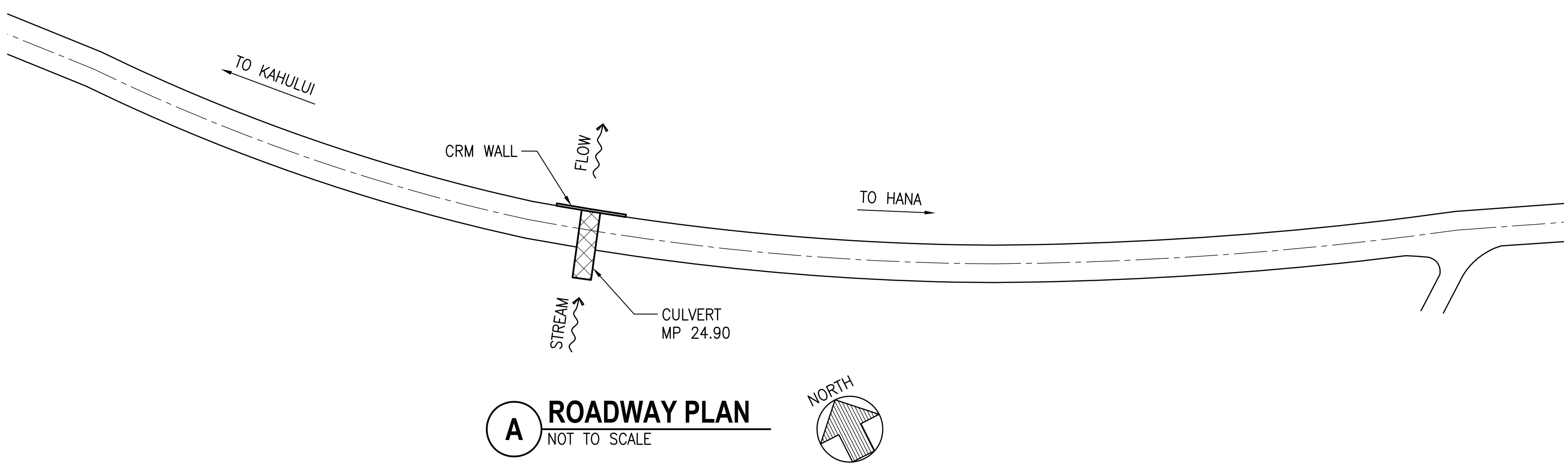
View of downstream CRM parapet.

45 C	CULVERT MP 24.90					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of CRM headwall / parapet at downstream side.



LOCATION MAP
NOT TO SCALE

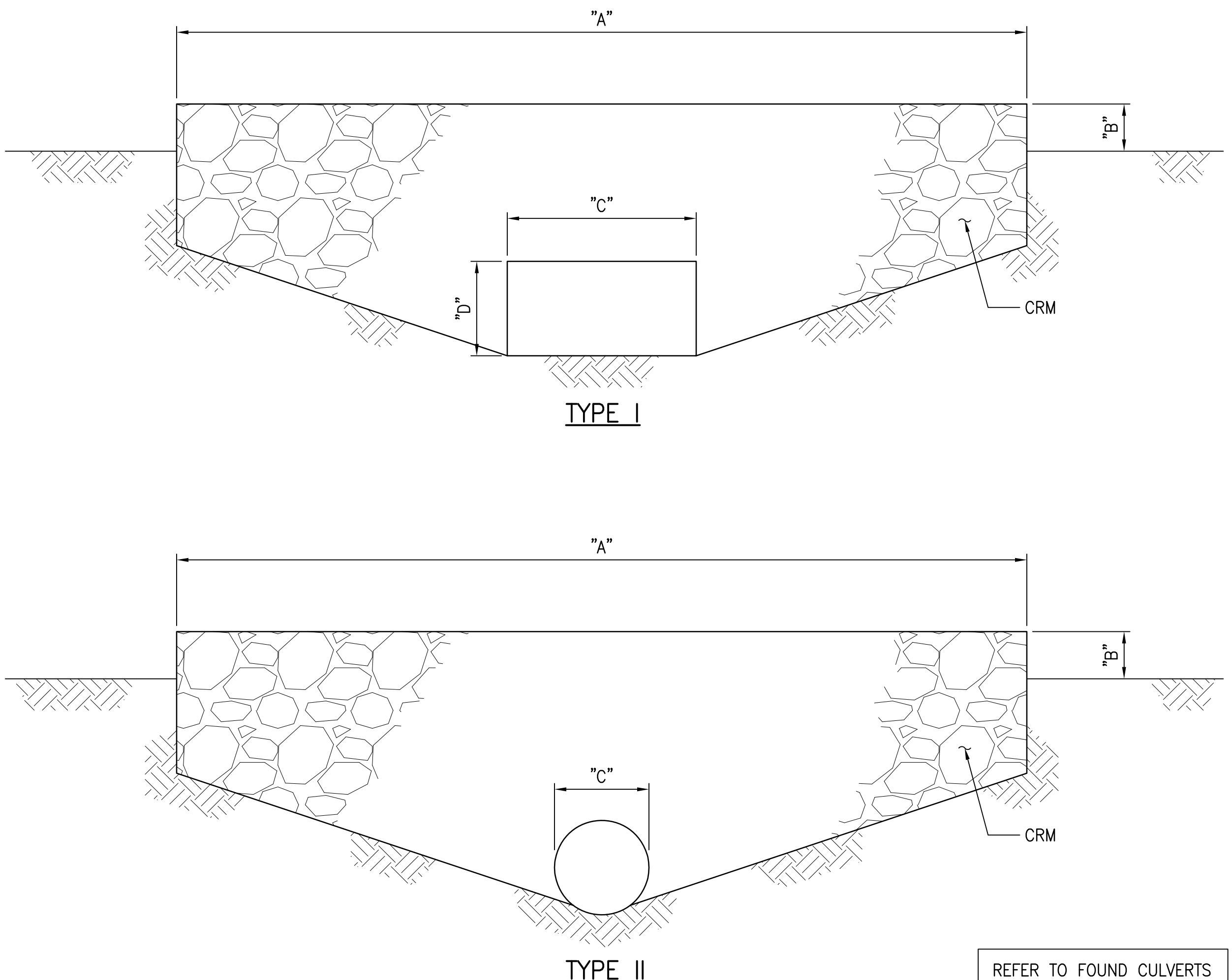


A ROADWAY PLAN
NOT TO SCALE

CULVERT MP 24.90

Drawing D: 45C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations	Drawing D: C-2
	2015

<table>
<tr><td rowspan="4">46
C</td><td colspan="5">CULVERT MP 26.13</td></tr>
<tr><td>Bridge Number:</td><td colspan="2">N/A</td><td>Island:</td><td>Maui</td></tr>
<tr><td>Date of Construction:</td><td colspan="2">Unknown</td><td>Route:</td><td>Hana Highway</td></tr>
<tr><td>Treatment Recommendations:</td><td>☑ Preservation</td><td>☑ Rehabilitation</td><td>☐ Restoration</td><td>☐ Replacement</td></tr>
</table>

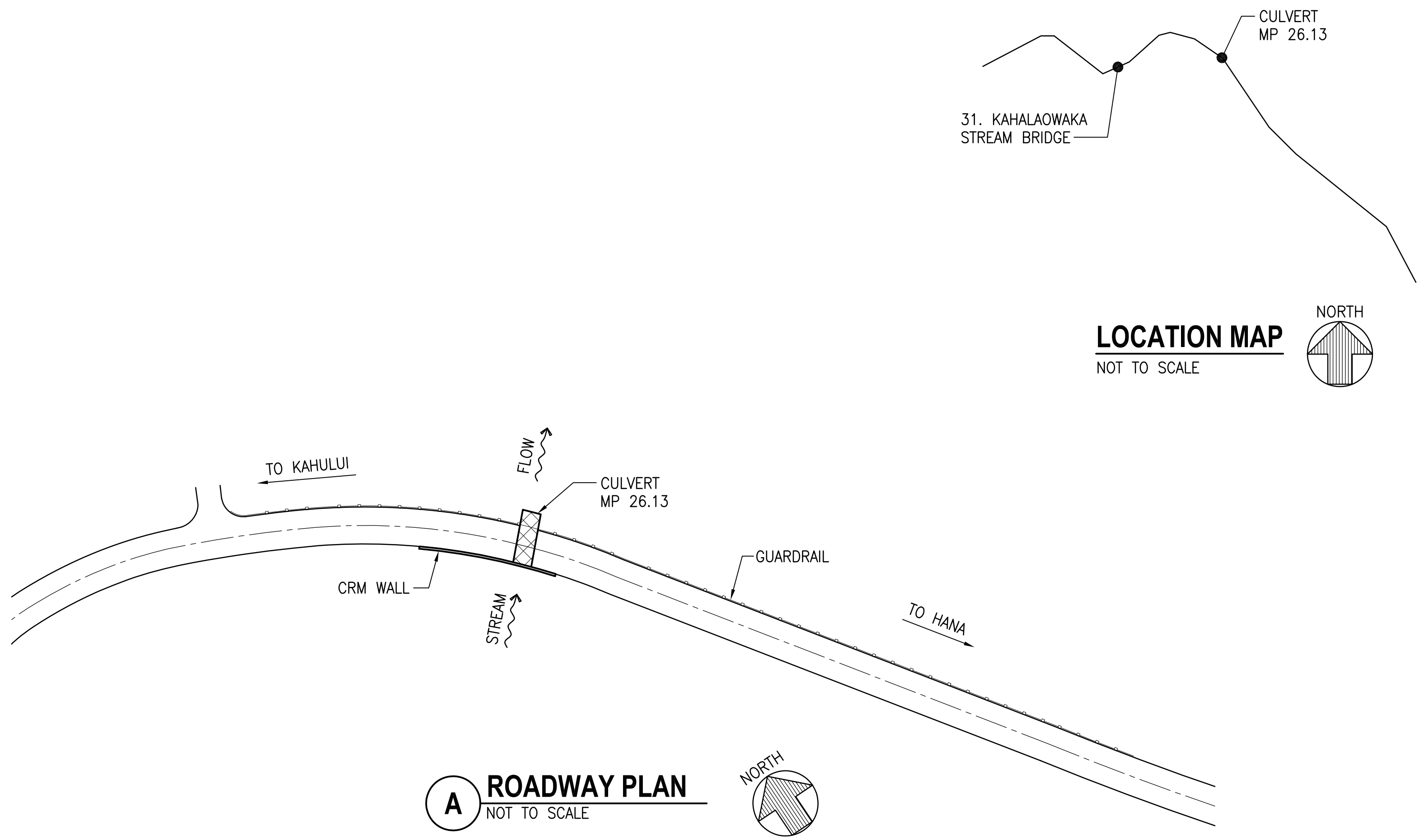
Kahului approach looking toward Hana.

View of upstream CRM parapet.

46 C	CULVERT MP 26.13					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream metal guardrail.

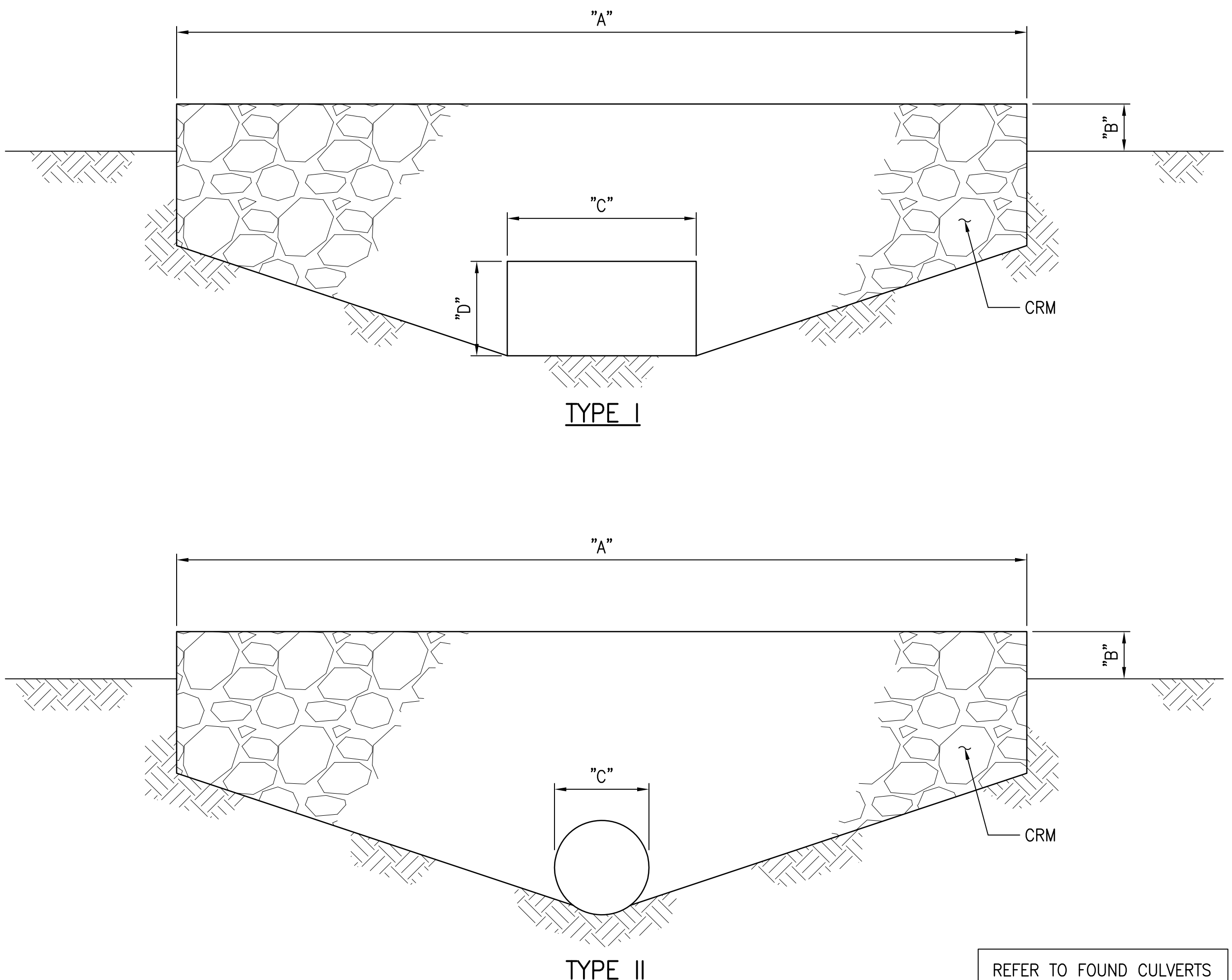
View of CRM headwall / parapet at upstream side.



CULVERT MP 26.13

Drawing D: 46C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

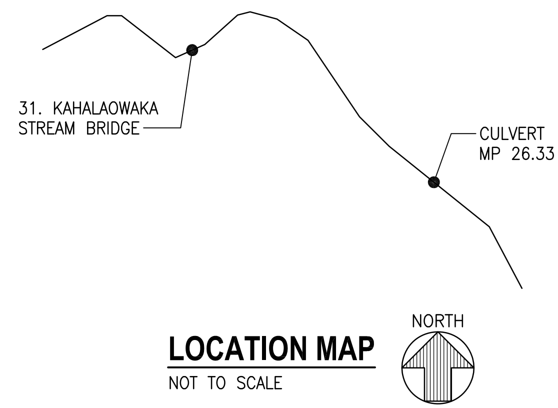
47 C	CULVERT MP 26.33			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

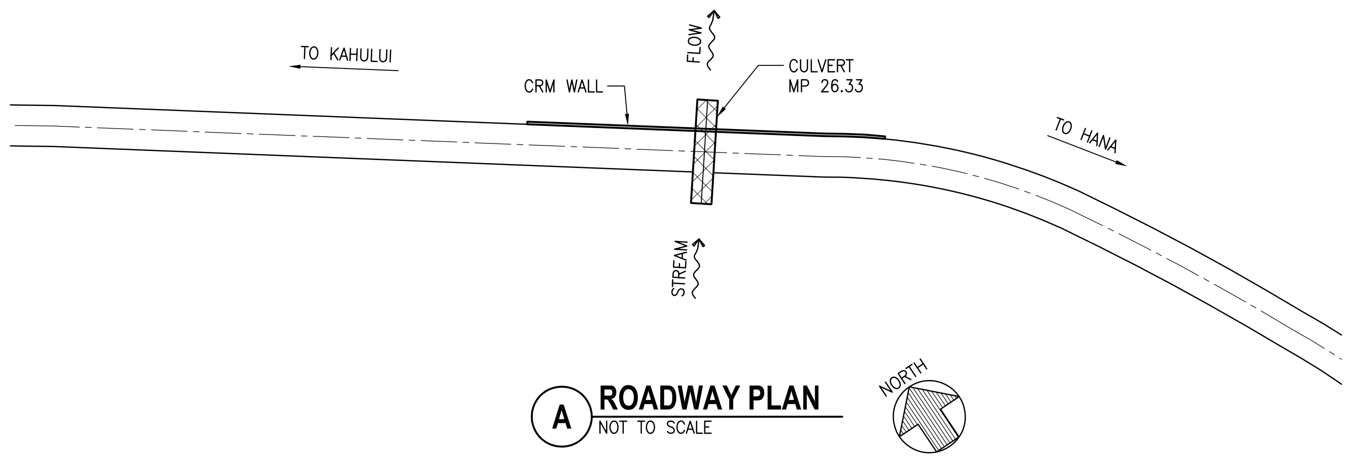
Kahului approach looking toward Hana.

View of downstream CRM parapet.

47 C	CULVERT MP 26.33				
	Bridge Number:	N/A		**Island:**	Maui
	Date of Construction:	Unknown		**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement

View of downstream CRM headwall and culvert opening.

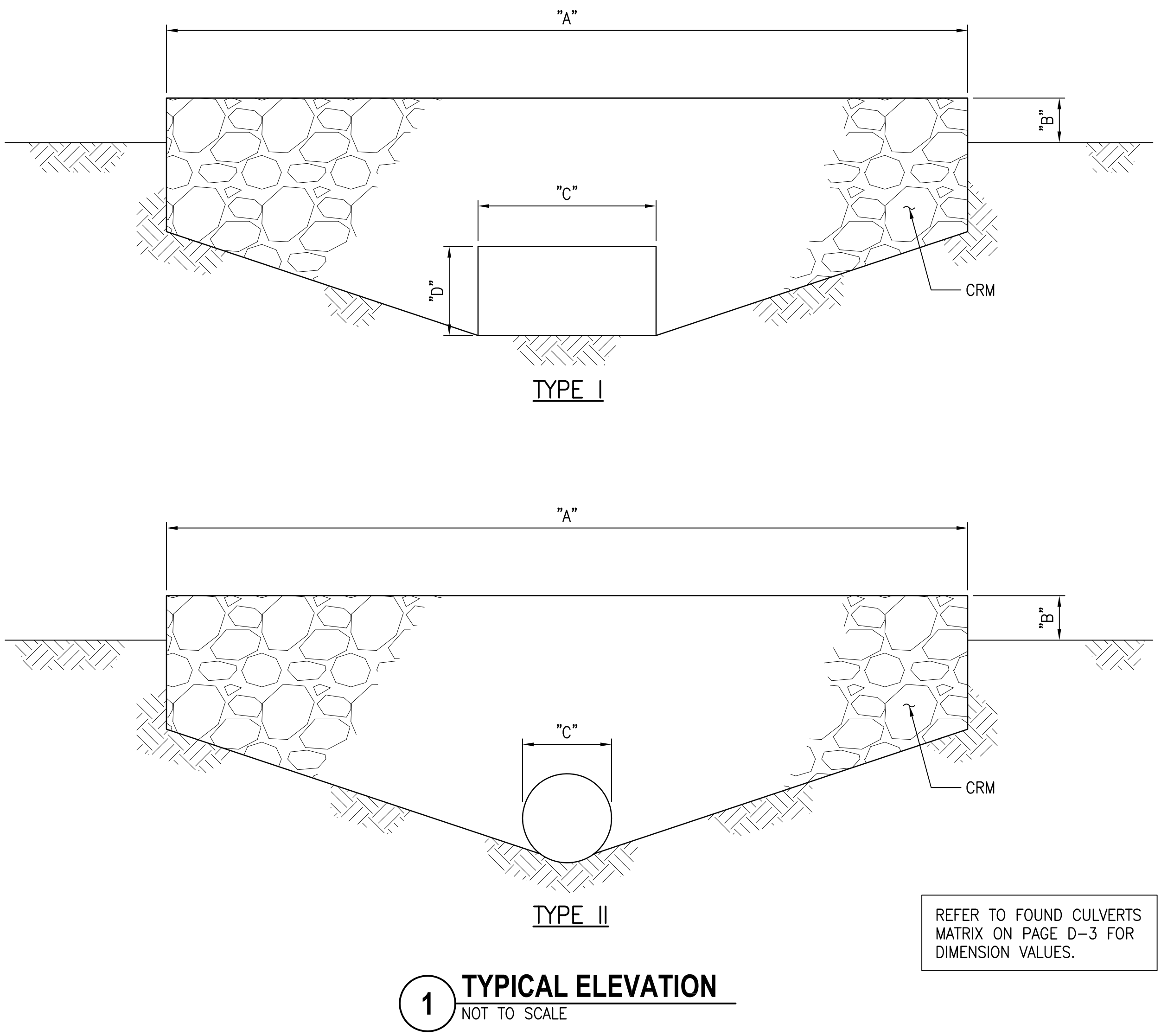




CULVERT MP 26.33

Drawing D: 47C-1

2015



Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

48 C	CULVERT MP 27.26			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

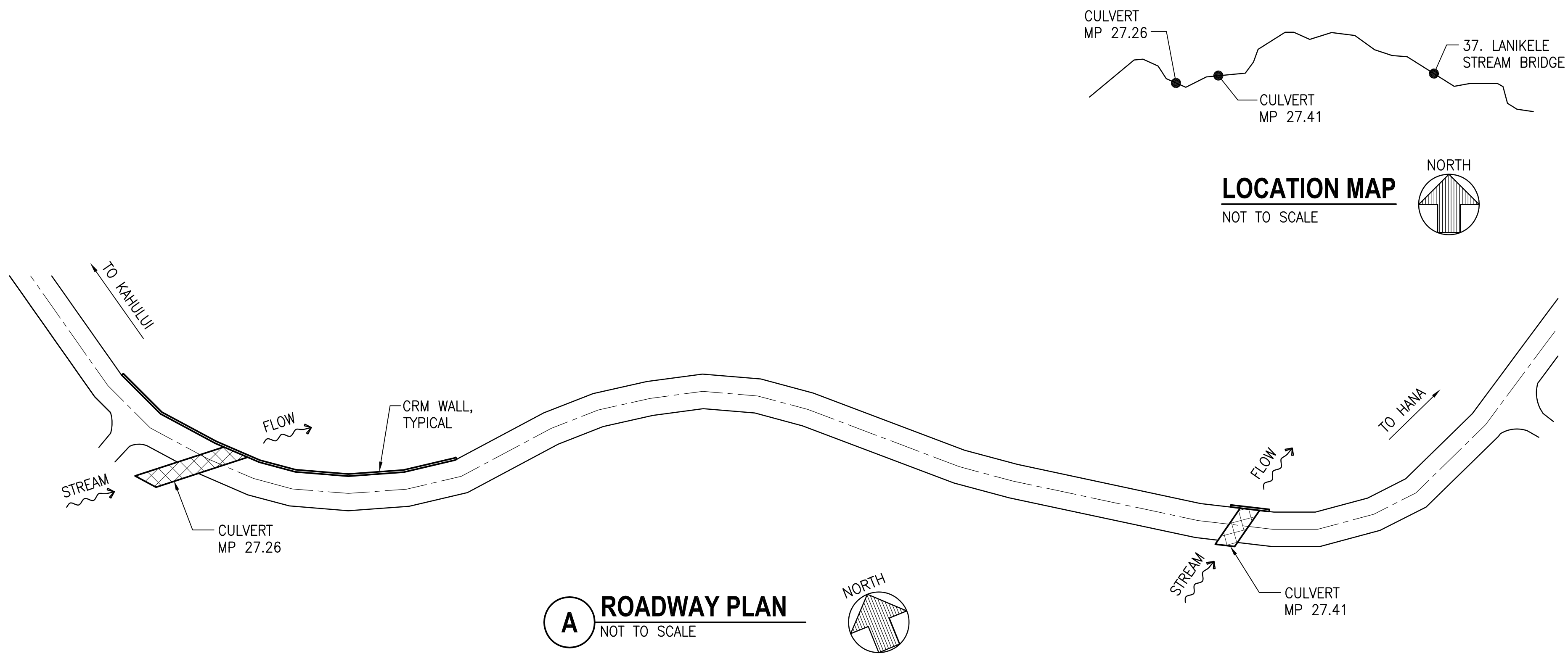
Kahului approach looking toward Hana.

View of upstream CRM parapet.

48 C	CULVERT MP 27.26					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

View of downstream CRM headwall / parapet covered with vegetation.

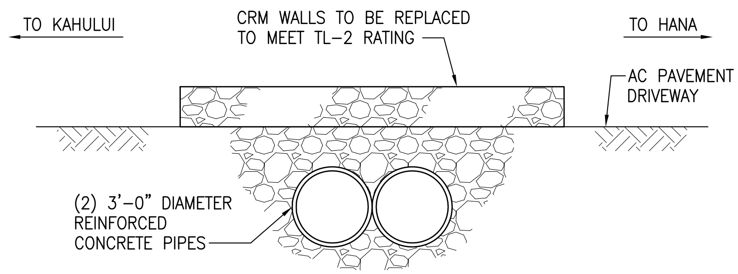
View of upstream through culvert.



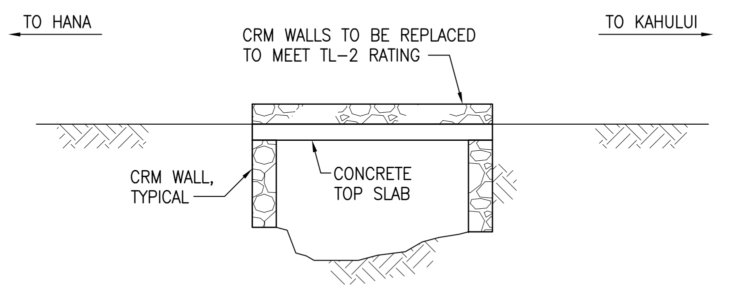
CULVERT MP 27.26 & CULVERT MP 27.41

Drawing D: 48C-1 & 49C-1

2015



1 UPSTREAM ELEVATION
NOT TO SCALE



2 DOWNSTREAM ELEVATION
NOT TO SCALE

CULVERT MP 27.26

Drawing D: 48C-2

2015

49 C	CULVERT MP 27.41			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

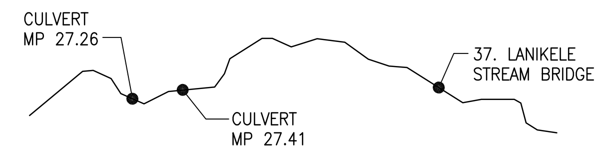
Kahului approach looking toward Hana.

View of downstream CRM parapet.

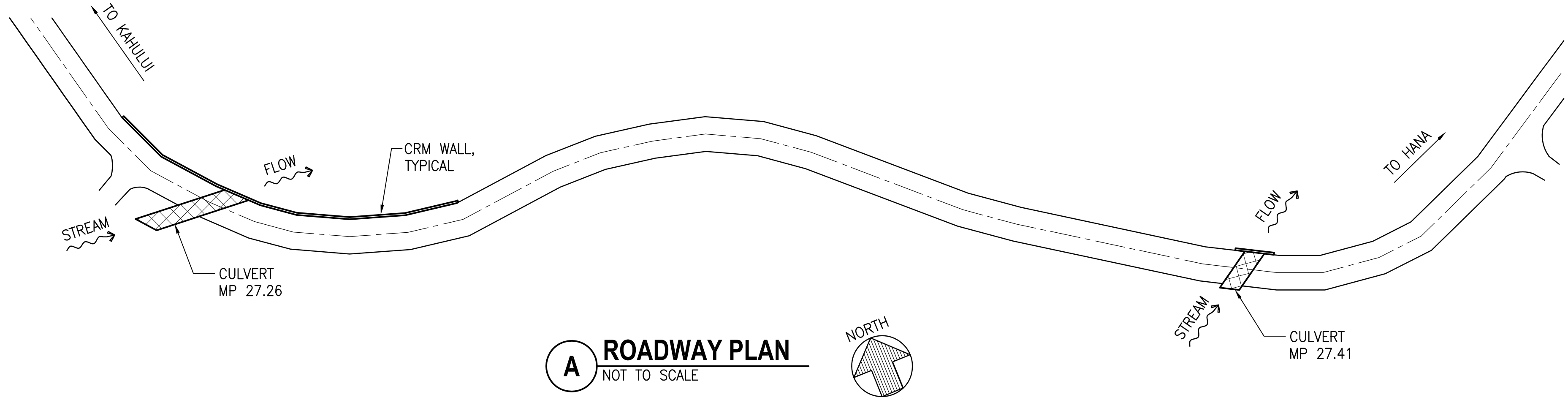
49 C CULVERT MP 27.41

Bridge Number:	N/A			**Island:**	Maui		
Date of Construction:	Unknown			**Route:**	Hana Highway		
Treatment Recommendations:	☑	Preservation	☑	Rehabilitation	☐ Restoration	☐	Replacement

24" diameter CMP outlet at downstream side.



LOCATION MAP
NOT TO SCALE

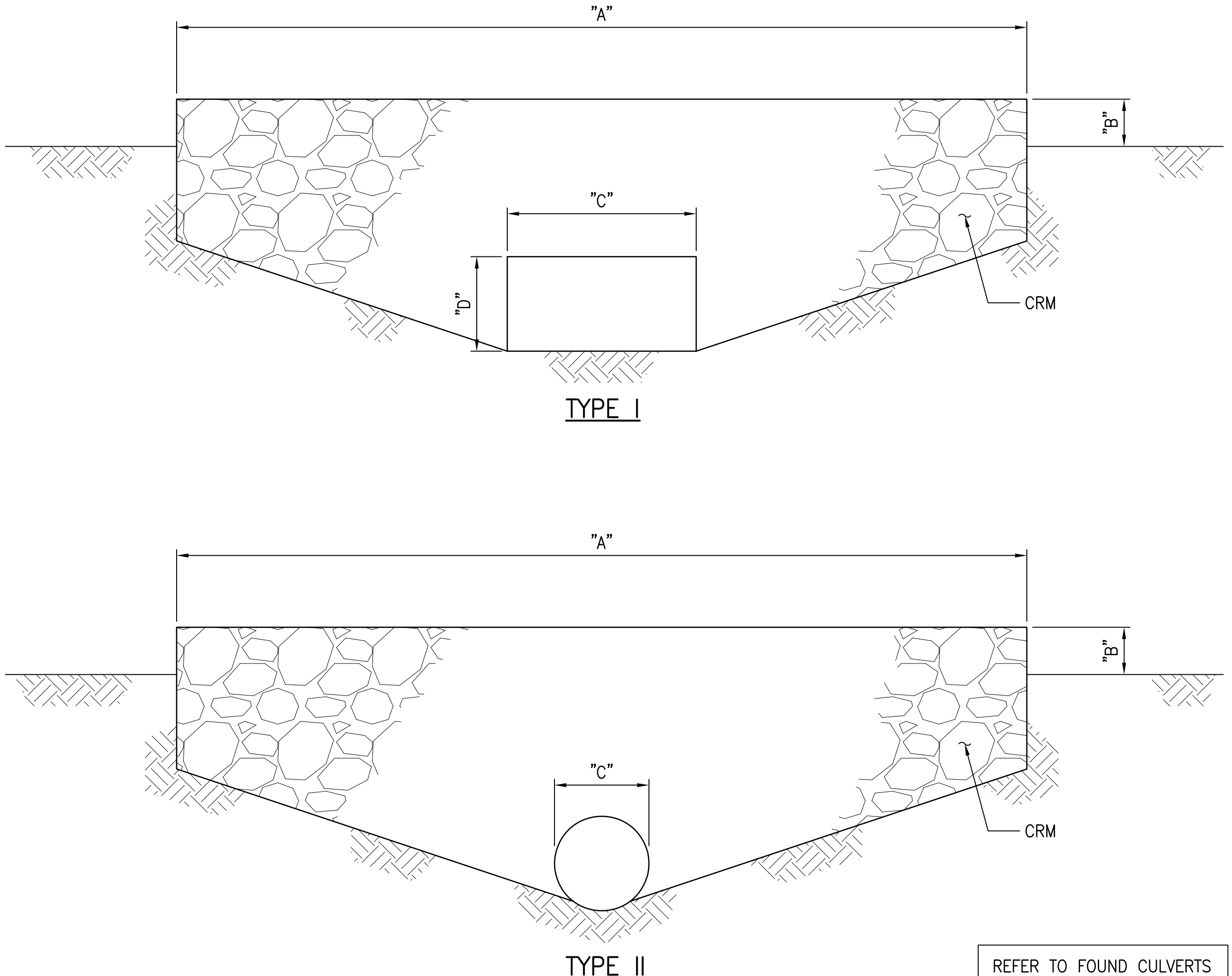


A **ROADWAY PLAN**
NOT TO SCALE

CULVERT MP 27.26 & CULVERT MP 27.41

Drawing D: 48C-1 & 49C-1

2015



REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

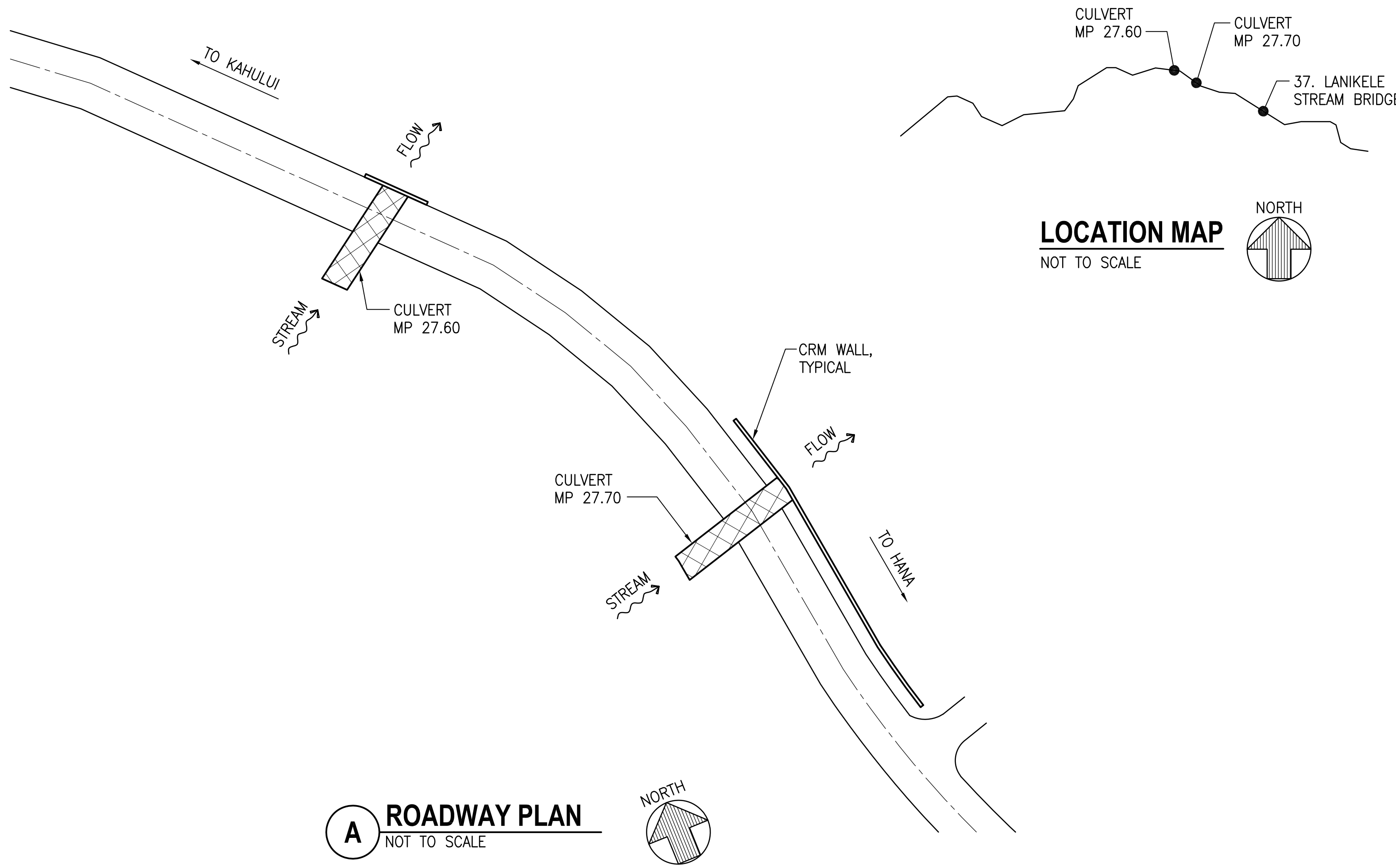
50 C	CULVERT MP 27.60			
	Bridge Number:	N/A	**Island:**	Maui
	Date of Construction:	Unknown	**Route:**	Hana Highway
	Treatment Recommendations:	☑ Preservation ☑ Rehabilitation	☐ Restoration	☐ Replacement

Kahului approach looking toward Hana.

View of downstream CRM parapet.

50 C	CULVERT MP 27.60						
	Bridge Number:	N/A		**Island:**	Maui		
	Date of Construction:	Unknown		**Route:**	Hana Highway		
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement	

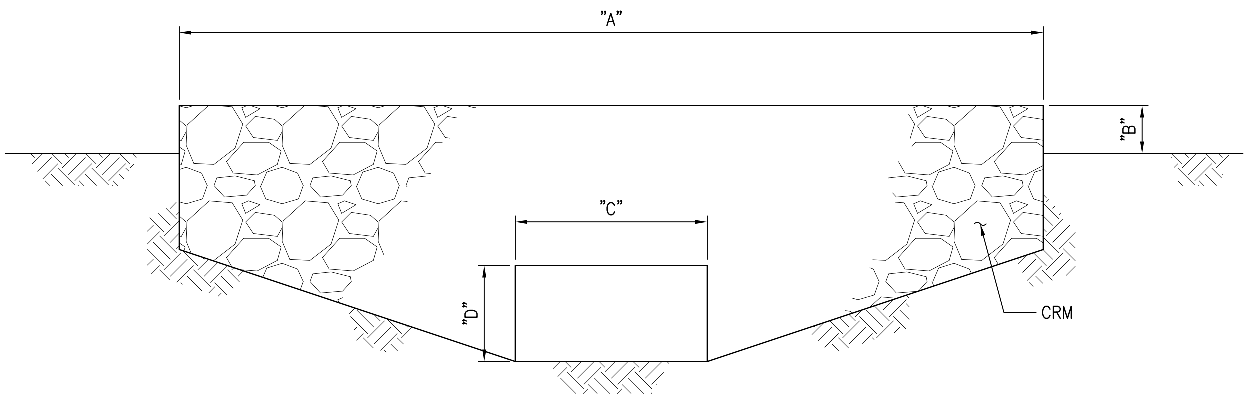
View of downstream CRM headwall / parapet.



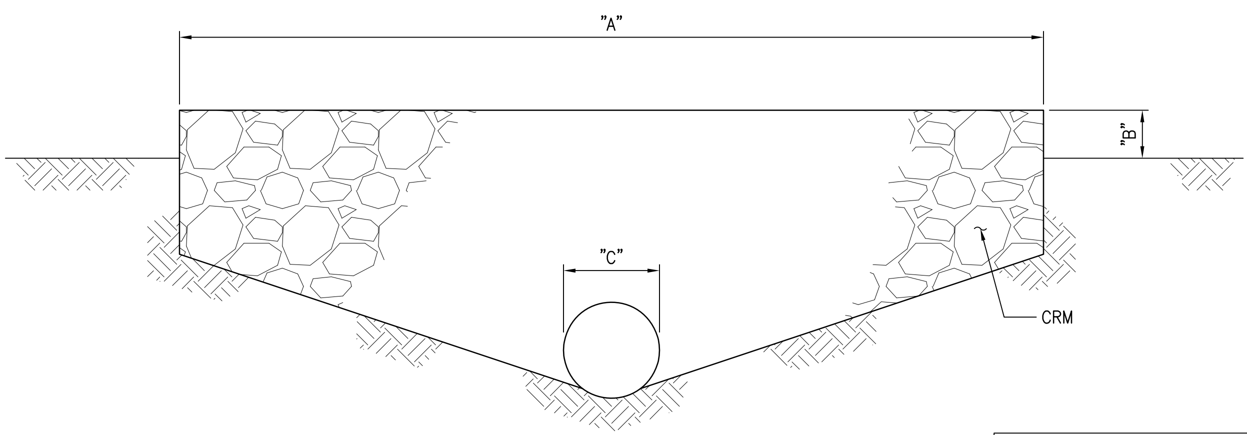
CULVERT MP 27.60 & CULVERT MP 27.70

Drawing D: 50C-1 & 51C-1

2015



TYPE I



TYPE II

REFER TO FOUND CULVERTS MATRIX ON PAGE D-3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

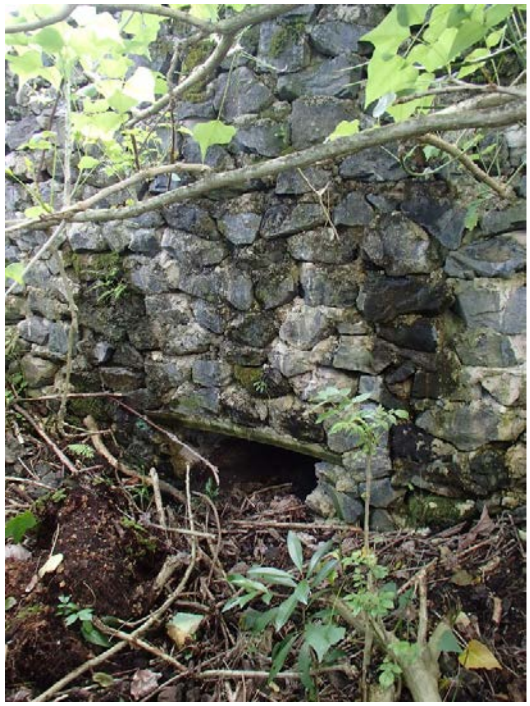
Various Miscellaneous Culvert Elevations	Drawing D: C-2
	2015

51 C	CULVERT MP 27.70					
	Bridge Number:	N/A		**Island:**	Maui	
	Date of Construction:	Unknown		**Route:**	Hana Highway	
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration	☐ Replacement	

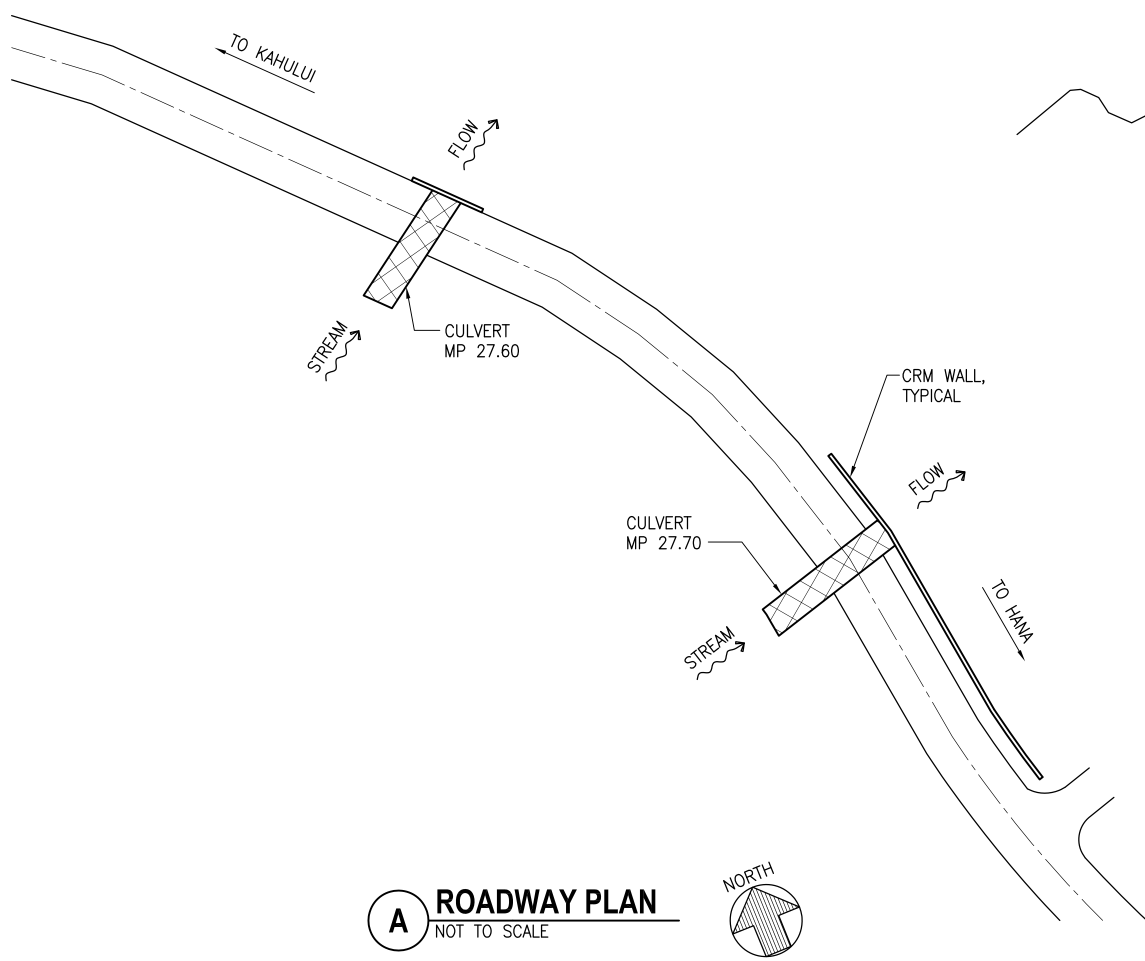
Kahului approach looking toward Hana.

View of downstream CRM parapet.

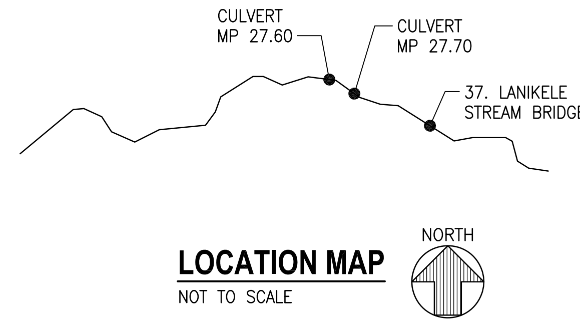
51 C	CULVERT MP 27.70						
	Bridge Number:	N/A		**Island:**	Maui		
	Date of Construction:	Unknown		**Route:**	Hana Highway		
	Treatment Recommendations:	☑ Preservation	☑ Rehabilitation	☐ Restoration		☐ Replacement	



View of downstream CRM headwall / parapet.



A ROADWAY PLAN
NOT TO SCALE

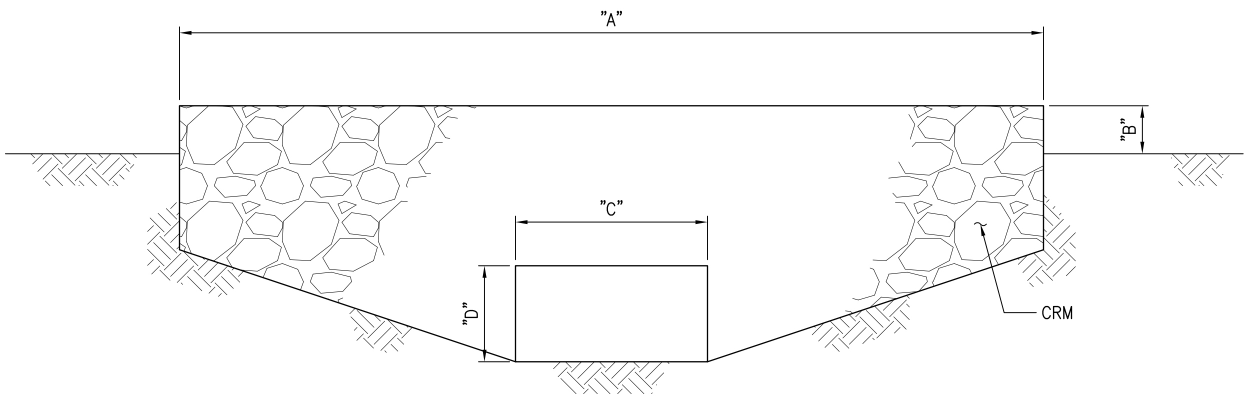


LOCATION MAP
NOT TO SCALE

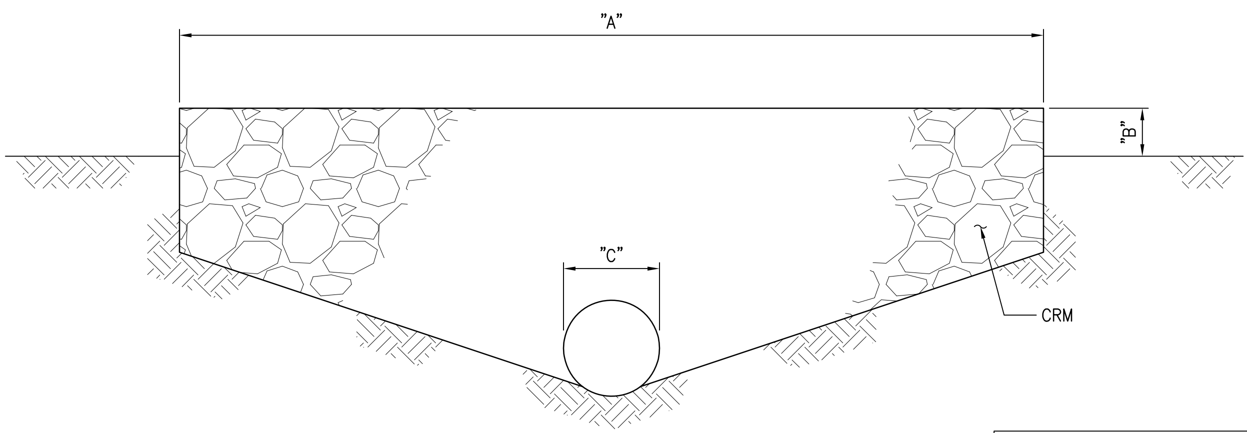
CULVERT MP 27.60 & CULVERT MP 27.70

Drawing D: 50C-1 & 51C-1

2015



TYPE I



TYPE II

REFER TO FOUND CULVERTS MATRIX ON PAGE D–3 FOR DIMENSION VALUES.

1 **TYPICAL ELEVATION**
NOT TO SCALE

Various Miscellaneous Culvert Elevations

Drawing D: C-2

2015

SECTION E

HILLSIDE BRIDGES

HILLSIDE BRIDGES OVERVIEW

Along the Hana Highway, Route 360, there are seven hillside bridges. These bridges are cantilevered off of the mountain side and were constructed for the purpose of widening the existing roadway. According to record drawings,[1, 2, 3] Hillside Bridges #1, 2, 3, 4, 6, and 7 were constructed in 2001 and Hillside Bridge #5 was built in 2004. Per record drawings, all railings were designed for TL-2 crash standards.

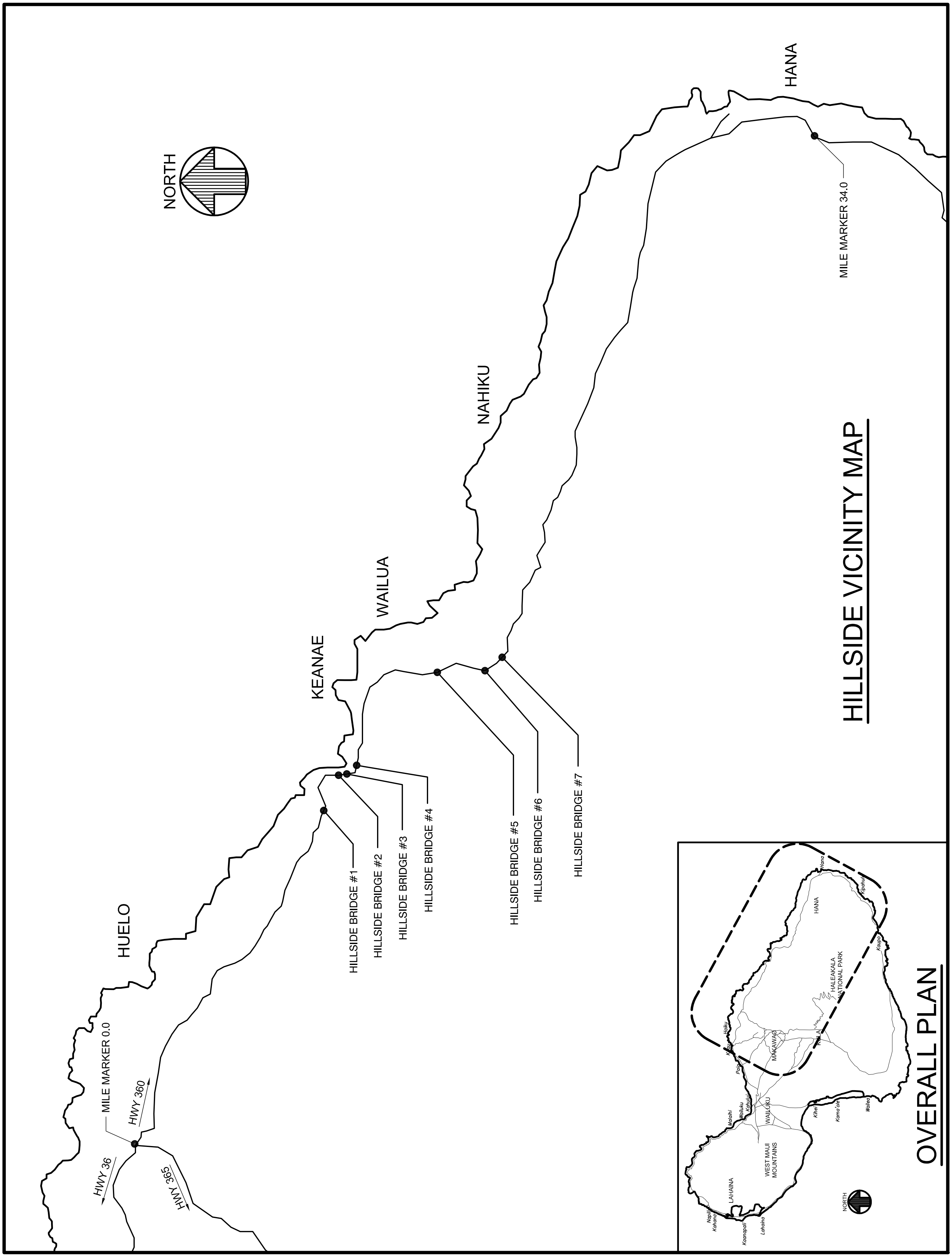
Routine inspections for Maui HDOT were conducted on all the hillside bridges during the months of November and December of 2013. Hillside Bridges #1, 2, and 4 are *functionally obsolete* with a rating of 2 for *deck geometry*. Hillside Bridges #5 and 6 are also *functionally obsolete* with a rating of 3 for *deck geometry*. Hillside Bridges #3 and #7 are not *functionally obsolete*. None of the hillside bridges are *structurally deficient*.

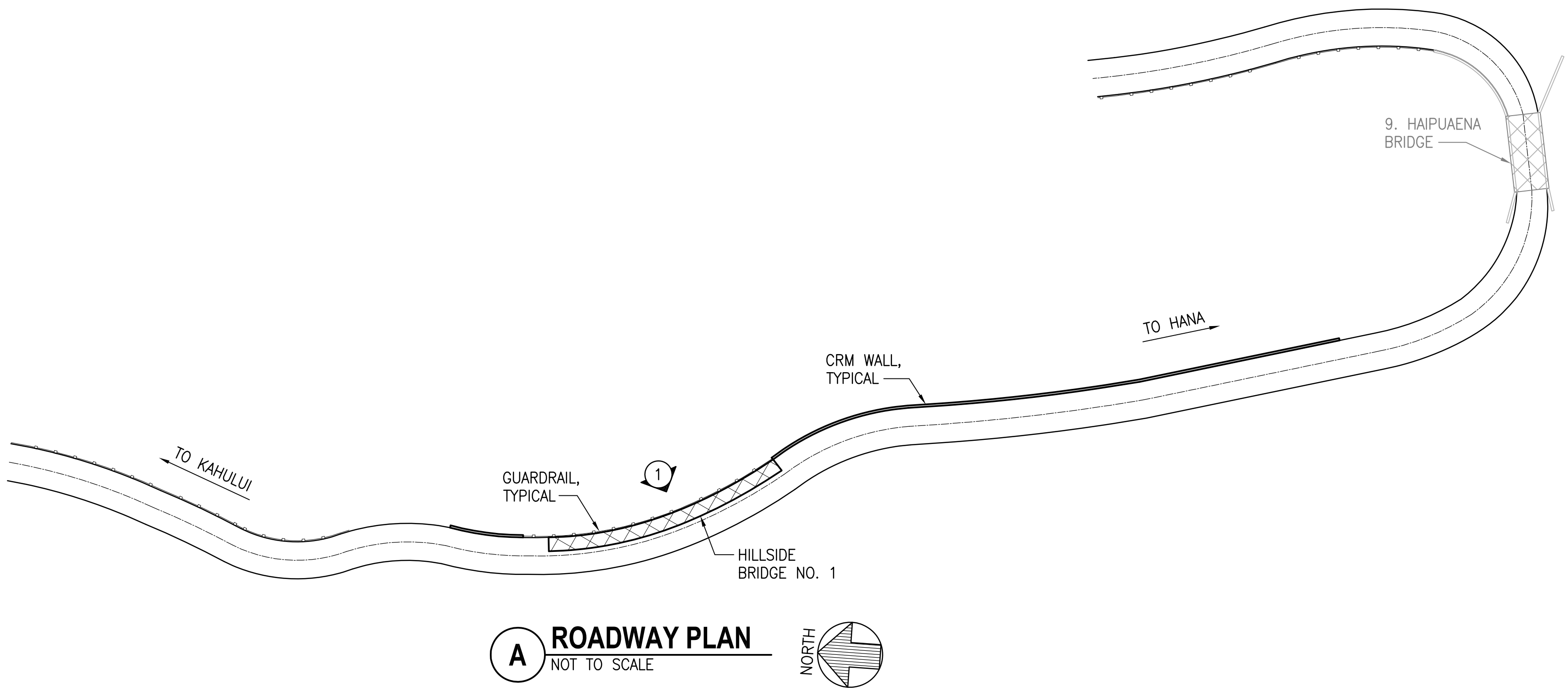
A 10-ton load posting sign is located between mile points 2 and 3 of Hana Highway, Route 360; however, per record drawings, all hillside bridges were designed for HL-93 loads.

As mentioned above, Hillside Bridges #1, 2, 4, 5, and 6 are *functionally obsolete*; however, no repair or rehabilitation recommendations are suggested for the bridges at this time. Additionally, no repair or rehabilitation recommendations are suggested for Hillside Bridges #3 and #7 at this time.

---

[1] State of Hawaii, Department of Transportation, Highways Division, *Hana Highway Emergency Federal-Aid Project Roadway Repairs at Various Locations*, February 2001.
[2] State of Hawaii, Department of Transportation, Highways Division, *Hana Highway Repairs and Maintenance at Various Locations, Phase-I*, March 2001.
[3] State of Hawaii, Department of Transportation, Highways Division, *Route 360 Hana Highway Repairs and Maintenance, Phase-3*, April 2004.


HILLSIDE VICINITY MAP
NORTH
HANA
MILE MARKER 34.0
NAHIKU
WAILUA
KEANAE
HUELO
MILE MARKER 0.0
HWY 360
HWY 36
HWY 365
HILLSIDE BRIDGE #1
HILLSIDE BRIDGE #2
HILLSIDE BRIDGE #3
HILLSIDE BRIDGE #4
HILLSIDE BRIDGE #5
HILLSIDE BRIDGE #6
HILLSIDE BRIDGE #7
OVERALL PLAN
HANA
HALEAKALA NATIONAL PARK
MAKAWAO
WAILUKU
WEST MAUI MOUNTAINS
LAHAINA



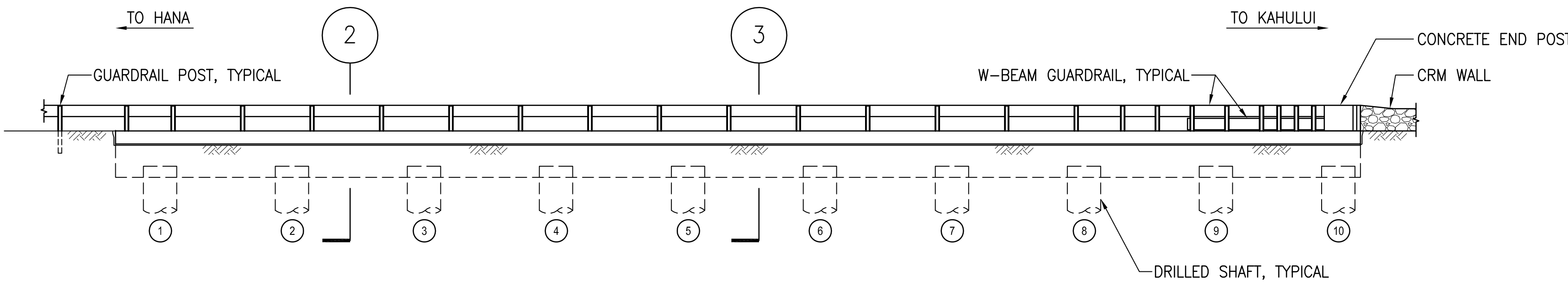
A **ROADWAY PLAN**
NOT TO SCALE

HILLSIDE BRIDGE NO. 1 (MP 11.40)

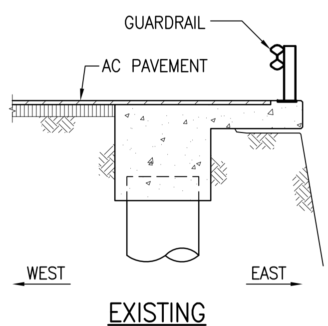
Structure Number: 009003600501140

Drawing E 1-1

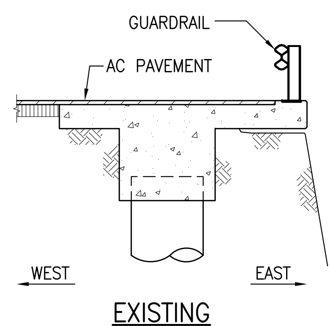
2015



1 EAST ELEVATION
NOT TO SCALE



2 SECTION TYPICAL AT DRILLED SHAFT 1 & 2
NOT TO SCALE



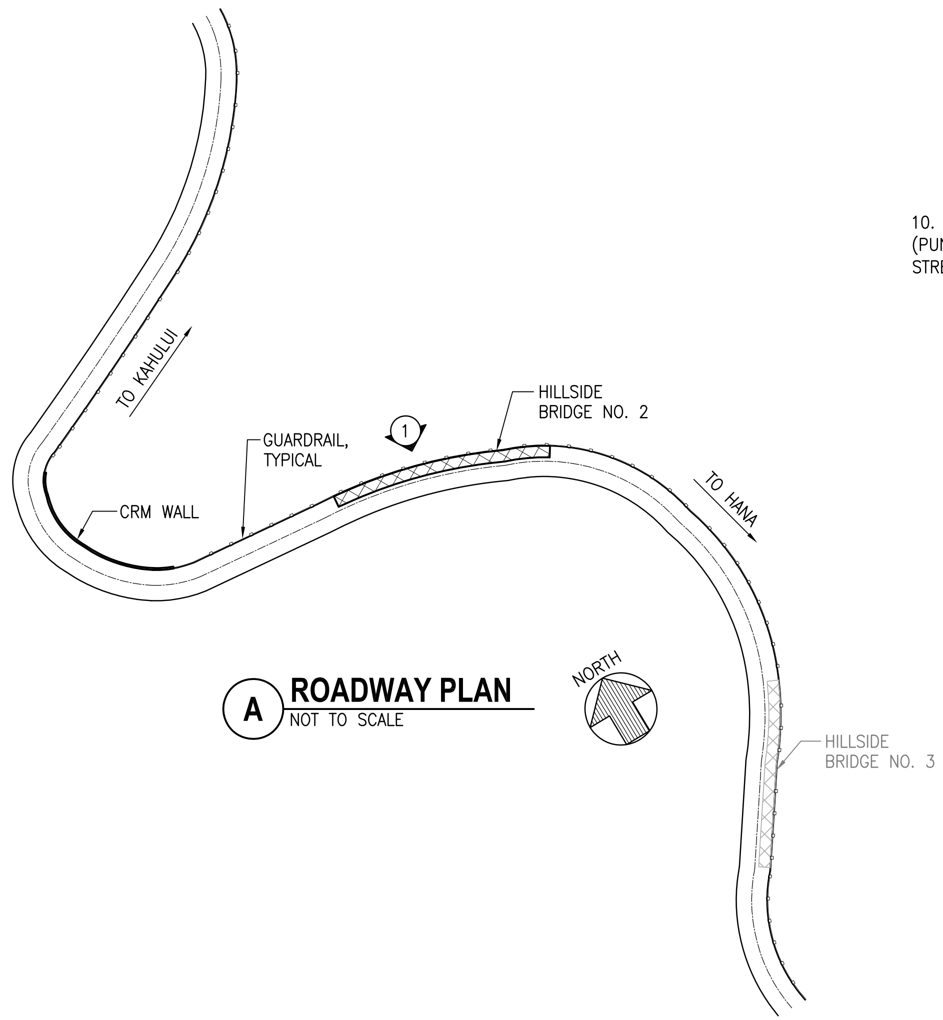
3 SECTION TYPICAL AT DRILLED SHAFT 3-10
NOT TO SCALE

HILLSIDE BRIDGE NO. 1 (MP 11.40)

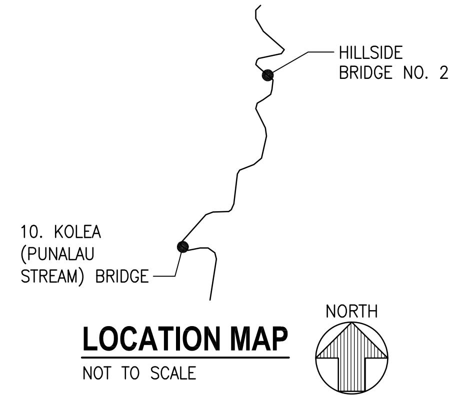
Structure Number: 009003600501140

Drawing E 1-2

2015



A ROADWAY PLAN
NOT TO SCALE



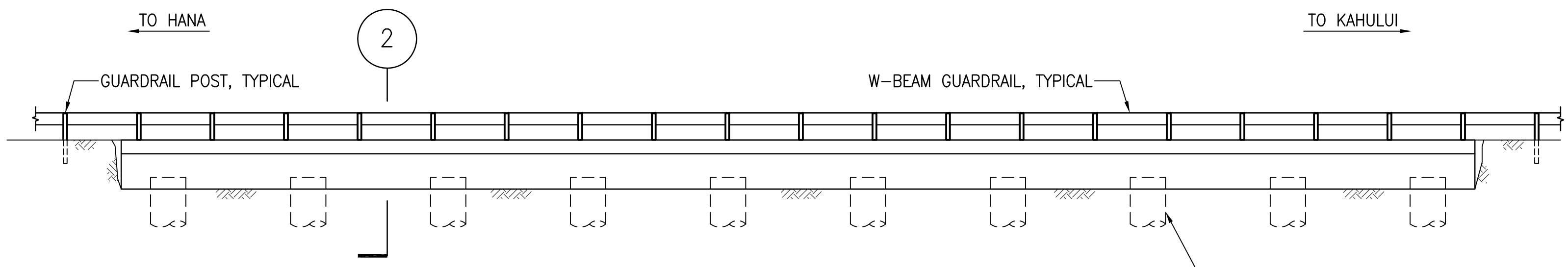
LOCATION MAP
NOT TO SCALE

HILLSIDE BRIDGE NO. 2 (MP 12.80)

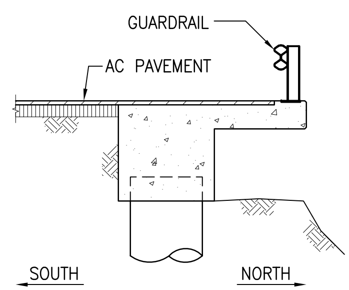
Structure Number: 009003600501280

Drawing E 2-1

2015



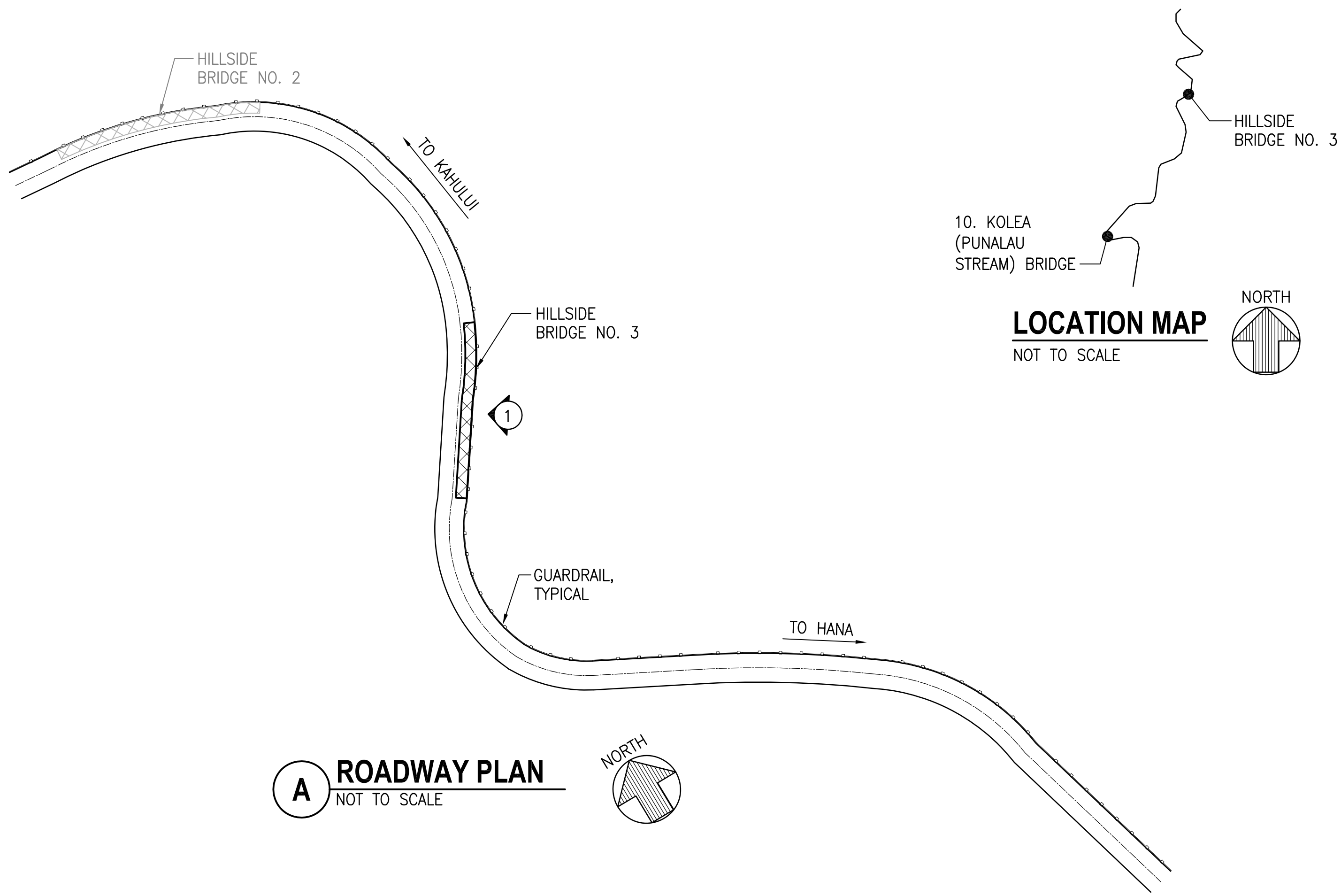
1 **NORTH ELEVATION**
NOT TO SCALE



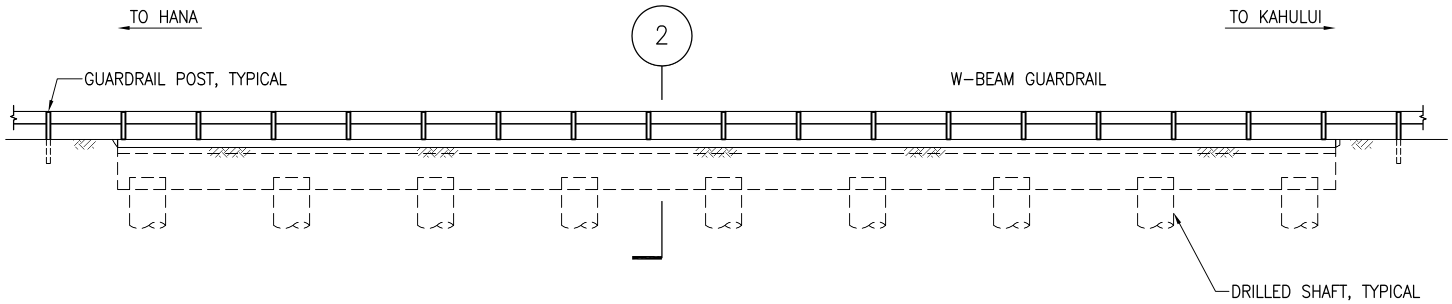
EXISTING

2 **SECTION TYPICAL**
NOT TO SCALE

HILLSIDE BRIDGE NO. 2 (MP 12.80)	Drawing E 2-2
Structure Number: 009003600501280	2015



HILLSIDE BRIDGE NO. 3 (MP 12.83)	Drawing E 3-1
Structure Number: 009003600501283	2015



1 **EAST ELEVATION**
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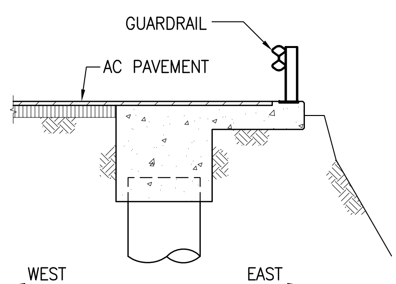


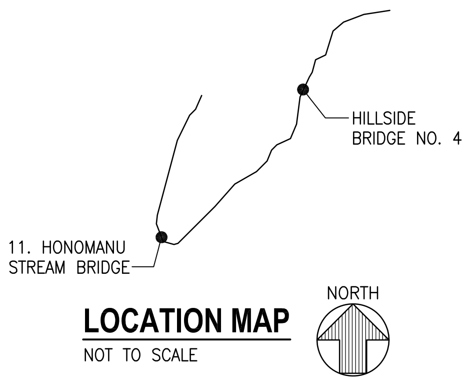
2 **SECTION TYPICAL**
NOT TO SCALE

HILLSIDE BRIDGE NO. 3 (MP 12.83)

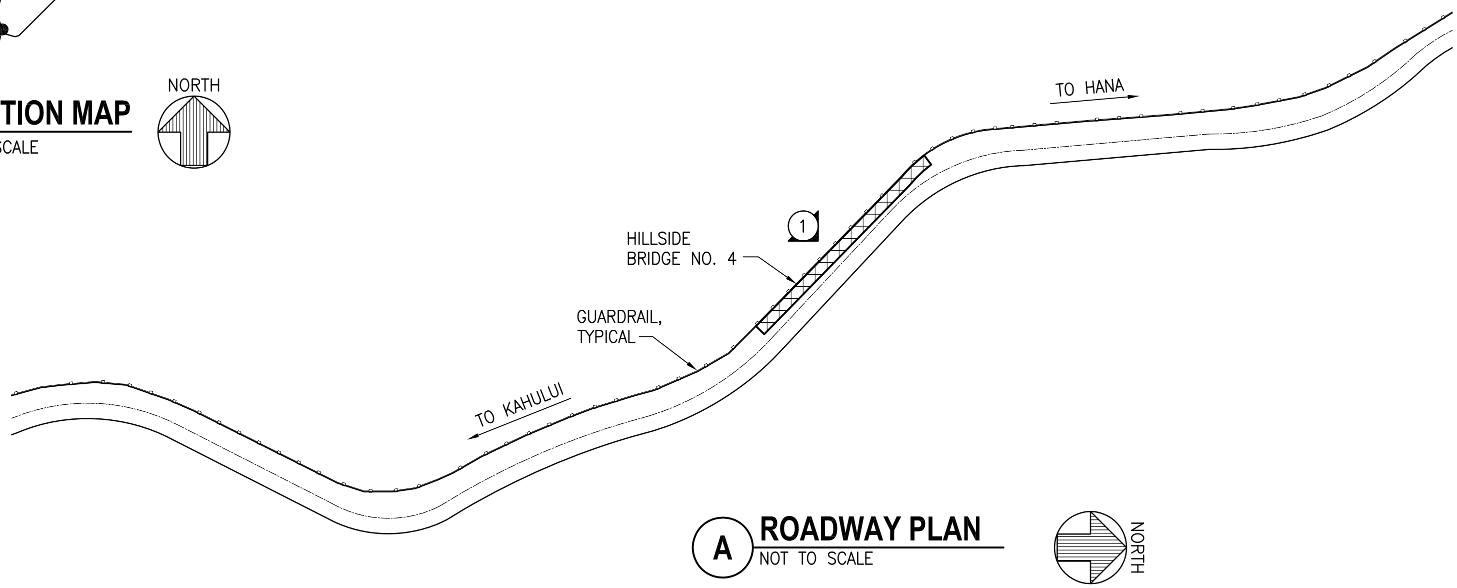
Structure Number: 009003600501283

Drawing E 3-2

2015

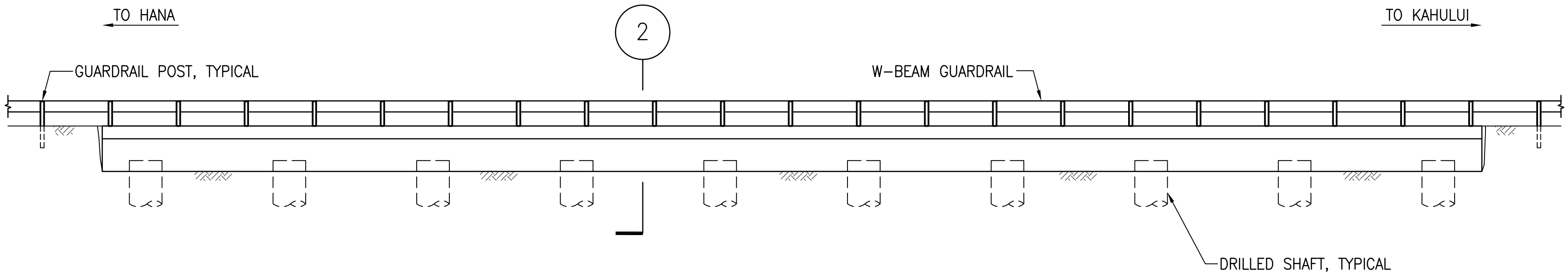


LOCATION MAP
NOT TO SCALE

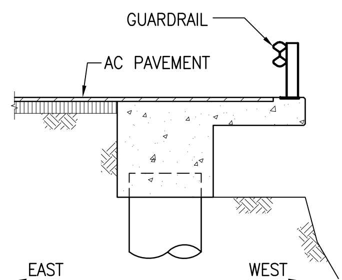


A ROADWAY PLAN
NOT TO SCALE

HILLSIDE BRIDGE NO. 4 (MP 14.30)	Drawing E 4-1
Structure Number: 009003600501430	2015



1 **WEST ELEVATION**
NOT TO SCALE



EXISTING

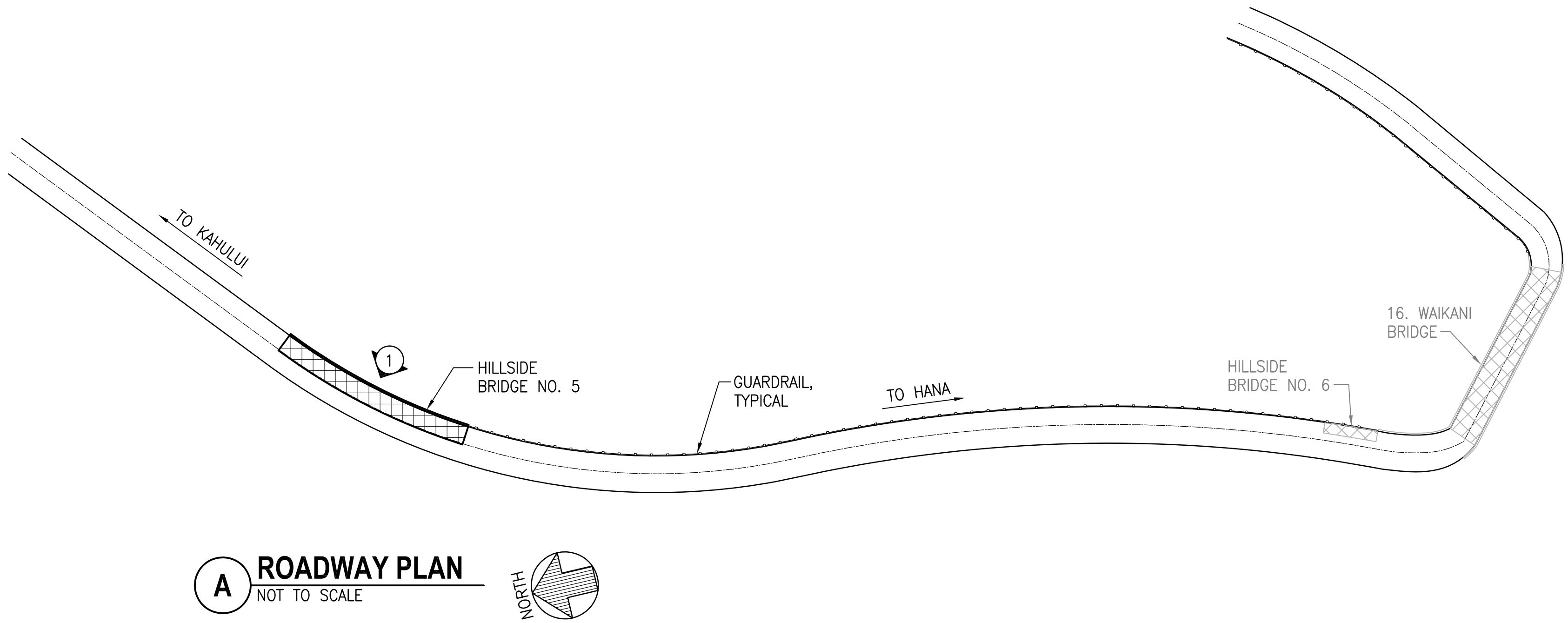
2 **SECTION TYPICAL**
NOT TO SCALE

HILLSIDE BRIDGE NO. 4 (MP 14.30)

Structure Number: 009003600501430

Drawing E 4-2

2015

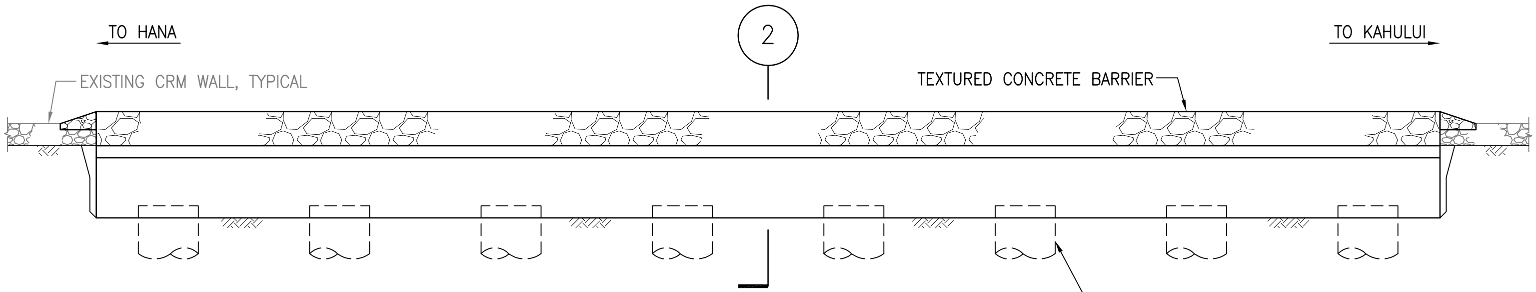


HILLSIDE BRIDGE NO. 5 (MP 19.10)

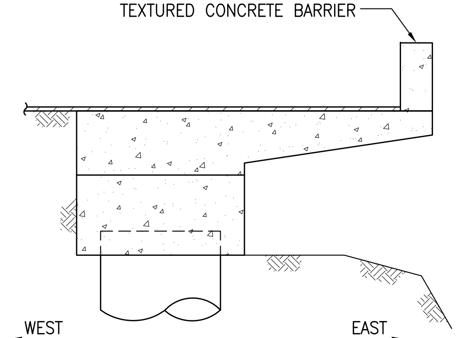
Structure Number: 009003600501910

Drawing E 5-1

2015



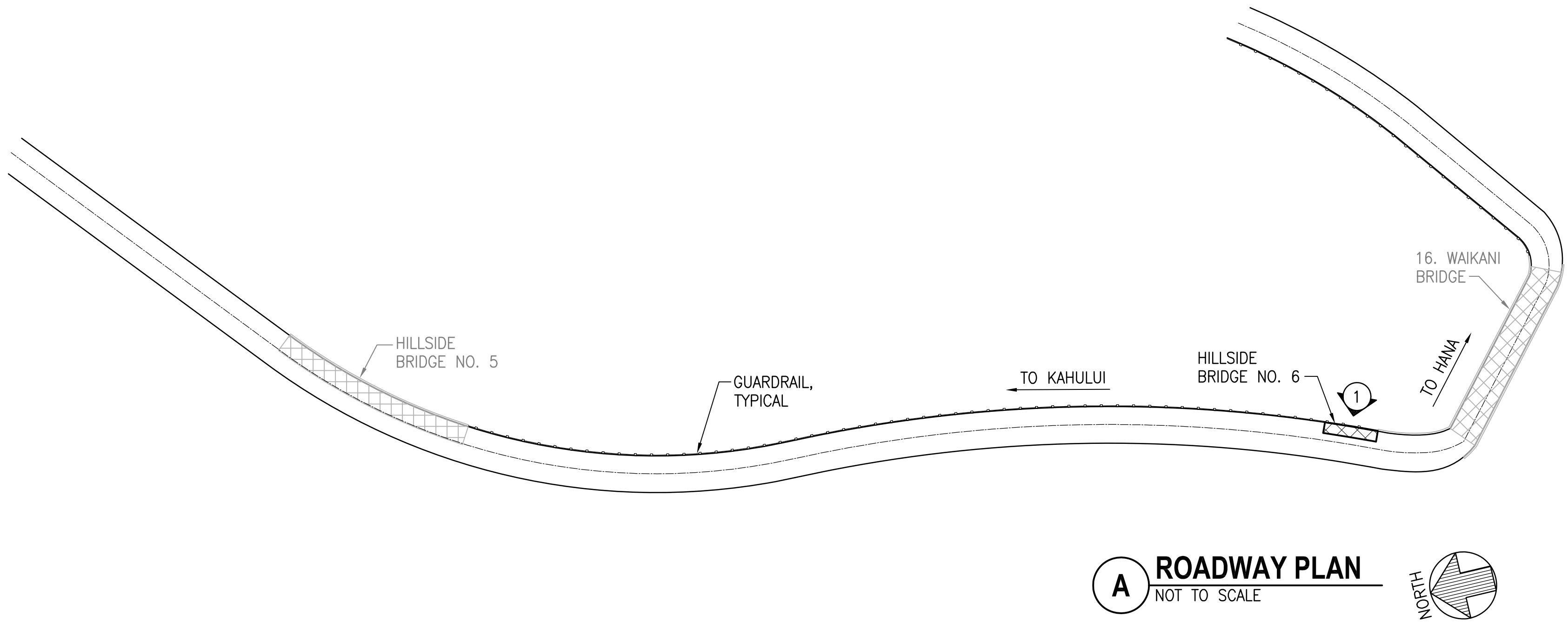
1 **EAST ELEVATION**
NOT TO SCALE



EXISTING

2 **SECTION TYPICAL**
NOT TO SCALE

HILLSIDE BRIDGE NO. 5 (MP 19.10)	Drawing E 5-2
Structure Number: 009003600501910	2015



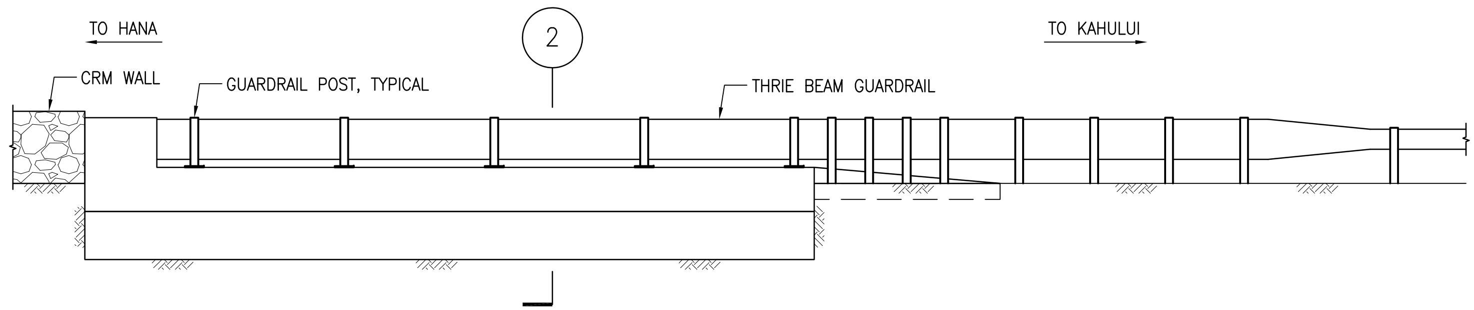
A ROADWAY PLAN
NOT TO SCALE

HILLSIDE BRIDGE NO. 6 (MP 19.20)

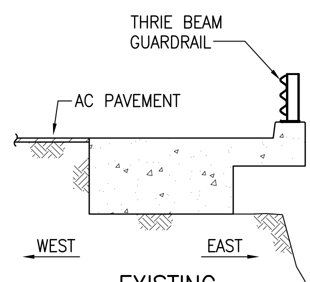
Structure Number: 009003600501920

Drawing E 6-1

2015

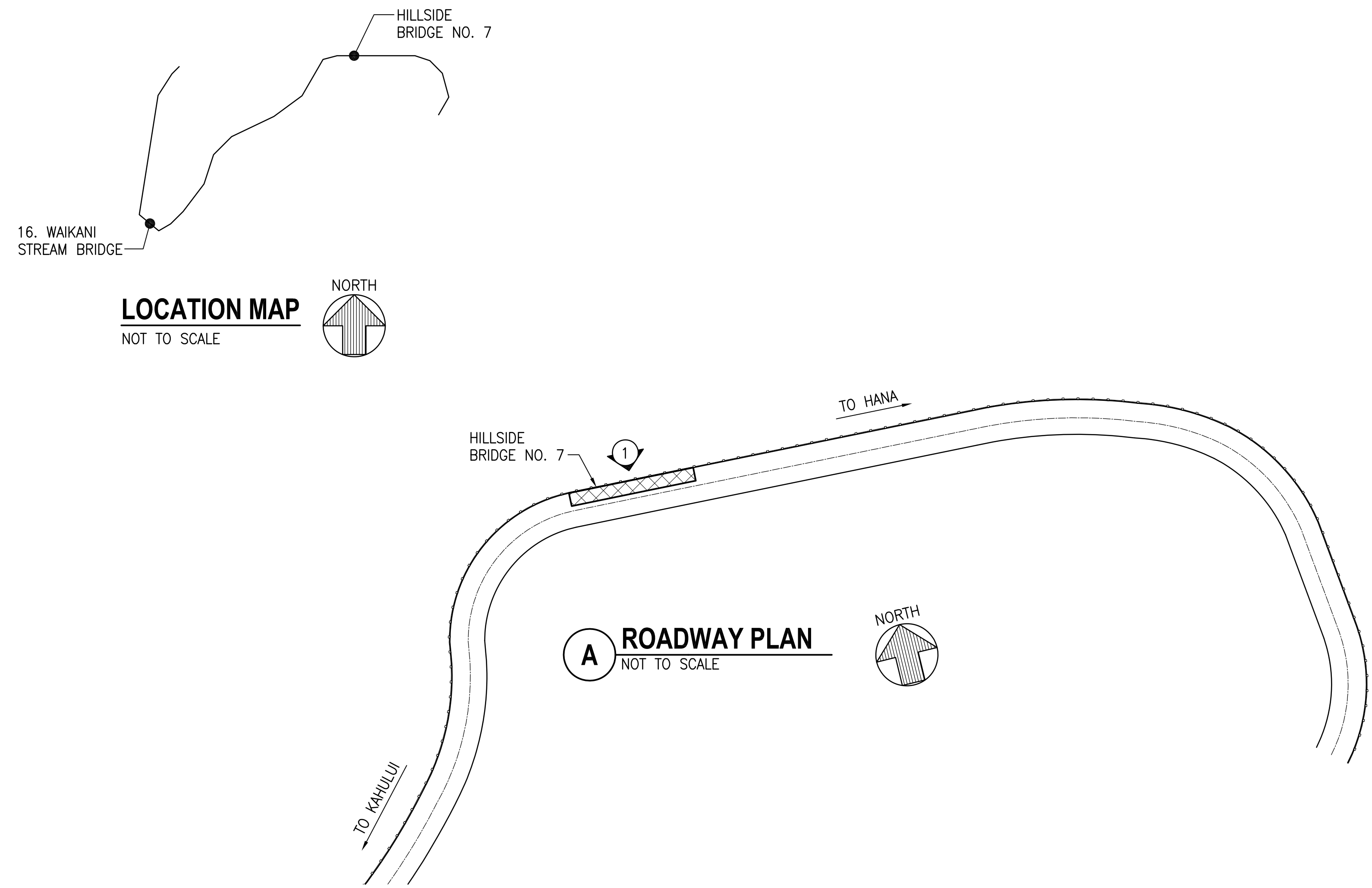


1 **EAST ELEVATION**
NOT TO SCALE

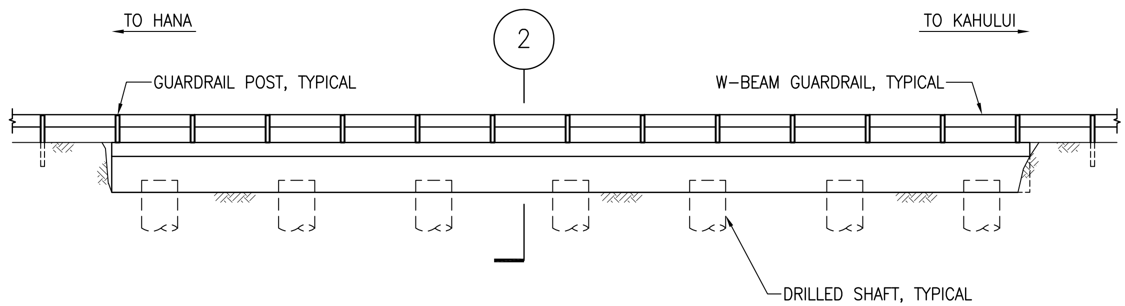


2 **SECTION TYPICAL**
NOT TO SCALE

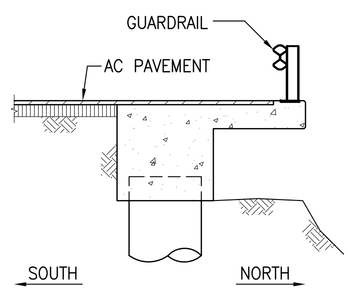
HILLSIDE BRIDGE NO. 6 (MP 19.20)	Drawing E 6-2
Structure Number: 009003600501920	2015



HILLSIDE BRIDGE NO. 7 (MP 19.80)	Drawing E 7-1
Structure Number: 009003600501980	2015



1 **NORTH ELEVATION**
NOT TO SCALE



EXISTING

2 **SECTION TYPICAL**
NOT TO SCALE

HILLSIDE BRIDGE NO. 7 (MP 19.80)	Drawing E 7-2
Structure Number: 009003600501980	2015

SECTION F

SUMMARY & CONCLUSION

SUMMARY & CONCLUSION

The Hana Belt Road Historic District, defined by the curvature of the road and outlined by its right-of-way, is a serene and picturesque escape that exemplifies Hawaii's early development and progress in connecting less accessible, rural locations to larger town hubs. Today, the well-traversed state-owned portion of the historic belt road known as the Hana Highway, Route 360, is a scenic journey and a world-wide destination in itself for tourists.

The Hana Highway, Route 360 also primarily serves local residents and commuters, who navigate the road and its weather-related hazards on a daily basis. The team engaged with numerous long-term community stakeholders and representatives, many of whom expressed a desire to retain the historic character and rural nature of the road and important bridge linkages, while acknowledging the need for safety improvements.

Due to changes in vehicular safety code requirements since the early 20th century when these structures were built, individual material conditions as these structures have aged, and increased traffic conditions along this particular road, many of the historic bridges and culverts along the Hana Highway, Route 360 require additional treatment beyond simply routine maintenance. As with any historic structure, there are several challenges to maintaining the historic character of each bridge and culvert identified in the *Hana Highway Historic Bridge Preservation Plan* (2015), while ensuring that upgrades for each structure meet current safety codes.

The greatest challenge the team encountered was meeting the safety requirement of providing crash-tested railings at each bridge. Unfortunately, the existing railings, which are considered character-defining features, could not be crash-tested *in situ* without damage. This almost guaranteed the removal of each bridge's key character defining feature.

Fortunately, however, once measured, many of the bridges were wider than the required curb-to-curb width allowable for the number of vehicles on the bridge at any given time. Subsequently, the team was able to identify instances where appropriate crash-tested railings can be placed on the interior side of the historic bridge railings/parapets, and the existing historic railings/parapets can be rehabilitated without complete removal.

Other challenges included addressing unreinforced structural elements such as existing abutments and wingwalls, and the existing geometry of approaches to each bridge or culvert. The team sought to provide creative solutions, looking to precedents from former preservation plans to meet these safety requirements while maintaining the historic character of the road.

This report has been subject to public comment the entire duration of its development, and proposed treatments have been presented to and generally accepted by the community and historic preservation regulators. Therefore, it is highly recommended that HDOT seek a PA with the SHPD, the ACHP, and the various preservation partners that were involved in this project, so that this report may be put into effect as a basis for future treatment of the historic bridges and culverts along the Hana Highway, Route 360. It is recommended that the PA be developed within one year, while the community is familiar with the *Hana Highway Historic Bridge Preservation Plan* (2015).