HDOT Bridge Asset Management Manual

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1.0 INTRODUCTION

The State of Hawaii Department of Transportation (HDOT) Bridge Asset Management (BAM) Manual documents policy and methods to maintain the inventory of Hawaii bridges in a State of Good Repair (SGR).

The most current version of the BAM Manual is on the HDOT website. Suggested edits or errors should be emailed with a recommended correction to the Statewide BAMP Manager. Text changes to the Manual are highlighted in red text and will indicate the Revision Date (Rev Date) in red text below the Publication Date (Pub Date) at the bottom right corner of the page.

All links in the BAM Manual are provided as a convenience to the reader, but may not be up to date.

1.1 Purpose

The BAM Manual was developed to provide context for life cycle bridge management, justify the structural need, and document the prioritization process to program the need for the Bridge Program. The Manual is dynamic as improvements are discovered and implemented. This Manual supports and aligns with the Statewide Transportation Asset Management Program (TAMP) that describes the Transportation Performance Measurement (TPM) targets for the bridge on the NHS routes in Hawaii. In addition to the TAMP, this Manual also supports the means for which the Bridge Program can achieve State Act 100 goals of fostering system preservation, promoting safety, and improving resiliency.

1.2 Definitions and Terms

Definitions used within this manual can be found in CFR 650. Subpart C contains terms related to bridges and Subpart E contains terms related to tunnels. Definitions from CFR 650 that are repeated here may be paraphrased or quoted directly from CFR 650. Other terms are provided for clarity and may be specific to this BIP Manual for the State of Hawaii Department of Transportation.

ADE is the abbreviation for Agency Defined Element.

Asset Management is defined in 23 USC 101(a)(2) as a “strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based on quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at a minimum practicable cost.”

BIP is the abbreviation for Bridge Inspection Program

Bridge is defined in CFR 650.305 as, “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 between under copings 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”

When used in this manual the term “bridge” includes all reportable structures which include bridges, culverts and tunnels unless stated otherwise.

BAM is the abbreviation for bridge asset management.

BAMP is the abbreviation for the Bridge Asset Management Program. The BAMP supports the objectives of the Bridge Program by identifying, addressing, and prioritizing the structural needs. In the context of this manual, BAMP is sometimes used interchangeably with the Bridge Program.

BME is the abbreviation for Bridge management element conforming to MBEI

BMS is the abbreviation for bridge management system

Bridge Preservation is defined by FHWA 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 or fair condition; and extend their useful life. Preservation actions may be preventative, or condition driven.

23 CFR is used as an abbreviation for the term “Code of Federal Regulations - Title 23”. The Code of Federal Regulations (CFR) is a codification of the general and permanent rules published in the Federal Register by the departments and agencies of the Federal Government. Title 23 is the section designated for Highways.

Capacity, according to the *AASHTO Guide to Bridge Preservation*, are limits to volume, size, or weight of traffic that a bridge can carry.

Condition, according to the *AASHTO Guide to Bridge Preservation*, is the presence, severity, and extent of defects in bridges, components, or elements.

Complex Bridge is a movable, suspension, cable stayed, and other bridges with unusual characteristics.

Durability, according to the *AASHTO Guide to Bridge Preservation,* is a qualitative assessment of the resistance of bridges and components to deterioration. A bridge has adequate durability if its materials, design details, and devices meet current standards, or if its materials, design details, and devices are obsolete but have adequate resistance to deterioration.

FAIR is the condition classification of a bridge when the minimum NBI Condition Rating of the three NBI Items for a bridge (58-Deck, 59-Superstructure, and 60-Substructure) is either 5 or 6. The condition classification of a culvert is, similarly, FAIR when the NBI condition rating for NBI Item 62-Culvert is either 5 or 6.

FMIS is the abbreviation for Financial Management Information System.

GOOD is the condition classification of a bridge when the minimum NBI Condition Rating of the three NBI Items for a bridge (58-Deck, 59-Superstructure, and 60-Substructure) is 7, 8, or 9. The condition classification of a culvert is, similarly, GOOD when the NBI condition rating for NBI Item 62-Culvert is 7, 8, or 9.

HDOT is the abbreviation for Hawaii Department of Transportation.

HEC-18 is the abbreviation for Hydraulic Engineering Circular No. 18. HEC-18, Evaluating Scour

at Bridges, presents the state of knowledge and practice for the design, evaluation, and inspection of bridges for scour.

HEC-23 is the abbreviation for Hydraulic Engineering Circular No. 23. HEC-23, Bridge Scour and Stream Instability Countermeasures, identifies and provides design guidelines for bridge scour and stream instability countermeasures.

Local Public Agency (**LPA)** within the state of Hawaii that own and/or are responsible for roadway bridge structures include County of Kauai, City and County of Honolulu, County of Maui, and the County of Hawaii. Other LPA that do not own, but may impact transportation infrastructure Programing include the Oahu Metropolitan Planning Organization, and the Maui Metropolitan Planning Organization.

Maintenance, in accordance with FHWA Guidance on Highway Preservation and Maintenance dated Feb. 25, 2016, describes work that is performed to maintain the condition of the transportation system or respond to specific conditions or events that restore the highway system to a functional state of operations. Maintenance is a critical component of an agency's asset management plan that includes *both routine and preventive* maintenance.

- **Routine Maintenance** involves work that is performed in reaction to an event, season, or activities that are done for short-term operational need that do not have preservation value. This work requires regular reoccurring attention. Per 23 U.S.C. 116 (d), owner agencies are required to properly maintain projects financed with Federal-aid funds. Therefore, routine maintenance activities are not eligible for Federal funds. Examples of routine maintenance include:
    - Trash, Litter, and Dead Animal Removal
    - Graffiti Removal
    - Hazardous Material Removal
    - Asphalt Patch with No Membrane on Concrete Deck
    - Accident Damage to Bridge and Its Appurtenances (Signs or bridge barriers)
    - Storm Damage
- **Preventive maintenance** (PM) or preservation activities retard future deterioration and avoid large expenses in bridge rehabilitation or replacements and are eligible for Federal funds. PM is a cost-effective strategy of extending the service life by applying cost effective treatments that are cyclical or condition based.

    Examples of **Cyclical** maintenance activities

    - Clean/Wash Bridge Deck and/or Super/Substructure
    - Clean and Flush Deck Drains
    - Clean Deck Joints
    - Deck/Parapet/Rail Sealing and Deck Crack Sealing
    - Seal Super/Substructure Concrete

    Examples of **Condition Based** maintenance activities

    - Deck Drain - Repair/Replace
    - Deck Joint Seal Replacement
    - Deck Joint Repair/Replace/Elimination
    - Electrochemical Extraction (ECE)/Cathodic Protection (CP)
    - Concrete Deck Repair in Conjunction with Overlays, CP Systems or ECE Treatment
    - Deck Overlays (thin polymer epoxy, asphalt with waterproof membrane, rigid overlays)
    - Repair/Replace Approach Slabs

- Superstructure/Substructure/Culvert Concrete Seal/Patch/Repair
- Superstructure/Substructure/Culvert Protective Coat for Concrete/Steel Elements
- Superstructure/Substructure Spot/Zone/Full Painting Steel Elements
- Steel Member Repair
- Fatigue Crack Mitigation (pin-and-hanger replacement, retrofit fracture critical members)
- Bearing Restoration (cleaning, lubrication, resetting, replacement)
- Movable Bridge Machinery Cleaning/Lubrication/Repair
- Pile Preservation (jackets/wraps/CP)
- Channel Cleaning / Debris Removal
- Scour Countermeasure (installation/repair)

NHS is the abbreviation of National Highway System.

National Bridge Inventory (NBI) is the aggregation of structure inventory and appraisal data collected to fullfil the requirements of the National Bridge Inspection Standards. Each State shall prepare and maintain an inventory of all bridges subject to the NBIS.

NBI Component Condition Rating (NBI Condition Rating) system is a rating system used to assess the physical condition of a component of a bridge and ranges from 0 (failed condition) to 9 (excellent condition) in accordance with the *Coding Guide*. This system is also known as General Condition Ratings or GCRs.

National Tunnel Inventory (NTI) is the aggregation of structure inventory and appraisal data collected to fulfill the requirements of the National Tunnel Inspection Standards. Each State shall prepare and maintain an inventory of all tunnels subject to the NTIS.

National Bridge Inspection Standards (NBIS) are the Federal regulations establishing requirements for inspection procedures, frequency of inspections, qualification of personnel, inspection reports, and preparation and maintenance of a State bridge inventory. The NBIS apply to all structures defined as bridges located on all public roads.

National Tunnel Inspection Standards (NTIS) are the Federal regulations establishing requirements for inspection procedures, frequency of inspections, qualification of personnel, inspection reports, and preparation and maintenance of a State tunnel inventory. The NTIS apply to all structures defined as tunnels located on all public roads.

NBE is the abbreviation of National Bridge Element

Non-NBI Bridge is a bridge not in the NBI, as it is not subject to the NBIS regulations. This is a type of “Non-Reportable Structure.” Non-NBI Bridges may have one or more of the following characteristics: (a) less than twenty feet long; (b) not subject to highway loads (i.e. may carry only pedestrian, water, etc.); (c) publicly owned but not on a public road; (d) not publicly owned

Non-Reportable Structure is a structure that is not required to be included in the annual NBI or NTI data submittal but may be included and managed in the BrM database. Examples include pedestrian bridges, privately owned structures, culverts and bridges less than 20 feet.

Owner is defined as a person or entity who has the legal or rightful title and is held responsible by the law as the owner of the property. The public sector owners in Hawaii are the State, and Counties of Big Island, Oahu, Kauai, and Maui.

POOR is the condition classification of a bridge when the minimum NBI Condition Rating of the three NBI Items for a bridge (58-Deck, 59-Superstructure, and 60-Substructure) is 4 or below. The condition classification of a culvert is, similarly, POOR when the NBI condition rating for NBI Item 62-Culvert is 4 or below.

Rehabilitation involves major work required to restore the structural integrity of a bridge, as well as work necessary to correct major safety defects. Rehabilitated bridges may be improved to restore the original design capacity or improved to meet current design standards which includes widening of the bridge. Projects provide complete or nearly complete restoration of bridge elements or components. Rehabilitation work can be done on one or multiple elements and/or components of a structure. Rehab examples include, but not limited to:

- Deck/Super/Sub partial/full replacement or strengthening
- Culvert or partial replacement or strengthening

Replacement of an existing bridge with a new structure constructed in the same general traffic corridor. The replacement must meet the current geometric, construction, and structural standards required for the types and volume of projected traffic on the facility over its design life. Replacements include a nominal amount of approach work sufficient to connect the new facility to the existing roadway or to return the grade line to an attainable touchdown point.

Resiliency is the ability of a bridge, or system of bridges, to withstand extreme events caused by natural, climate change-related, or man-made hazards and remain in service.

Robustness, according to the *AASHTO Guide to Bridge Preservation*, in a bridge is the absence of vulnerabilities to sudden failure by earthquake, flood, overload, fatigue, fracture, or security.

Shall is applied in this Manual to mean the same as must. Must is a regulatory or legal term and means that conformance is required and mandatory without exception.

SRMHS is the abbreviation for the FHWA Seismic Retrofitting Manual for Highway Structures.

Structure is defined in this Manual as a bridge, culvert, tunnel, or destination sign structure, unless specified otherwise.

State of Good Repair (SGR) The *2011 FHWA Bridge Preservation Guide* defines State of Good Repair as: “A condition in which the existing physical assets, both individually and as a system (a) are functioning as designed within their useful service life, (b) are sustained through regular maintenance and replacement programs. SGR represents just one element of a comprehensive capital investment program that also addresses system capacity and performance.” The HDOT Bridge Program uses this term to describe its programmatic efforts of (a) improving the condition of POOR and FAIR bridges and (b) maintaining the condition of GOOD bridges, both individually and as a system.

Statewide Transportation Asset Management Plan (TAMP) – The Statewide Transportation Asset Management Plan was prepared on June 30, 2019 as required by the FAST Act, describes the processes and formally defines HDOT’s framework for asset management.

Tunnel The term “tunnel” means an enclosed roadway for motor vehicle traffic with vehicle access limited to portals, regardless of type of structure or method of construction, that requires, based on the owner’s determination, special design considerations that may include lighting, ventilation, fire protection systems, and emergency egress capacity. The term “tunnel” does not include bridges or

culverts inspected under the National Bridge Inspection Standards (23 CFR 650 Subpart C).

1.3 Standards and Regulatory Documents

All inspections and reports for bridges must be in accordance of the following list of applicable standards, regulations & references. The current version or edition is applicable, including subsequent revisions, interims or errata unless stated otherwise. The current version for inspection contracts is the active version on the date the contract is awarded. The list indicates the Document Order of Precedence for inspections and a basis to resolve conflicts. Please notify the Statewide BAMP Manager when there is unresolved or conflicting information.

The signs for bridges and tunnels must comply with the Manual on Uniform Traffic Control Devices or MUTCD.

1.3.1 Asset Management Reference Documents

1. AASHTO Guide to Bridge Preservation Actions (GBPA), First Edition, 2021.
2. AASHTO Manual for the Assessment of Safety Hardware 2016 (MASH 2016), Second Edition, 2016.
3. AASHTO Manual for Bridge Element Inspection (MBEI), Second Edition, 2019.
4. State of Hawaii Statewide Transportation Asset Management Plan (TAMP)
5. FHWA Recording and Coding Guide (*Coding Guide*) - FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, FHWA Report No. PD-96-001 December 1995.
6. FHWA Bridge Preservation Guide: Maintaining a Resilient Infrastructure to Preserve Mobility (2018 FHWA Bridge Preservation Guide), 2018.
7. FHWA Bridge Preservation Guide: Maintaining a State of Good Repair Using Cost Effective Investment Strategies (2011 FHWA Bridge Preservation Guide), FHWA-HIF-11042, 2011.
8. FHWA Seismic Retrofitting Manual for Highway Structures: Part 1 – Bridges (SRMHS), Publication No. FHWA-HRT-06-032, January 2006.
9. HDOT Design Criteria for Highway Drainage
10. Hydraulic Engineering Circular No. 18 (HEC-18), Evaluating Scour at Bridges, Fifth Edition, FHWA-HIF-12-003, 2012.
11. Hydraulic Engineering Circular No. 23 (HEC-23), Bridge Scour and Stream Instability Countermeasures, FHWA, 2009.

2.0 THE TAMP AND THE HDOT'S BRIDGE MANAGEMENT SYSTEM (BMS)

The Statewide Transportation Asset Management Plan (TAMP) bridge targets objectively justify the HDOT's investment decisions to operate, maintain, and improve the bridges on NHS routes. The TAMP is a 10-year Plan that describes funding need and funding gaps for the 4-year planning done in the STIP.

For the current performance period, 2022-2026, the HDOT has established 2- and 4-year targets and 10-year goals for its NHS bridges. The 2- and 4-year targets serve as interim indicators of changes in condition levels to help the HDOT assess its long-term state of good repair goals. The selected targets and goals are found in Chapter 3 of the TAMP.

To achieve these targets and goals, the HDOT employs and continues to enhance its Bridge Management System (BMS). The HDOT's BMS is a strategic and systematic data-driven process that utilizes life cycle strategic programming. The Bridge Inspection Program (BIP), AASHTOWare BrM, and the Bridge Asset Management program (BAMP) are all important components of the BMS.

The HDOT, through the TAMP, has determined an investment strategy that minimizes or eliminates the performance gap of its assets. The selected annual funding and corresponding performance gaps of NHS Bridge Assets are found in Chapter 8 of the TAMP.

While the selected investment strategy is the result of collaboration between various parties in the HDOT, as indicated in the TAMP, the Statewide BAMP Manager plays a significant, but limited, role. Using the policies and methodologies contained in this manual, the Statewide BAMP Manager identifies, develops investment strategies to address, and prioritizes structural needs of bridges. Selection and approval of the final investment strategy is ultimately outside the limits of the Statewide BAMP Manager's authority.

3.0 BRIDGE INSPECTIONS AND DATA

Foundational to the HDOT's BMS being a data-driven process are its Bridge Inspection Program (BIP) and AASHTOWare's Bridge Management software (BrM). Through the BIP, inspectors collect essential bridge condition and appraisal data on a 24-month, or less, cycle in accordance with the NBIS and other HDOT BIP requirements. Subsequently, this data, along with inspection reports and other related bridge information, are processed and stored in BrM.

The timeliness of the collection as well as the quality of the data are paramount for the BAMP to make informed asset management decisions. Information on how the BIP addresses these concerns, as well as its processes in general, can be found in the BIP Manual.

3.1 Condition Data

Inspectors, through the BIP, collect two types of bridge condition data: NBI Component Condition Ratings (NBI Condition Ratings) and Element Condition States. Of the two types of bridge condition data, the BAMP principally utilizes Element Condition States in its asset management data-driven decision-making. Element Condition States provide the most granular level of bridge condition data, are both qualitative *and* quantitative, and, therefore, provide the most detailed, accurate, and precise information about a bridge's condition. NBI Condition Ratings, on the other hand, are intended to provide an *overall* characterization (i.e. qualitative evaluation) of the bridge component being rated and, also, are used to classify the entire bridge's condition. While convenient and simplistic, NBI Condition Ratings inherently have more variability and, therefore, tend to be less reliable for asset management decision-making.

To maximize the benefits and minimize the shortcomings of using both types of bridge condition data, inspectors, at the direction of the BAMP, utilize an Element-Condition-States-to-NBI-Condition-Rating Conversion Table (i.e. Element-to-NBI Conversion Table). This improves the Bridge Program's asset management by enabling Element Condition States to drive decisions to achieve specific NBI Condition Ratings. Furthermore, utilizing the conversion table strengthens the precision of NBI Condition Ratings, ultimately improving data quality and minimizing potential for project programming oversight.

NBI Condition Ratings, Bridge and Culvert Condition Classification, Element Condition States, and the Element-to-NBI Conversion Table are described further in the subsequent subsections.

3.1.1 NBI Component Condition Ratings (NBI Condition Ratings)

NBI Condition Ratings are used to describe the existing, in-place bridges or culverts as compared to the as-built condition. Inspectors evaluate the NBI Items below in accordance with the NBI Condition Ratings, as well as the Element-to-NBI Conversion Table.

NBI Item 58: Deck

NBI Item 59: Superstructure

NBI Item 60: Substructure

NBI Item 62: Culvert

NBI Condition Ratings and their respective descriptions, in accordance with the *Coding Guide*, are shown in the table below.

Rating	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.

In instances where an inspector find discrepancies between the applicable NBI Condition Rating description from the *Coding Guide* and the resulting NBI Condition Rating from the Element-to-NBI Conversion Table, inspectors are instructed to notify the Statewide BAMP Manager and document the discrepancy and basis for the discrepancy in the inspection report.

3.1.2 Bridge and Culvert Condition Classification

In accordance with 23 CFR 490.409, the overall condition of bridges and culverts are classified using NBI Condition Ratings. The three condition classifications, GOOD, FAIR, and POOR, are described in the table below.

Condition Classification	Description
GOOD	The condition classification of a bridge is GOOD when the minimum NBI Condition Rating of the three NBI Items for a bridge (58-Deck, 59-Superstructure, and 60-Substructure) is 7, 8, or 9. The condition classification of a culvert is, similarly, GOOD when the NBI condition rating for NBI Item 62-Culvert is 7, 8, or 9.
FAIR	The condition classification of a bridge is FAIR when the minimum NBI Condition Rating of the three NBI Items for a bridge (58-Deck, 59-Superstructure, and 60-Substructure) is either 5 or 6. The condition classification of a culvert is, similarly, FAIR when the NBI condition rating for NBI Item 62-Culvert is either 5 or 6.
POOR	The condition classification of a bridge is POOR when the minimum NBI Condition Rating of the three NBI Items for a bridge (58-Deck, 59-Superstructure, and 60-Substructure) is 4 or below. The condition classification of a culvert is, similarly, POOR when the NBI condition rating for NBI Item 62-Culvert is 4 or below.

3.1.3 Element Condition States

Element Condition States are collected for the following types of elements: Primary Elements, Non-Primary Elements, and Protective System Elements. Primary Elements are elements along the load path and their condition contribute directly to their respective component's NBI Condition Rating. Non-Primary Elements may be load path elements; however, their failure do not pose a significant risk to the safety to their related elements. Consequently, the condition of Non-Primary Elements do not contribute directly to NBI Condition Ratings. Protective System Elements are "child-elements" of Primary and Non-Primary Elements, as applicable. They help preserve the condition of their "parent-elements."

Elements Considered							
PRIMARY							
Element	**Units**	**Element Number**					
		Steel	**PSC**	**RC**	**Timber**	**Masonry**	**Other**
Deck/Slab *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Deck	ft^2		13	12	31		60
Open Grid Deck	ft^2	28					
Concrete Filled Grid Deck	ft^2	29					
Corrugated or Orthotropic Deck	ft^2	30					
Slab	ft^2			38	54		65
Top Flange	ft^2		15	16			
Superstructure							
Closed Web/Box Girder	ft	102	104	105			106
Girder/Beam	ft	107	109	110	111		112
Stringer	ft	113	115	116	117		118
Truss	ft	120			135		136
Arch	ft	141	143	144	146	145	142
Main Cable	ft	147					
Secondary Cable	each	148					149
Floor Beam	ft	152	154	155	156		157
Pin, Pin and Hangar Assembly	each	161					
Gusset Plate	each	162					
Substructure *Related Non-Primary Element Types include: Bearings*							
Column	each	202	204	205	206		203
Column Tower (Trestle)	ft	207			208		
Pier Wall	ft			210	212	213	211
Abutment	ft	219		215	216	217	218
Pile Cap/Footing	ft			220			
Pile	each	225	226	227	228		229
Pier Cap	ft	231	233	234	235		236
Movable (roller, sliding, etc.) Bearings*	each	311					
Culvert *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Culvert	ft	240	245	241	242	244	243
NON-PRIMARY							
Element	**Units**	**Element Number**					

Elements Considered							
		Steel	PSC	RC	Timber	Masonry	Other
Approach Slab *Related Primary Element Types include: Deck/Slab and Culvert*							
Approach Slab	ft^2		320	321			
Bridge Rail *Related Primary Element Types include: Deck/Slab and Culvert*							
Bridge Rail	ft	330		331	332	334	333
Joint *Related Primary Element Types include: Deck/Slab and Culvert*							
Strip Seal	ft	300					
Pourable	ft	301					
Compression	ft	302					
Assembly with Seal (Modular)	ft	303					
Open	ft	304					
Assembly without Seal	ft	305					
Other	ft	306					
Bearing *Related Primary Element Types include: Substructure*							
Elastomeric	each	310					
Enclosed/Concealed	each	312					
Fixed	each	313					
Pot	each	314					
Disk	each	315					
Other	each	316					

PROTECTIVE SYSTEM		
Element	**Units**	**Element Number**
Wearing Surface	ft^2	510
Steel Protective Coating	ft^2	515
Concrete Reinforcing Steel Protective System	ft^2	520
Concrete Protective Coating	ft^2	521

*The Bridge Program considers Movable Bearings to be Primary Substructure Elements due to the elevated risk to safety, they pose, in the event of failure.

Element Condition States comprise of four continuous datatypes. That is, the Element Condition States for a particular bridge element can range from 0% to 100%; however, the sum of all Element Condition States for the particular bridge element must not exceed 100%. The following are the HDOT's Supplemental Element Evaluation Criteria. Inspectors use this criteria in conjunction with the MBEI when collecting Element Condition States. More information on this process can be found in the BIP Manual.

Condition State (CS)	Description
1	This portion of the element is new and has no defects. For Primary Elements, the portion of the element with defects that are superficial and have no impact on the element's structural capacity. For Non-Primary Elements, the portion of the element with defects that are superficial and have no impact on the element's ability to function as designed. For Protective System Elements, the portion of the element with defects that are superficial and have no impact on the element's ability to preserve the condition of its "parent-element."
2	The portion of the element that received repairs that improve the element, but the repair is not considered equal to the original element.
3	For Primary Elements, the portion of the element with defects that do not significantly affect the element's structural capacity, does not warrant structural analysis, and is substantial enough to warrant repairs or rehabilitation. For Non-Primary Elements, the portion of the element with defects that limit the element's ability to function as designed and is substantial enough to warrant corrective action, such as repairs or replacement. For Protective System Elements, the portion of the element with defects that limit the element's effectiveness of preserving the condition of its "parent-element" and warrants corrective action, such as repairs.
4	For Primary Elements, the portion of the element with defects that affect the element's structural capacity, warrants structural analysis, and requires rehabilitation or replacement. For Non-Primary Elements, the portion of the element with defects that results in the failure of the element to function as designed and warrants corrective action such as replacement. For Protective System Elements, the portion of the element with defects that result in the failure of the element to preserve the condition of its "parent-element" and warrants corrective action, such as replacement.

3.1.4 Element-Condition-States-to-NBI-Condition-Rating Conversion Table (Element-to-NBI Conversion Table)

There are currently two Element-to-NBI Conversion Table profiles – a general profile and a profile for concrete decks. Concrete decks are of special consideration due to their unique modes of deterioration and internal redundancy. Concrete Deck top surface deterioration occurs from direct exposure to vehicular traffic, water, and contaminants. Furthermore, top surface deterioration can be prevented with a properly constructed and maintained wearing surface. Concrete Deck soffits, on the other hand, generally have little to no direct exposure to these hazards, and, therefore, do not experience the *same* deterioration. Concrete Deck soffit deterioration typically results from Concrete Deck top surface deterioration. Deterioration of the Concrete Deck soffit can also be indicative of a load capacity deficiency.

Element-to-NBI Conversion Table				
General Profile				
	CS1 %	**CS2 %**	**CS3 %**	**CS4 %**
8	CS1 ≤ 100%	Not permitted.	Not permitted.	Not permitted.
7		CS2 ≤ 100%	CS3 ≤ 5%	Not permitted.
6			5% < CS3 ≤ 30%	Not permitted.
5			30% < CS3 ≤ 100%	Not permitted.
4				CS4 ≤ 5%
3				5% < CS4 ≤ 20%
2				20% < CS4 ≤ 100%
Concrete Deck Profile				
	CS1 %	**CS2 %**	**CS3 %**	**CS4 %**
8	CS1 ≤ 100%	Not permitted.	Not permitted.	Not permitted.
7		CS2 ≤ 100%	CS3 ≤ 5%	Not permitted.
6			5% < CS3 ≤ 30%	Not permitted.
5			30% < CS3 ≤ 60%	CS4 ≤ 5%
4			60% < CS3 ≤ 100%	5% < CS4 ≤ 25%
3				25% < CS4 ≤ 50%
2				50% < CS4 ≤ 100%

To improve the effectiveness of the Element-to-NBI Conversion Table, feedback from inspectors is required. The BAMP and inspectors both may require calibration. Means of calibration include, but is not limited to, providing additional element evaluation criteria, utilizing ADEs, modifying an existing profile or creating a new profile in the Element-to-NBI Conversion Table, and additional training.

3.1.5 Asset Management Considerations

To support asset management decision-making further, the Element-to-NBI Conversion Table is often modified, incorporating additional discrete rating steps. These additional rating steps assist by providing thresholds to trigger bridge actions. Below is a depiction on where these additional steps are placed. To convert from a Modified Element-to-NBI Conversion Table to an Element-to-NBI Conversion Table, these additional discrete steps are rounded down. For instance, a 7.8 equates to a 7.

Modified Element-to-NBI Conversion Table				
General Profile				
	CS1 %	**CS2 %**	**CS3 %**	**CS4 %**
8	CS1 ≤ 100%	Not permitted.	Not permitted.	Not permitted.
7.8		***CS2 ≤ 20%***	***Not permitted.***	***Not permitted.***
7.6		***20% < CS2 ≤ 40%***	***Not permitted.***	***Not permitted.***
7.4		***40% < CS2 ≤ 100%***	***Not permitted.***	***Not permitted.***
7			CS3 ≤ 5%	Not permitted.
6			5% < CS3 ≤ 30%	Not permitted.
5.5			***30% < CS3 ≤ 65%***	***Not permitted.***
5			65% < CS3 ≤ 100%	Not permitted.
Concrete Deck Profile				
	CS1 %	**CS2 %**	**CS3 %**	**CS4 %**
8	CS1 ≤ 100%	Not permitted.	Not permitted.	Not permitted.
7.95		***CS2 ≤ 5%***	***Not permitted.***	***Not permitted.***
7.90		***5% < CS2 ≤ 10%***	***Not permitted.***	***Not permitted.***
7.85		***10% < CS2 ≤ 100%***	***Not permitted.***	***Not permitted.***
7			CS3 ≤ 5%	Not permitted.
6			5% < CS3 ≤ 30%	Not permitted.
5.5			***30% < CS3 ≤ 45%***	***Not permitted.***
5			45% < CS3 ≤ 60%	CS4 ≤ 5%

Also, in lieu of describing the condition of an element with Element Condition States, it is often helpful to use its corresponding NBI Condition Rating for simplicity. For instance, the condition of a Primary Superstructure element with 25% in CS3 can be described as having an NBI condition rating of 6.

3.2 Appraisal Data

Inspectors, through the BIP, collect appraisal data in accordance with the *Coding Guide*. Key NBI Items that require Appraisal Ratings include the following:

NBI Item 68: Deck Geometry

NBI Item 69: Underclearances

NBI Item 71: Waterway adequacy

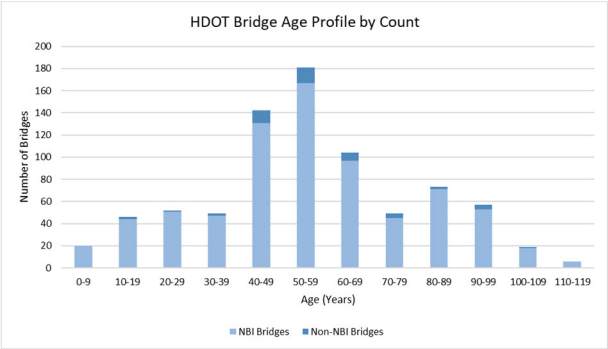
NBI Item 72: Approach Roadway Alignment

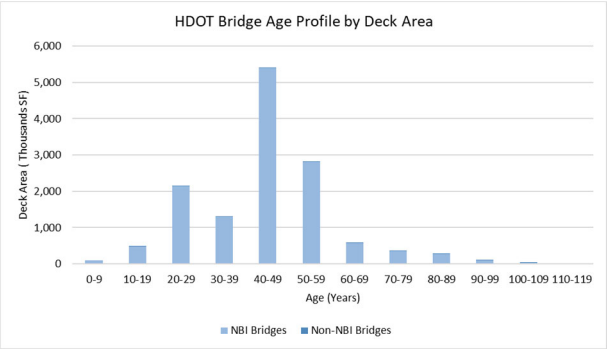
The Bridge Program utilizes this data when evaluating bridge capacity and robustness in *Structural Rehabilitation vs Bridge Replacement Assessments*. The Appraisal Ratings and their descriptions are shown in the table below.

Appraisal Rating	Description
N	Not applicable
9	Superior to present desirable criteria
8	Equal to present desirable criteria
7	Better than present minimum criteria
6	Equal to present minimum criteria
5	Somewhat better than minimum adequacy to tolerate being left in place as is
4	Mets minimum tolerable limits to be left in place as is
3	Basically intolerable requiring high priority of corrective action
2	Basically intolerable requiring high priority of replacement
1	This value of rating code not used
0	Bridge closed

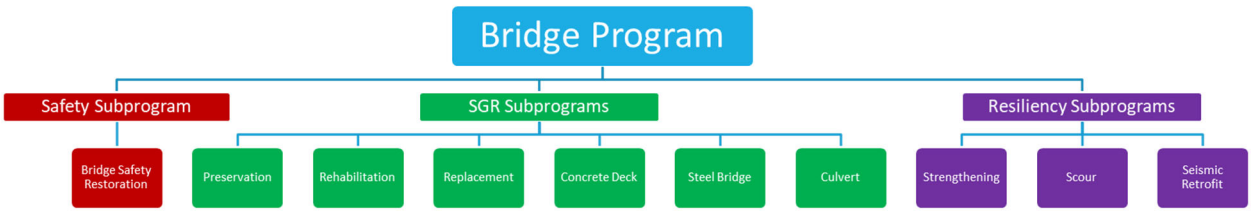
4.0 THE BRIDGE ASSET MANAGEMENT PROGRAM (BAMP)

The HDOT Bridge Program consists of NBI and non-NBI bridges on NHS and non-NHS routes. Consequently, the BAMP is a complex asset management program that consists of a variety of bridge structure and material types that vary widely in terms of age and exposure to hazards. Furthermore, bridges generally are innately intricate, consisting of components and elements that deteriorate in and at different modes and rates. The deterioration of some components or elements may also adversely affect the condition of other components or elements. A diverse range of structural needs with associated risks, as a result, exist within the program.





To effectively manage and meet these intricate challenges, the BAMP utilizes an array of subprograms as shown below.



These subprograms can be categorized into three types with the following primary purposes:

- **Safety** – identify and address structural needs to restore bridge public safety
- **State of Good Repair (SGR)** – identify and address structural needs to improve or maintain bridge condition
- **Resiliency** – identify and address structural needs to improve or maintain bridge resiliency

In totality, these subprograms enable the Bridge Program to achieve system preservation, promote safety, and improve resiliency. This is in alignment with the targets and goals contained within the TAMP and State Act 100.

These subprograms are described in detail in the subsequent sections.

4.0.1 Other Structure Programs

The Bridge Program is the predominant structure program in the HDOT. Other structure programs, such as the Tunnel Program and Destination Sign Structures Program, are not as large, nor as developed. Consequently, funding for these programs are often combined with the Bridge Program on an as-need basis.

4.1 Preservation Subprogram

The function of the Preservation Subprogram, as a SGR Subprogram, is to identify and address bridge condition needs through actions that either improve or maintain condition. The Preservation Subprogram, specifically, aims to ensure GOOD bridges are maintained and remain in GOOD condition, thereby extending their service life.

With the passing of the Moving Ahead for Progress in the 21st Century Act (MAP-21) and the Fixing America's Surface Transportation (FAST) Act, the significance of this subprogram cannot be understated. Both MAP-21 and the FAST Act, as stated in the *2018 FHWA Bridge Preservation Guide*, "recognized preservation as a vital component of achieving and sustaining a desired state of good repair of highway facilities." To this end, bridge preservation became eligible for Federal funding through MAP-21.

Condition-driven and cyclic strategies are used, through coordination between the BAMP and District Maintenance, to achieve this function.

Details of this subprogram are provided in the subsections below.

4.1.1 Bridge Eligibility

Bridges that are in GOOD condition are eligible to be in the Preservation Subprogram with the following exceptions:

- Steel bridges – Bridges with steel primary elements in their Deck, Superstructure, or Substructure components are managed through the Steel Bridge Subprogram.
- Culverts – Culvert bridges are managed through the Culvert Subprogram.
- Concrete decks – Concrete decks and slab *components* are managed through the Concrete Deck Subprogram.

4.1.2 Bridge Data Considered

Condition data is analyzed to identify bridge structural needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Preservation Subprogram. Element Condition States for the following elements is critical for these strategies. Elements that are excluded are managed through other subprograms or do not trigger actions.

Elements Considered							
PRIMARY							
Element	Units	Element Number					
		Steel	PSC	RC	Timber	Masonry	Other
Deck/Slab *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Deck	ft^2				31		60
Slab	ft^2				54		65
Superstructure							
Closed Web/Box Girder	ft		104	105			106
Girder/Beam	ft		109	110	111		112
Stringer	ft		115	116	117		118
Truss	ft				135		136
Arch	ft		143	144	146	145	142
Secondary Cable	each						149
Floor Beam	ft		154	155	156		157
Substructure *Related Non-Primary Element Types include: Bearings*							
Column	each		204	205	206		203
Column Tower (Trestle)	ft				208		
Pier Wall	ft			210	212	213	211
Abutment	ft			215	216	217	218
Pile Cap/Footing	ft			220			
Pile	each		226	227	228		229
Pier Cap	ft		233	234	235		236
Movable (roller, sliding, etc.) Bearings	each	311					

4.1.3 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Preservation Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Preservation Subprogram**					
Element Type	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Primary		≤ 5%	Not permitted.	7	Repair

Bridge *cyclic-based* needs are identified through the Preservation Subprogram on a scheduling basis and through work candidates issued by bridge inspectors. These needs are shown below.

***Cyclic-Based* Needs Identified through the Preservation Subprogram**	
Need	**Description**
Bridge Cleaning	Clean all components of the bridge. Remove dirt, debris, and other material by scraping, brushing, sweeping, flushing, or by using other hand or mechanical means. Open and clean all bridge drainage systems: scuppers, drainage pipes, troughs, and catch basins. Remove debris from deck expansion joints. Clean abutment areas, pier areas, and bridge members. Remove vegetation. Perform other cleaning as required.
Channel Cleaning	Maintenance of natural drainage or stream channels and side slopes, including removal of debris and rock slides, to ensure proper flow.

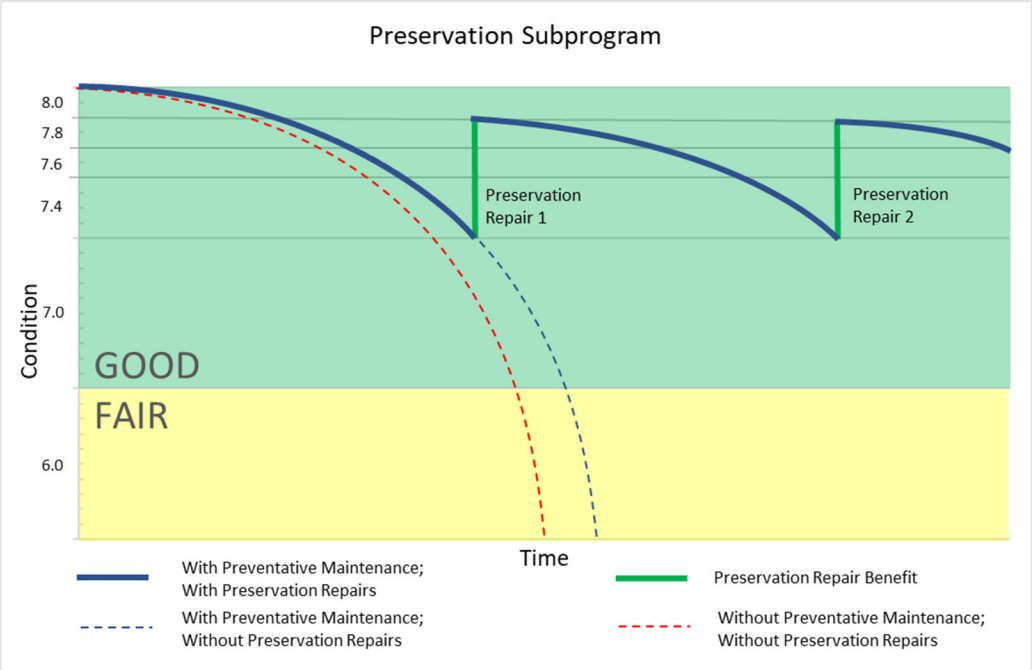
4.1.4 Subprogram Actions

Preservation Subprogram Actions to address both condition- and cyclic-based needs are tabulated below. Preservation Subprogram condition-based actions are triggered by Primary Element needs. The needs of *related* Non-Primary Elements and Protective System Elements are addressed when their respective Primary Element needs are addressed.

Preservation Subprogram Actions				
Primary Element Type	**Related Non-Primary Element Types**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
01 Preservation - Repairs				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Repair(s)** of Affected Primary Element(s) • **All Needs** on Joints • **Repair(s)** on all other Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$250,000/Bridge	12
Superstructure		• **Repair(s)** of Affected Primary Element(s)	$250,000/Bridge	15
Substructure	• Bearings	• **Repair(s)** of Affected Primary Element(s) • **Repair*(s)*** *of Related Non-Primary Element Types* • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$250,000/Bridge	18
Cyclic Preventative Maintenance				
		• **Clean Bridge**	$2,000/Bridge	2
		• **Clean Channel**	$10,000/Bridge	5

4.1.5 Life Cycle Planning (LCP) Analysis

With its function being to ensure GOOD bridges are maintained and remain in GOOD condition, the Preservation Subprogram plays a critical role in LCP. The condition-driven and cyclic strategies within the subprogram help preserve and maintain bridges within the HDOT's inventory at least cost. This is supported through comparing strategies over time as shown in the graph below.



Comparing the three strategies, it is clear the the *With Preventative Maintenance; With Preservation Repairs* strategy improves, preserves, and maintains bridges over the long-term. This strategy can also be described as *Keeping GOOD bridges GOOD*.

By comparing the annualized costs of a *Keeping GOOD bridges GOOD* strategy with a *Restoring FAIR bridges to GOOD* strategy, for an average-sized bridge (12,000 SF Deck Area), it is evident that *Keeping GOOD bridges GOOD* minimizes costs while preserving condition. This is shown below.

Least Life Cycle Cost (LLCC) Analysis			
Primary Element Type	**Subprogram Action**	**Annual Cost**	
		Discount Rate	
		-0.3%	**0%**
Keeping GOOD bridges GOOD			
Deck/Slab	01 Preservation - Repairs	$21,179	$20,833
Superstructure	01 Preservation - Repairs	$17,019	$16,667
Substructure	01 Preservation - Repairs	$14,246	$13,889
[redacted]	Clean Bridge	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$55,459**	**$54,389**
Restoring FAIR bridges to GOOD			
Deck/Slab	06 Preservation - Rehabilitation	$40,437	$39,130
Superstructure	06 Preservation - Rehabilitation	$156,626	$150,000
Substructure	06 Preservation - Rehabilitation	$106,752	$100,000
[redacted]	Clean Bridge	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$306,829**	**$292,130**

4.2 Rehabilitation Subprogram

The function of the Rehabilitation Subprogram, as a SGR Subprogram, is to identify and address bridge condition needs through actions that improve condition. The Rehabilitation Subprogram, specifically, aims to ensure FAIR or POOR bridges are restored to GOOD condition, thereby extending their service life.

Rehabilitation involves major work required to restore the structural integrity of a bridge, as well as work necessary to correct major safety, especially with regard to capacity. Rehabilitated bridges may be strengthened to restore the original design capacity or improved to meet current design standards which includes widening of the bridge deck or superstructure. Rehabilitation projects can be limited to elements within a single bridge component or can encompass multiple bridge components.

4.2.1 Bridge Eligibility

Bridges that are in FAIR or POOR condition are eligible to be in the Rehabilitation Subprogram with the following exceptions:

- Steel bridges – Bridges with steel primary elements in their Deck, Superstructure, or Substructure components are managed through the Steel Bridge Subprogram.
- Culverts – Culvert bridges are managed through the Culvert Subprogram.
- Concrete decks – Concrete decks and slab *components* are managed through the Concrete Deck Subprogram.
- Bridges with significant capacity deficiencies.

4.2.2 Bridge Data Considered

Condition data is analyzed to identify bridge needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Rehabilitation Subprogram. Bridge Element Condition States from the following elements is critical for these strategies. Elements that are excluded are managed through other subprograms or do not trigger actions.

Elements Considered							
PRIMARY							
Element	Units	Element Number					
		Steel	PSC	RC	Timber	Masonry	Other
Deck/Slab *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Deck	ft^2				31		60
Slab	ft^2				54		65
Superstructure							
Closed Web/Box Girder	ft		104	105			106
Girder/Beam	ft		109	110	111		112
Stringer	ft		115	116	117		118
Truss	ft				135		136
Arch	ft		143	144	146	145	142
Secondary Cable	each						149
Floor Beam	ft		154	155	156		157
Substructure *Related Non-Primary Element Types include: Bearings*							
Column	each		204	205	206		203
Column Tower (Trestle)	ft				208		
Pier Wall	ft			210	212	213	211
Abutment	ft			215	216	217	218
Pile Cap/Footing	ft			220			
Pile	each		226	227	228		229
Pier Cap	ft		233	234	235		236
Movable (roller, sliding, etc.) Bearings	each	311					

4.2.3 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in Section A.1 of the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Rehabilitation Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Rehabilitation Subprogram**					
Element Type	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Primary		> 65%	Not permitted.	5	Rehabilitation of Component
Primary		≤ 5%	≤ 5%	4	Structural Repair of Component
Primary		> 5%	≤ 5%	4	Structural Rehabilitation of Bridge
Primary			> 5%	3 thru 2	Structural Rehabilitation of Bridge*

*If NBI Condition Rating ≤ 3, a *Structural Rehabilitation of Bridge vs Bridge Replacement Assessment* shall be conducted. See Subsection 4.3.4.

Bridge *cyclic-based* needs are identified through the Rehabilitation Subprogram on a scheduling basis and through work candidates issued by bridge inspectors. These needs are shown below.

Cyclic-Based* Needs Identified through the Rehabilitation Subprogram	
Need	**Description**
Bridge Cleaning	Clean all components of the bridge. Remove dirt, debris, and other material by scraping, brushing, sweeping, flushing, or by using other hand or mechanical means. Open and clean all bridge drainage systems: scuppers, drainage pipes, troughs, and catch basins. Remove debris from deck expansion joints. Clean abutment areas, pier areas, and bridge members. Remove vegetation. Perform other cleaning as required.
Channel Cleaning	Maintenance of natural drainage or stream channels and side slopes, including removal of debris and rock slides, to ensure proper flow.

*Note, Cyclic-Based Needs are only identified for FAIR, not POOR, bridges.

4.2.4 Subprogram Actions

Rehabilitation Subprogram Actions to address both condition- and cyclic-based needs are tabulated below. Rehabilitation Subprogram condition-based actions are triggered by Primary Element needs. The needs of *related* Non-Primary Elements and Protective System Elements are addressed when their respective Primary Element needs are addressed.

Rehabilitation Subprogram Actions[I]				
Primary Element Type	**Related Non-Primary Element Types**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
06 Preservation – Rehabilitation				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Rehabilitation of Component**, addressing all Needs on all Deck/Slab Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$75/Deck Area SF	23
Superstructure		• **Rehabilitation of Component**, addressing all Needs on all Superstructure Primary Elements	$375/Deck Area SF	30
Substructure	• Bearings	• **Rehabilitation of Component**, addressing all Needs on all Substructure Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$375/Deck Area SF	45
04 Rehabilitation - Structural Repairs[II]				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Structural Repair of Component**, addressing all Needs on all Deck/Slab Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-	$75/Deck Area SF	23

Rehabilitation Subprogram Actions[I]				
		Primary Elements		
Superstructure		• **Structural Repair of Component**, addressing all Needs on all Superstructure Primary Elements	$375/Deck Area SF	30
Substructure	• Bearings	• **Structural Repair of Component**, addressing all Needs on all Substructure Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$375/Deck Area SF	45
03 Rehabilitation - Structural Rehabilitation[III]				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Structural Rehabilitation of Bridge**, addressing all Needs on all Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$800/Deck Area SF	33
Superstructure				
Substructure	• Bearings			
Cyclic Preventative Maintenance [IV]				
		• **Clean Bridge**	$2,000/Bridge	2
		• **Clean Channel**	$10,000/Bridge	5

[I]When a GOOD bridge requires structural modifications to support improvements to the bridge, the resulting Subprogram Action is *05 Rehabilitation – Capacity-Driven.* This Subprogram Action enables the bridge to be in a state of good repair longer but it is driven by capacity, not condition, needs.

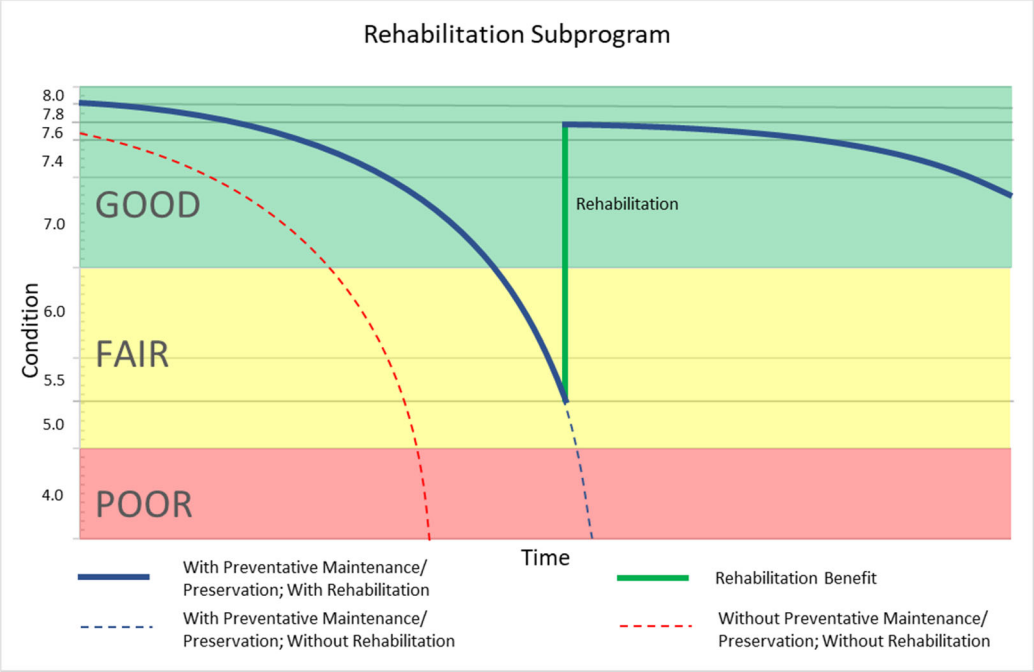
[II]When an immediate safety hazard need to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *02 Rehabilitation – Immediate Structural Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

[III]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *01 Rehabilitation – Immediate Structural Rehabilitation* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

(IV)Only FAIR bridges are eligible for Cyclic Preventative Maintenance. The structural needs of a POOR bridge need to be addressed in order for the bridge to eligible for Cyclic Preventative Maintenance.

4.2.5 Life Cycle Planning (LCP) Analysis

With its function being to ensure FAIR or POOR bridges are restored to GOOD condition, the Rehabilitation Subprogram plays a critical role in LCP. The condition-driven strategies within the subprogram help improve bridges within the HDOT's inventory. This is supported through comparing strategies over time as shown in the graph below.



Comparing the three strategies, it is clear the the Rehabilitation Subprogram *With Preventative Maintenance / Preservation; With Rehabilitation* strategy improves bridges over the long-term. This strategy can also be described as *Restoring FAIR bridges to GOOD*.

By comparing the annualized costs of a *Restoring FAIR bridges to GOOD* strategy with a *Restoring POOR bridges to GOOD* strategy, for an average-sized bridge (12,000 SF Deck Area), it is evident that *Restoring FAIR bridges to GOOD* minimizes costs while improving condition. This is shown below.

Least Life Cycle Cost (LLCC) Analysis			
Primary Element Type	**Subprogram Action**	**Annual Cost**	
		Discount Rate	
		-0.3%	**0%**
Restoring FAIR bridges to GOOD			
Deck/Slab	06 Preservation - Rehabilitation	$40,437	$39,130
Superstructure	06 Preservation - Rehabilitation	$156,626	$150,000
Substructure	06 Preservation - Rehabilitation	$106,752	$100,000
[redacted]	Clean Bridge	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$306,829**	**$292,130**
Restoring POOR bridges to GOOD			
[redacted]	03 Rehabilitation - Structural Rehabilitation	$314,180	$300,000
	TOTAL	**$314,180**	**$300,000**

4.3 Replacement Subprogram

The function of the Replacement Subprogram, as a SGR Subprogram, is to identify and address bridge condition needs through actions that improve condition. The Replacement Subprogram, specifically, aims to identify and address POOR bridges by replacing them with new (GOOD) bridges when rehabilitation is no longer reasonable or economically viable when Life-Cycle Costs (LLC) are considered.

4.3.1 Bridge Eligibility

Bridges that are in POOR condition are eligible to be in the Replacement Subprogram with the following exceptions:

- Steel bridges – Bridges with steel primary elements in their Deck, Superstructure, or Substructure components are managed through the Steel Bridge Subprogram.
- Culverts – Culvert bridges are managed through the Culvert Subprogram.
- Bridges with significant capacity deficiencies.

4.3.2 Bridge Data Considered

Condition data is analyzed to identify bridge needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Replacement Subprogram. Bridge Element Condition States from the following elements is critical for these strategies. Elements that are excluded are managed through other subprograms or do not trigger actions.

Elements Considered							
PRIMARY							
Element	Units	Element Number					
		Steel	PSC	RC	Timber	Masonry	Other
Deck/Slab *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Deck	ft^2				31		60
Slab	ft^2				54		65
Superstructure							
Closed Web/Box Girder	ft		104	105			106
Girder/Beam	ft		109	110	111		112
Stringer	ft		115	116	117		118
Truss	ft				135		136
Arch	ft		143	144	146	145	142
Secondary Cable	each						149
Floor Beam	ft		154	155	156		157
Substructure *Related Non-Primary Element Types include: Bearings*							
Column	each		204	205	206		203
Column Tower (Trestle)	Ft				208		
Pier Wall	Ft			210	212	213	211
Abutment	Ft			215	216	217	218
Pile Cap/Footing	Ft			220			
Pile	each		226	227	228		229
Pier Cap	Ft		233	234	235		236
Movable (roller, sliding, etc.) Bearings	each	311					

4.3.3 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in Section A.1 of the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Replacement Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Replacement Subprogram**					
Element Type	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Primary			> 5%	3 thru 2	Bridge Replacement*

*If NBI Condition Rating ≤ 3, a *Structural Rehabilitation of Bridge vs Bridge Replacement Assessment* shall be conducted. See the following subsection.

4.3.4 Structural Rehabilitation of Bridge vs Bridge Replacement Assessment

The BAMP has developed a multi-tiered assessment to provide justification for Bridge Replacement. Tier 1 involves assessing if the bridge is deficient in terms of Condition, Capacity, or Robustness. If the bridge is deficient in at least two areas, Replacement may be warranted. Tier 2 is a more advanced assessment as it involves Preservation Cycle Cost Analysis (PCCA). PCCA provides a means to assess the cost-effectiveness of structurally rehabilitating and continuing preservation of a bridge (i.e. the preservation cost) compared to that of replacing the bridge (i.e. the basic cost). Tier 3 provides a check for alignment with the HDOT's Resiliency Policy. This is outlined below.

TIER 1 – Assess Areas of Deficiencies

1. Is the bridge Condition deficient? (i.e. NBI Condition Rating ≤ 3?)
2. Is the bridge Capacity deficient?
    a. Deck Geometry (NBI Item 68) ≤ 3?
    b. Underclearances (NBI Item 69) ≤ 3?
    c. Bridge Posting (NBI Item 70) ≤ 4?
    d. Approach Roadway Alignment (NBI Item 72) ≤ 3?
3. Is the bridge deficient in Robustness?
    a. Channel and Channel Protection (NBI Item 61) ≤ 3?
    b. Waterway Adequacy (NBI Item 71) ≤ 3?
    c. Scour Critical Bridge (NBI Item 113) ≤ 3?
    d. Fracture Critical Bridge (NBI Item 92A) = Y?

TIER 2 – Perform Preservation Cycle Cost Analysis (PCCA) in accordance with the GBPA

TIER 3 – Verify the determined action is in alignment with the HDOT's Resiliency Policy

4.3.5 Subprogram Actions

Replacement Subprogram Actions to address condition-based needs are tabulated below. Replacement Subprogram condition-based actions are triggered by Primary Element needs. The needs of *related* Non-Primary Elements and Protective System Elements are addressed when their respective Primary Element needs are addressed.

Replacement Subprogram Actions[I]				
Primary Element Type	**Related Non-Primary Element Types**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
02 Replacement – Condition-Driven[II]				
[redacted]		• **Bridge Replacement**	$6,030/Deck Area SF for a new Concrete Bridge OR $3,250/Deck Area SF for a new Steel Bridge	75

[I]When a GOOD or FAIR bridge requires replacement to support improvements to the bridge, the resulting Subprogram Action is *03 Replacement - Capacity-Driven.* This Subprogram Action results in a bridge that is in a state of good repair but it is driven by capacity, not condition, needs.

[II]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *01 Replacement - Immediate Temporary Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

4.4 Steel Bridge Subprogram

Acknowledging the enhanced risk of corrosion that steel bridges have in Hawaii's climate and the fracture critical designs of several steel bridges, the BAMP has developed the Steel Bridge Subprogram to help ensure the structural needs of this subset of bridges are adequately met.

The function of the Steel Bridge Subprogram, as a SGR Subprogram, is to identify and address *steel* bridge structural needs through actions that improve or maintain condition. Running parallel to the Preservation, Rehabilitation, and Replacement Subprograms, the Steel Bridge Subprogram aims to address the structural needs of GOOD, FAIR, and POOR steel bridges. Unlike these subprograms, however, the Steel Bridge Subprogram is crucially dependent on an effective Steel Protective Coating (i.e. paint).

4.4.1 Bridge Eligibility

Bridges with steel primary elements in their Deck, Superstructure, ***or*** Substructure components are eligible to be in the Steel Bridge Subprogram. Exclusions include:

- Concrete decks – Concrete decks and slab *components* are managed through the Concrete Deck Subprogram.

4.4.2 Bridge Data Considered

Condition data is analyzed to identify bridge needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Steel Bridge Subprogram. Element Condition States for the following elements is critical for these strategies. Elements that are excluded are managed through other subprograms or do not trigger actions.

Elements Considered							
PRIMARY							
Element	**Units**	**Element Number**					
		Steel	**PSC**	**RC**	**Timber**	**Masonry**	**Other**
Deck/Slab *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Deck	ft^2				31		60
Open Grid Deck	ft^2	28					
Concrete Filled Grid Deck	ft^2	29					
Corrugated or Orthotropic Deck	ft^2	30					
Slab	ft^2				54		65
Superstructure							
Closed Web/Box Girder	ft	102	104	105			106
Girder/Beam	ft	107	109	110	111		112
Stringer	ft	113	115	116	117		118
Truss	ft	120			135		136
Arch	ft	141	143	144	146	145	142
Main Cable	ft	147					
Secondary Cable	each	148					149
Floor Beam	ft	152	154	155	156		157
Pin, Pin and Hangar Assembly	each	161					
Gusset Plate	each	162					
Substructure *Related Non-Primary Element Types include: Bearings*							
Column	each	202	204	205	206		203
Column Tower (Trestle)	ft	207			208		
Pier Wall	ft			210	212	213	211
Abutment	ft	219		215	216	217	218
Pile Cap/Footing	ft			220			
Pile	each	225	226	227	228		229
Pier Cap	ft	231	233	234	235		236
Movable (roller, sliding, etc.) Bearings*	each	311					
PROTECTIVE SYSTEM							
Element	**Units**	**Element Number**					
Steel Protective Coating	ft^2	515					

4.4.3 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Steel Bridge Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Steel Bridge Subprogram**					
Element Type(s)	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Steel Protective Coating		≤ 5%	Not permitted.	7	Spot Painting
Primary	≤ 100%	Not permitted.	Not permitted.	8 thru 7.4	
Steel Protective Coating		> 5%	≤ 100%	6 thru 2	Bridge Repainting
Primary	≤ 100%	Not permitted.	Not permitted.	8 thru 7.4	
Steel Protective Coating		> 5%	≤ 100%	6 thru 2	Bridge Repair and Repainting
Primary		≤ 5%	Not permitted.	7	
Steel Protective Coating		> 5%	≤ 100%	6 thru 2	Bridge Rehabilitation and Repainting
Primary		> 65%	Not permitted.	5	
Steel Protective Coating		> 5%	≤ 100%	6 thru 2	Bridge Structural Repair and Repainting
Primary		≤ 5%	≤ 5%	4	
Primary		> 5%	≤ 5%	4	Bridge Structural Rehabilitation and Repainting
Primary		> 5%	> 5%	3 thru 2	Bridge Structural Rehabilitation and Repainting *
Primary		> 5%	> 5%	3 thru 2	Bridge Replacement*

*If NBI Condition Rating ≤ 3, a *Structural Rehabilitation of Bridge vs Bridge Replacement Assessment* shall be conducted. See Subsection 4.3.4.

Bridge *cyclic-based* needs are identified through the Steel Bridge Subprogram on a scheduling basis and through work candidates issued by bridge inspectors. These needs are shown below.

Cyclic-Based* Needs Identified through the Steel Bridge Subprogram	
Need	**Description**
Bridge Painting	Provide containment for surface preparation and painting. Using solvent and blast cleaning methods, prepare steel element surfaces. Apply coating(s) meeting coating thickness and application method requirements.
Bridge Cleaning	Clean all components of the bridge. Remove dirt, debris, and other material by scraping, brushing, sweeping, flushing, or by using other hand or mechanical means. Open and clean all bridge drainage systems: scuppers, drainage pipes, troughs, and catch basins. Remove debris from deck expansion joints. Clean abutment areas, pier areas, and bridge members. Remove vegetation. Perform other cleaning as required.
Channel Cleaning	Maintenance of natural drainage or stream channels and side slopes, including removal of debris and rock slides, to ensure proper flow.

*Note, Cyclic-Based Needs are only identified for GOOD and FAIR bridges.

4.4.4 Subprogram Actions

Steel Bridge Subprogram Actions to address both condition- and cyclic-based needs are tabulated below. Steel Bridge Subprogram condition-based actions are triggered by Steel Protective Coating (i.e. paint) needs for GOOD or FAIR bridges and by Primary Element needs for POOR bridges. The needs of *related* Non-Primary Elements and other Protective System Elements are addressed when their respective Primary Element needs are addressed.

Steel Bridge Subprogram Actions[I], [II]				
Primary Element Type	**Related Non-Primary Element Types**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
12 PM – Steel Bridge – Localized Paint Restoration				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Spot Paint** affecting Primary and Related Non-Primary Elements	$250,000/Bridge	4
Superstructure				
Substructure	• Bearings			
11 PM – Steel Bridge –Painting Restoration				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Repaint Bridge**	$315/Deck Area SF	7
Superstructure				
Substructure	• Bearings			
10 Preservation – Steel Bridge – Repairs & Painting				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Repair(s)** of Affected Primary Element(s) • **All Needs** on Joints • **Repair(s)** on all other Related Non-Primary Element Types • **Repaint Bridge** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements	$640/Deck Area SF	10
Superstructure				
Substructure	• Bearings			
09 Preservation – Steel Bridge – Rehabilitation & Painting				
Deck/Slab	• Joints • Bridge Rails	• **Bridge Rehabilitation**, addressing all Needs on all	$1,200/Deck Area SF	13

Steel Bridge Subprogram Actions[I], [II]				
	• Approach Slabs	Primary Elements • **All Needs** on all Related Non-Primary Element Types • **Repaint Bridge** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements		
Superstructure	[redacted]			
Substructure	• Bearings			
07 Rehabilitation – Steel Bridge – Structural Repairs & Painting[III]				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Bridge Structural Repair**, addressing all Needs on all Primary Elements • **All Needs** on all Related Non-Primary Element Types • **Repaint Bridge** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements	$1,200/Deck Area SF	13
Superstructure	[redacted]			
Substructure	• Bearings			
06 Rehabilitation – Steel Bridge – Structural Rehabilitation & Painting[IV]				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Bridge Structural Rehabilitation**, addressing all Needs on all Primary Elements • **All Needs** on all Related Non-Primary Element Types • **Repaint Bridge** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements	$2,600/Deck Area SF	16
Superstructure	[redacted]			
Substructure	• Bearings			
04 Replacement – Steel Bridge – Condition-Driven[V]				
[redacted]		• **Bridge Replacement**	$6,030/Deck Area SF for a new Concrete Bridge OR $3,250/Deck Area SF for a	75

Steel Bridge Subprogram Actions[I], [II]			
[redacted]		new Steel Bridge	
Cyclic Preventative Maintenance [VI]			
[redacted]	• **Paint Bridge**	$315/Deck Area SF	7
	• **Clean Bridge**	$2,000/Bridge	2
	• **Clean Channel**	$10,000/Bridge	5

[I]When a GOOD steel bridge requires structural modifications to support improvements to the bridge, the resulting Subprogram Action is *08 Rehabilitation – Steel Bridge – Capacity-Driven.* This Subprogram Action enables the bridge to be in a state of good repair longer but it is driven by capacity, not condition, needs.

[II]When a GOOD or FAIR steel bridge requires replacement to support improvements to the bridge, the resulting Subprogram Action is *05 Replacement – Steel Bridge – Capacity-Driven.* This Subprogram Action results in a bridge that is in a state of good repair but it is driven by capacity, not condition, needs.

[III]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *03 Rehabilitation – Steel Bridge – Immediate Structural Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

[IV]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *02 Rehabilitation – Steel Bridge – Immediate Structural Rehabilitation* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

[V]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *01 Replacement – Steel Bridge – Immediate Temporary Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

[VI]Only FAIR bridges are eligible for Cyclic Preventative Maintenance. The structural needs of a POOR bridge need to be addressed in order for the bridge to eligible for Cyclic Preventative Maintenance.

4.4.5 Life Cycle Planning (LCP) Analysis

Running parallel to the Preservation, Rehabilitation, and Replacement Subprograms, the Steel Bridge Subprogram utilizes LCP to address the structural needs of GOOD, FAIR, and POOR steel bridges. The condition-driven and cyclic strategies within the subprogram help preserve and maintain steel bridges within the HDOT's inventory at least cost. The Steel Bridge Subprogram, however, is heavily dependent on maintaining a robust Steel Protective Coating (i.e. Paint) System. When a robust Paint System is maintained, deterioration of the steel substrate is arrested.

By comparing the annualized costs of *Keeping GOOD steel bridges GOOD with an Effective Paint System, Keeping GOOD steel bridges GOOD with an Ineffective Paint System, Restoring FAIR steel bridges to GOOD*, and *Restoring POOR steel bridges to GOOD* strategies for an average-sized steel bridge (6,000 SF Deck Area), it is evident that *Keeping GOOD bridges GOOD with an Effective Paint System* is the strategy with least cost. The other strategies are progressively more expensive. This is shown below.

Least Life Cycle Cost (LLCC) Analysis			
Primary Element Type	**Subprogram Action**	**Annual Cost**	
		Discount Rate	
		-0.3%	**0%**
Keeping GOOD steel bridges GOOD with an Effective Paint System			
[redacted]	*11 PM – Steel Bridge –Painting Restoration*	$272,440	$270,000
	Clean Bridge	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$275,453**	**$273,000**
Keeping GOOD steel bridges GOOD with an Ineffective Paint System			
[redacted]	*10 Preservation – Steel Bridge – Repairs & Painting*	$389,213	$384,000
	Clean Bridge	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$392,226**	**$387,000**
Restoring FAIR steel bridges to GOOD			
[redacted]	09 Preservation – Steel Bridge – Rehabilitation & Painting	$563,885	$553,846
	Clean Bridge	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$566,899**	**$556,846**
Restoring POOR steel bridges to GOOD			

Least Life Cycle Cost (LLCC) Analysis			
	06 Rehabilitation – Steel Bridge – Structural Rehabilitation & Painting	$997,124	$975,000
[redacted]	**TOTAL**	**$997,124**	**$975,000**

4.5 Culvert Subprogram

Recognizing the significant design and performance differences that culverts have when compared to traditional bridges, the BAMP has developed the Culvert Subprogram to help ensure the structural needs of this subset of bridges are adequately met.

The function of the Culvert Subprogram, as a SGR Subprogram, is to identify and address *culvert* structural needs through actions that improve or maintain condition. Running parallel to the Preservation, Rehabilitation, and Replacement Subprograms, the Culvert Subprogram aims to address the structural needs of GOOD, FAIR, and POOR culverts.

4.5.1 Bridge Eligibility

Bridges with Culvert primary elements are eligible to be in the Culvert Subprogram.

4.5.2 Bridge Data Considered

Condition data is analyzed to identify bridge needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Culvert Subprogram. Element Condition States for the following elements is critical for these strategies. Elements that are excluded are managed through other subprograms or do not trigger actions.

Elements Considered							
PRIMARY							
Element	Units	Element Number					
		Steel	PSC	RC	Timber	Masonry	Other
Culvert *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Culvert	ft	240	245	241	242	244	243

4.5.3

4.5.4 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Culvert Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Culvert Subprogram**					
Element Type(s)	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Primary	[redacted]	≤ 5%	Not permitted.	7	Repair
Primary		> 65%	Not permitted.	5	Rehabilitation of Culvert
Primary		≤ 5%	≤ 5%	4	Structural Repair of Culvert
Primary		> 5%	≤ 5%	4	Structural Rehabilitation of Culvert
Primary		> 5%	> 5%	3 thru 2	Structural Rehabilitation of Culvert*
Primary		> 5%	> 5%	3 thru 2	Culvert Replacement*

*If NBI Condition Rating ≤ 3, a *Structural Rehabilitation of Bridge vs Bridge Replacement Assessment* shall be conducted. See Subsection 4.3.4.

Bridge *cyclic-based* needs are identified through the Culvert Subprogram on a scheduling basis and through work candidates issued by bridge inspectors. These needs are shown below.

Cyclic-Based* Needs Identified through the Culvert Subprogram	
Need	**Description**
Culvert Cleaning	Clean entrances and interior of culverts. Remove debris, vegetation, silt, and large rocks using a skid loader, hand tools, or high-pressure water as appropriate.
Channel Cleaning	Maintenance of natural drainage or stream channels and side slopes, including removal of debris and rock slides, to ensure proper flow.

*Note, Cyclic-Based Needs are only identified for GOOD and FAIR bridges.

4.5.5 Subprogram Actions

Culvert Subprogram Actions to address both condition- and cyclic-based needs are tabulated below. Culvert Subprogram condition-based actions are triggered by Primary Element needs. The needs of *related* Non-Primary Elements and Protective System Elements are addressed when their respective Primary Element needs are addressed.

Culvert Subprogram Actions[I], [II]				
Primary Element Type	**Related Non-Primary Element Types**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
10 Preservation – Culvert – Repairs				
Culvert	• Joints • Bridge Rails • Approach Slabs	• **Repair(s)** of Affected Primary Element(s) • **All Needs** on Joints • **Repair(s)** on all other Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$250,000/Culvert	10
09 Preservation – Culvert – Rehabilitation				
Culvert	• Joints • Bridge Rails • Approach Slabs	• **Rehabilitation of Culvert**, addressing all Needs on all Culvert Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$125/Deck Area SF	19
07 Rehabilitation – Culvert – Structural Repairs [III]				
Culvert	• Joints • Bridge Rails • Approach Slabs	• **Structural Repair of Culvert**, addressing all Needs on all Culvert Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$125/Deck Area SF	19
06 Rehabilitation – Culvert – Structural Rehabilitation [IV]				

Culvert Subprogram Actions[I], [II]				
Culvert	• Joints • Bridge Rails • Approach Slabs	• **Structural Rehabilitation of Culvert**, addressing all Needs on all Primary Elements • **All Needs** on all Related Non-Primary Element Types • **All Needs** on all Protective System Elements affecting Primary and Related Non-Primary Elements	$175/Deck Area SF	24
04 Replacement – Culvert – Condition-Driven[V]				
		• **Culvert Replacement**	$2,000/Deck Area SF	75
Cyclic Preventative Maintenance				
		• **Clean Culvert**	$2,000/Bridge	2
		• **Clean Channel**	$10,000/Bridge	5

[I]When a GOOD culvert requires structural modifications to support improvements to the culvert, the resulting Subprogram Action is *08 Rehabilitation – Culvert – Capacity-Driven.* This Subprogram Action enables the culvert to be in a state of good repair longer but it is driven by capacity, not condition, needs.

[II]When a GOOD or FAIR culvert requires replacement to support improvements to the culvert, the resulting Subprogram Action is *05 Replacement – Culvert – Capacity-Driven.* This Subprogram Action results in a culvert that is in a state of good repair but it is driven by capacity, not condition, needs.

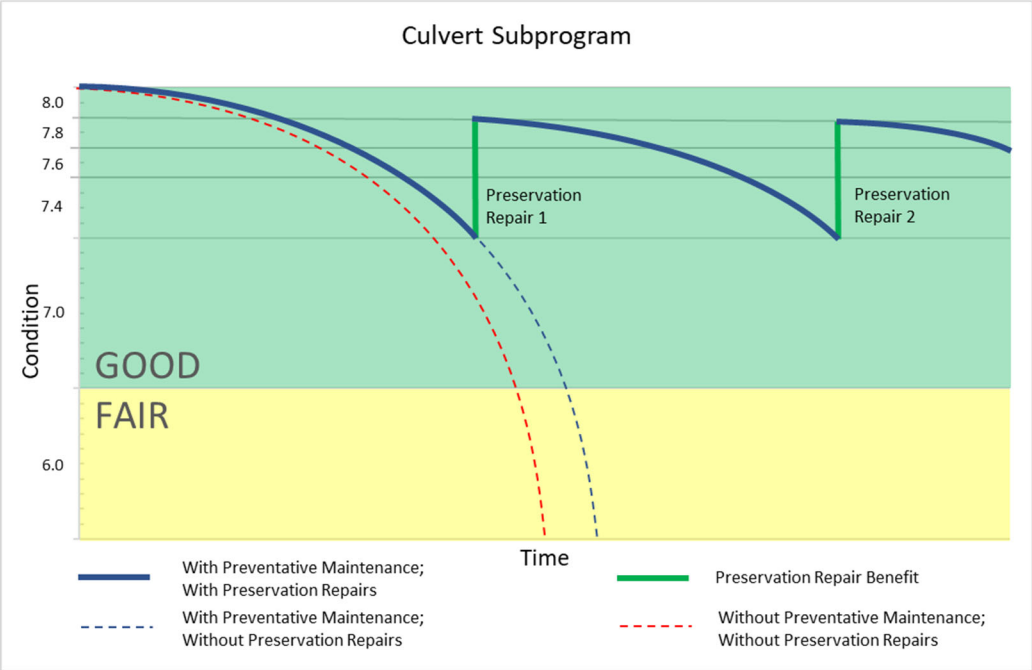
[III]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *03 Rehabilitation – Culvert – Immediate Structural Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

[IV]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *02 Rehabilitation – Culvert – Immediate Structural Rehabilitation* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

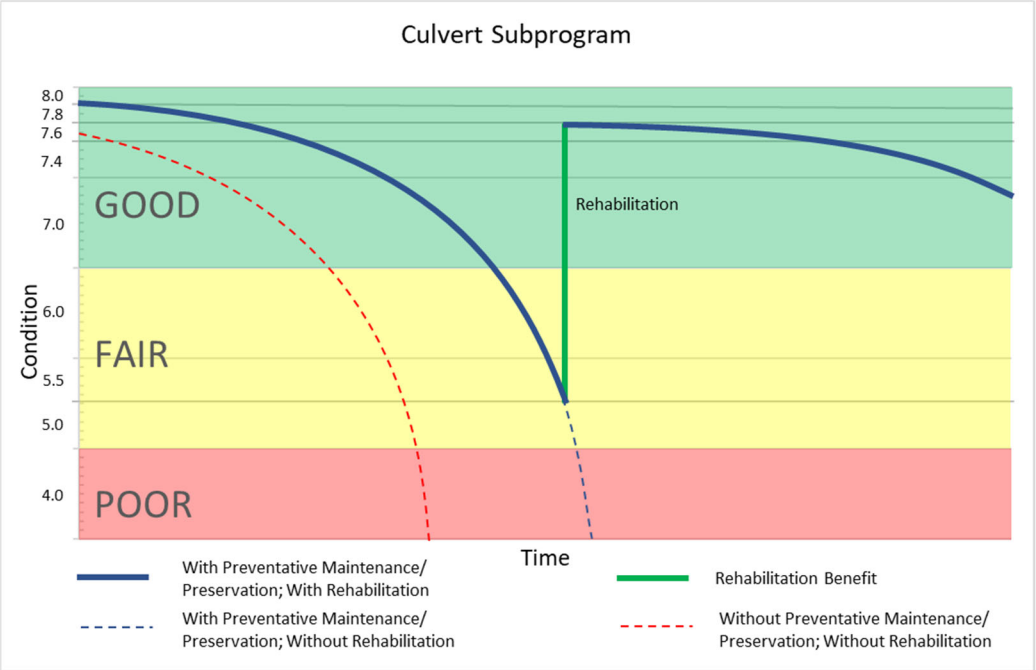
[V]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *01 Replacement – Culvert – Immediate Temporary Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

4.5.6 Life Cycle Planning (LCP) Analysis

Running parallel to the Preservation, Rehabilitation, and Replacement Subprograms, the Culvert Subprogram utilizes LCP to address the structural needs of GOOD, FAIR, and POOR culverts. The condition-driven and cyclic strategies within the subprogram help preserve and maintain bridges within the HDOT's inventory at least cost. This is supported through comparing strategies over time as shown in the both graphs below.



Comparing the three strategies, it is clear the *With Preventative Maintenance; With Preservation Repairs* strategy improves, preserves, and maintains culverts over the long-term. This strategy can also be described as *Keeping GOOD bridges GOOD*.



Similarly, in the above graph, it is clear the *With Preventative Maintenance / Preservation; With Rehabilitation* strategy improves bridges over the long-term. This strategy can also be described as *Restoring FAIR bridges to GOOD*.

By comparing the annualized costs of *Keeping GOOD bridges GOOD, Restoring FAIR bridges to GOOD*, and *Restoring POOR bridges to GOOD* strategies for an average-sized culvert (5,000 SF Deck Area), it is evident that *Keeping GOOD bridges GOOD* is the strategy with least cost. *Restoring FAIR bridges to GOOD* is more cost-effective than a *Restoring POOR bridges to GOOD* strategy. This is shown below.

Least Life Cycle Cost (LLCC) Analysis			
Primary Element Type	**Subprogram Action**	**Annual Cost**	
		Discount Rate	
		-0.3%	**0%**
Keeping GOOD bridges GOOD			
Culvert	10 Preservation – Culvert – Repairs	$25,339	$25,000
[redacted]	Clean Culvert	$1,002	$1,000
	Clean Channel	$2,012	$2,000
	TOTAL	**$28,353**	**$28,000**
Restoring FAIR bridges to GOOD			
Culvert	09 Preservation – Culvert – Rehabilitation	$33,792	$32,895
[redacted]	Clean Culvert	$1,002	$1,000

Least Life Cycle Cost (LLCC) Analysis			
[redacted]	Clean Channel	$2,012	$2,000
	TOTAL	**$36,805**	**$35,895**
Restoring POOR bridges to GOOD			
Culvert	06 Rehabilitation – Culvert – Structural Rehabilitation	$37,732	$36,458
[redacted]	**TOTAL**	**$37,732**	**$36,458**

4.6 Concrete Deck Subprogram

The Concrete Deck Subprogram was developed recognizing the importance of maintaining the structural integrity of concrete bridge decks and slabs (i.e. concrete decks/slabs) to provide adequate level of service for the traveling public. Furthermore, it was developed with the intent to improve the asset management of concrete decks/slabs. Running parallel to the Preservation and Rehabilitation Subprograms, the Concrete Deck Subprogram aims to address the structural needs of GOOD, FAIR, and POOR concrete decks/slabs.

4.6.1 Bridge Eligibility

Bridges with concrete deck/slab component primary elements are eligible to be in the Concrete Deck Subprogram.

4.6.2 Bridge Data Considered

Condition data is analyzed to identify bridge needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Concrete Deck Subprogram. Element Condition States for the following elements is critical for these strategies. Elements that are excluded are managed through other subprograms or do not trigger actions.

Elements Considered							
PRIMARY							
Element	**Units**	**Element Number**					
		Steel	**PSC**	**RC**	**Timber**	**Masonry**	**Other**
Deck/Slab *Related Non-Primary Element Types include: Approach Slabs, Bridge Rail, and Joints*							
Deck	ft^2		13	12			
Slab	ft^2			38			
Top Flange	ft^2		15	16			
PROTECTIVE SYSTEM							
Element	**Units**	**Element Number**					
Wearing Surface	ft^2	510					

4.6.3 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in Section A.1 of the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Concrete Deck Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Concrete Deck Subprogram**					
Element Type(s)	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Deck/Slab Without Wearing Surface					
Primary	≤ 5%	≤ 5%	Not permitted.	7	Repair
Primary	≤ 10%	≤ 5%	Not permitted.	7	Repair and Construct Overlay
Primary	> 10%	≤ 5%	Not permitted.	7	Partial Depth Reconstruction & Overlay Construction
Primary		>45%; ≤ 60%	≤ 5%	5	Partial Depth Reconstruction & Overlay Construction
Primary		> 60%	> 5%	4 thru 2	Full Depth Replacement & Overlay Reconstruction
Deck/Slab With Wearing Surface					
Wearing Surface	≤ 5%	≤ 5%	Not permitted.	7	Wearing Surface Repairs
Primary	≤ 10%	Not permitted.	Not permitted.	8 thru 7.9	
Wearing Surface	> 5%	≤ 5%	Not permitted.	7	Overlay Restoration
Primary	≤ 10%	Not permitted.	Not permitted.	8 thru 7.9	
Wearing Surface	> 5%	≤ 5%	Not permitted.	7	Repair and Construct Overlay
Primary		≤ 5%	Not permitted.	7	
Wearing Surface		> 30%	≤ 100%	5 thru 2	Repair and Construct Overlay
Primary	≤ 10%	< 5%	Not	7	

Condition-Based Needs driving the Concrete Deck Subprogram					
			permitted.		
Wearing Surface		> 30%	≤ 100%	5 thru 2	Partial Depth Reconstruction & Overlay Construction
Primary	> 10%	≤ 5%	Not permitted.	7	
Wearing Surface					Partial Depth Reconstruction & Overlay Construction
Primary		>45%; ≤ 60%	≤ 5%	5	
Wearing Surface					Full Depth Replacement & Overlay Reconstruction
Primary		> 60%	> 5%	4 thru 2	

4.6.4 Subprogram Actions

Concrete Deck Subprogram Actions to address condition-based needs are tabulated below. Concrete Deck Subprogram condition-based actions are triggered by Wearing Surface needs for GOOD or FAIR bridges and by Primary Element needs for POOR bridges. The needs of *related* Non-Primary Elements and other Protective System Elements are addressed when their respective Primary Element needs are addressed.

Concrete Deck Subprogram Actions[1]				
Primary Element Type	**Related Non-Primary Element Types**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
05 PM – Concrete Deck – Overlay Restoration				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Restore Overlay on Deck/Slab** Element(s)	$75/Deck Area SF	10
03 Preservation – Concrete Deck – Repairs & Overlay Construction				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Repair Deck/Slab** Element(s) • **All Needs** on Joints • **Repair(s)** on all other Related Non-Primary Element Types • **Restore/Construct Deck/Slab Overlay** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements	$125/Deck Area SF	15
02 Preservation – Concrete Deck – Partial Depth Reconstruction & Overlay Construction				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Partial Depth Reconstruction of Deck/Slab** Element(s) • **All Needs** on Joints • **Repair(s)** on all other Related Non-Primary Element Types • **Restore/Construct Deck/Slab Overlay** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements	$400/Deck Area SF	20

Concrete Deck Subprogram Actions[I]				
01 Rehabilitation – Concrete Deck – Structural Rehabilitation, Full Depth Reconstruction, & Overlay Construction				
Deck/Slab	• Joints • Bridge Rails • Approach Slabs	• **Full Depth Reconstruction of Deck/Slab** Element(s) • **All Needs** on all Related Non-Primary Element Types • **Restore/Construct Deck/Slab Overlay** • **All Needs** on all other Protective System Elements affecting Primary and Related Non-Primary Elements	$1,100/Deck Area SF	28

[II]When a GOOD Concrete Deck does not meet the prescribed thresholds, but improvements are requested for the Concrete Deck, the resulting Subprogram Action is *04 Preservation – Concrete Deck – Repairs / Repairs & Overlay Construction (Capacity-Driven)* or, when an overlay exists, *06 PM - Concrete Deck - Overlay Repairs / Overlay Restoration (Capacity-Driven).* This Subprogram Action results in a Concrete Deck that is in a state of good repair but it is driven by capacity, not condition, needs.

4.6.5 Life Cycle Planning (LCP) Analysis

Running parallel to the Preservation and Rehabilitation Subprograms, the Concrete Deck Subprogram utilizes LCP to address the structural needs of GOOD, FAIR, and POOR Concrete decks. The condition-driven strategies within the subprogram help preserve and maintain concrete decks/slabs within the HDOT's inventory at least cost. The Concrete Deck Subprogram, however, is heavily dependent on utilizing an effective wearing surface (e.g. Deck Overlay). When an effective Deck Overlay is maintained, deterioration of the Concrete Deck is virtually arrested.

By comparing the annualized costs of *Keeping GOOD Concrete Decks GOOD with an Effective Deck Overlay, Keeping GOOD Concrete Decks GOOD with an Ineffective Deck Overlay, Restoring FAIR Concrete Decks to GOOD*, and *Restoring POOR Concrete Decks to GOOD* strategies for an average-sized bridge (12,000 SF Deck Area), it is evident that *Keeping GOOD Concrete Decks GOOD with an Effective Deck Overlay* is the strategy with least cost. The other strategies are progressively more expensive. This is shown below.

Least Life Cycle Cost (LLCC) Analysis			
Primary Element Type	**Subprogram Action**	**Annual Cost**	
		Discount Rate	
		-0.3%	**0%**
Keeping GOOD Concrete Decks GOOD with an Effective Deck Overlay			
[redacted]	*05 PM - Concrete Deck - Overlay Restoration*	$91,222	$90,000
	TOTAL	**$91,222**	**$90,000**
Keeping GOOD Concrete Decks GOOD with an Ineffective Deck Overlay			
[redacted]	*03 Preservation - Concrete Deck - Repairs & Overlay Construction*	$102,117	$100,000
	TOTAL	**$102,117**	**$100,000**
Restoring FAIR Concrete Decks to GOOD			
[redacted]	02 Preservation - Concrete Deck - Partial Full Depth Reconstruction & Overlay Construction	$246,912	$240,000
	TOTAL	**$246,912**	**$240,000**
Restoring POOR concrete decks to GOOD			
	01 Rehabilitation - Concrete Deck - Structural Rehab, Full Depth Recon, & Overlay Con	$490,799	$471,429
[redacted]	**TOTAL**	**$490,799**	**$471,429**

4.7 Strengthening Subprogram

The function of the Strengthening Subprogram, as a Resiliency Subprogram, is to identify and address structural needs to improve or maintain resiliency. The Strengthening Subprogram, specifically, aims to identify and address structural needs of bridges that are load capacity deficient.

4.7.1 Bridge Eligibility

Bridges that do not carry legal loads (i.e. Legal Load Rating Factor < 1.0) are eligible to be in the Strengthening Subprogram.

4.7.2 Bridge Data Considered

- NBI Item 70: Bridge Posting
- NBI Item 41: Structure Open, Posted, or Closed to Traffic

Bridge Data that is excluded does not trigger actions.

4.7.3 Data-based Bridge Needs

The Strengthening Subprogram is *driven* by the data-based needs tabulated below. That is, the data-based needs below trigger Subprogram Actions.

***Data-Based* Needs driving the Strengthening Subprogram**			
NBI Item 70	**NBI Item 41**	**Bridge Condition**	**Need**
<5	A, B, D, or E	GOOD or FAIR	Strengthening (Capacity-Driven)
<5	A, B, D, or E	POOR	Strengthening (Condition-Driven)

4.7.4 Subprogram Actions

Strengthening Subprogram Actions to address data-based needs are tabulated below.

Strengthening Subprogram Actions	
Subprogram Action Description	**Anticipated Unit Cost**
01 Rehabilitation - Strengthening - Condition-Driven	
• **Strengthening of Load Deficient Elements**	$200/Deck Area SF
02 Rehabilitation - Strengthening - Capacity-Driven	
• **Strengthening of Load Deficient Elements**	$300/Deck Area SF

4.8 Scour Subprogram

The function of the Scour Subprogram, as a Resiliency Subprogram, is to identify and address structural needs to improve or maintain resiliency. The Scour Subprogram, specifically, aims to identify and address structural needs of bridges that are vulnerable to scour.

4.8.1 Bridge Eligibility

Bridges that are, or may be, scour critical are eligible to be in the Scour Subprogram.

4.8.2 Bridge Data Considered

The Scour Subprogram utilizes the following bridge data. Bridge data not listed do not trigger actions.

- NBI Item 113: Scour Critical
    - Scour evaluation reports assess design year scour and bridge stability utilizing HEC-18 when applicable. Bridges may be rated scour critical due to design year storm events, but may not show signs of scour in the biennial or special bridge inspections.
- Scour Defect 6000
    - This defect is identified through biennial or special bridge inspections. The severity of the Scour Defect 6000 may change NBI Item 113 to a 3 or less. The defects are assessed based on foundational material, foundation type (e.g. spread footings or deep foundations), and history of scour.
- Bridge Cross Sections
    - Historical Bridge Cross Sections are compared to cross sections taken during an inspection to assess potential changes to the streambed.
- Plan of Actions (POAs)
    - When a bridge is scour critical (NBI Item 113 ≤ 3), a POA is required. POAs may involve monitoring during storm events and/or a post-event inspection. Procedures for monitoring during storm events, performing potential bridge closures, utilizing detour routes, and executing post-event inspections and recommended structural countermeasures are detailed in the POA.

4.8.3 Data-based Bridge Needs

The Scour Subprogram is *driven* by the data-based needs tabulated below. That is, the data-based needs below trigger Subprogram Actions.

***Data-Based* Needs driving the Scour Subprogram**		
Bridge Condition	**Need**	**Comments**
GOOD or FAIR	Install Scour Countermeasures	May be installed to resist theoretical scour per HEC-18, even if no scour is apparent per an inspection. NBI Item 113 is revised to a 7 when scour countermeasures of scour critical bridges (NBI Item 113 ≤ 3) are designed using HEC-23 criteria.
GOOD or FAIR	Repair Substructure for Scour	NBI Item 113 is revised to a 7 or 8 when repairs of scour critical bridges (NBI Item 113 ≤ 3) are designed using HEC-23 criteria. Repairs that do not follow HEC-23 do not revise NBI Item 113.
FAIR or POOR	Rehabilitate Substructure for Scour	NBI Item 113 is revised to a 7 or 8 when rehabilitations of scour critical bridges (NBI Item 113 ≤ 3) are designed using HEC-23 criteria. Rehabilitations that do not follow HEC-23 do not revise NBI Item 113.
	Perform Scour Monitoring	Scour monitoring is performed when required by a POA or when recommended by an inspection report.
	Perform Scour Evaluation	Scour Evaluation is required for all bridges over water.

4.8.4 Subprogram Actions

Scour Subprogram Actions to address condition-based needs are tabulated below.

Scour Subprogram Actions	
Subprogram Action Description	**Anticipated Unit Cost**
04 PM - Scour – Countermeasures	
• **Install Scour Countermeasures**	$2,000/CY Countermeasure Material
03 Preservation – Scour – Repairs	
• **Repair Substructure for Scour**	$2,000/CY Substructure Material
02 Rehabilitation – Scour – Repairs[(I)]	
• **Rehabilitate Substructure for Scour**	$2,000/CY Substructure Material

[(I)]When an immediate safety hazard needs to be addressed, this Subprogram Action may be phased. The resulting Subprogram Action is *01 Rehabilitation – Scour – Immediate Repairs* and eliminates the immediate safety hazard but does not necessarily improve the condition of the element(s).

4.9 Seismic Retrofit Subprogram

The function of the Seismic Retrofit Subprogram, as a Resiliency Subprogram, is to identify and address structural needs to improve or maintain resiliency. The Seismic Retrofit Subprogram, specifically, aims to identify and address structural needs of bridges that are vulnerable to effects of earthquakes.

4.9.1 Bridge Eligibility

Bridges that do not meet seismic evaluation performance criteria are eligible to be in the Seismic Retrofit Subprogram.

4.9.2 Bridge Data Considered

Bridge Data considered in the Seismic Retrofit Subprogram include the designs of bearing seats, columns, and connections. The adequacy of these designs are verified through seismic evaluation, considering seismic vulnerability.

4.9.3 Data-based Bridge Needs

The Seismic Retrofit Subprogram is *driven* by the data-based needs tabulated below. That is, the data-based needs below trigger Subprogram Actions.

***Data-Based* Needs driving the Seismic Retrofit Subprogram**		
Actual Bearing Seat Width / Required Bearing Seat Width	**Bridge Condition**	**Need**
<100%	GOOD or FAIR	Seismic Retrofit (Capacity-Driven)

4.9.4 Subprogram Actions

Seismic Retrofit Subprogram Actions to address data-based needs are tabulated below.

Seismic Retrofit Subprogram Actions	
Subprogram Action Description	**Anticipated Unit Cost**
01 Rehabilitation – Seismic Retrofit – Capacity-Driven	
• **Seismic Retrofit of Bridge** in accordance with the SRMHS	$300/Deck Area SF

4.10 Bridge Safety Restoration Subprogram

The function of the Bridge Safety Restoration Subprogram is to identify and address structural needs, that are not promptly being addressed through the SGR or Resiliency Subprograms, to restore bridge public safety.

4.10.1 Bridge Eligibility

All Bridges are eligible to be in the Bridge Safety Restoration Subprogram with the following exceptions:

- Bridges that are in SGR or Resiliency Subprograms and have ongoing or programmed projects that will address the identified bridge public safety need.

4.10.2 Bridge Data Considered

Condition data is analyzed to identify bridge needs and specify appropriate actions, considering risk, to support condition-driven strategies within the Bridge Safety Restoration Subprogram. Element Condition States for the following elements is critical for these strategies. Elements that are excluded do not trigger actions.

Elements Considered							
NON-PRIMARY							
Element	Units	Element Number					
		Steel	PSC	RC	Timber	Masonry	Other
Bridge Rail *Related Primary Element Types include: Deck/Slab and Culvert*							
Bridge Rail	ft	330		331	332	334	333
Joint *Related Primary Element Types include: Deck/Slab and Culvert*							
Strip Seal	ft	300					
Compression	ft	302					
Assembly with Seal (Modular)	ft	303					
Assembly without Seal	ft	305					
Other	ft	306					

4.10.3 Data-based Bridge Needs

Bridge *condition*-based needs are identified using a range of Element Condition States and, for convenience, a corresponding NBI Condition Rating. All bridge condition-based needs can be found in the Appendix. These needs are defined further through work candidates issued by bridge inspectors in BrM.

The Bridge Safety Restoration Subprogram is *driven* by the condition-based needs tabulated below. That is, the condition-based needs below trigger Subprogram Actions.

***Condition-Based* Needs driving the Bridge Safety Restoration Subprogram**					
Element Type	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Bridge Rail			≤ 5%	4	Structural Rehabilitation
Bridge Rail		≤ 5%	> 5%	3 thru 2	Replacement
Joints		> 30%	≤ 100%	5.5 thru 2	Replacement

4.10.4 Subprogram Actions

Bridge Safety Restoration Subprogram Actions that address condition-based needs are tabulated below. These actions are triggered by Non-Primary Element needs.

Bridge Safety Restoration Subprogram Actions				
Non-Primary Element Type	**Related Primary Element Type**	**Subprogram Action Description**	**Anticipated Unit Cost**	**Anticipated Frequency, No. of Years**
03 Rehabilitation - Bridge Safety Restoration - Railing Structural Rehabilitation				
Bridge Rail	Deck/Slab	• **Structurally Rehabilitate Bridge Rail**	$250,000/Bridge	-
02 Rehabilitation - Bridge Safety Restoration - Railing Replacement				
Bridge Rail	Deck/Slab	• **Replace Bridge Rail** with Bridge Rail that is MASH 2016 compliant	$700/Ft of Bridge Rail	-
01 PM - Bridge Safety Restoration - Deck Joint Replacement				
Joints	Deck/Slab	• **Replace Joint**	$250,000/Bridge	-

5.0 BRIDGE PROJECT PRIORITIZATION AND PROGRAMMING

Bridge project prioritization occurs in two levels – at the subprogram level and at the overall program level. Subsequent of prioritization, projects are then programmed to address the structural needs of the Bridge Program.

5.1 Subprogram Project Prioritization

Subprogram Actions (i.e. Projects), as defined in previous sections, are prioritized based on the risk of the corresponding Bridge Need being addressed. This is tabulated below.

Subprogram	Subprogram Action
Bridge Inspection	00 Bridge Inspection
Bridge Safety Restoration	01 PM - Bridge Safety Restoration - Deck Joint Replacement
	02 Rehabilitation - Bridge Safety Restoration - Railing Replacement
	03 Rehabilitation - Bridge Safety Restoration - Railing Structural Rehabilitation
Replacement	01 Replacement - Immediate Temporary Repairs
	02 Replacement - Condition-Driven
	03 Replacement - Capacity-Driven
Rehabilitation	01 Rehabilitation - Immediate Structural Rehabilitation
	02 Rehabilitation - Immediate Structural Repairs
	03 Rehabilitation - Structural Rehabilitation
	04 Rehabilitation - Structural Repairs
	05 Rehabilitation - Capacity-Driven
	06 Preservation - Rehabilitation
Preservation	01 Preservation - Repairs
Scour	00 Scour Evaluation
	00 Scour Monitoring
	01 Rehabilitation - Scour - Immediate Repairs
	02 Rehabilitation - Scour - Repairs
	03 Preservation - Scour - Repairs
	04 PM - Scour - Countermeasures
Concrete Deck	01 Rehabilitation - Concrete Deck - Structural Rehab, Full Depth Recon, & Overlay Con
	02 Preservation - Concrete Deck - Partial Full Depth Reconstruction & Overlay Construction
	03 Preservation - Concrete Deck - Repairs & Overlay Construction
	04 Preservation - Concrete Deck - Repairs / Repairs & Overlay Construction (Capacity-Driven)
	05 PM - Concrete Deck - Overlay Restoration
	06 PM - Concrete Deck - Overlay Repairs / Overlay Restoration (Capacity-Driven)
Strengthening	01 Rehabilitation - Strengthening - Condition-Driven
	02 Rehabilitation - Strengthening - Capacity-Driven

Subprogram	Subprogram Action
Seismic Retrofit	01 Rehabilitation - Seismic Retrofit - Capacity-Driven
Steel Bridge	01 Replacement - Steel Bridge - Immediate Temporary Repairs
	02 Rehabilitation - Steel Bridge - Immediate Structural Rehabilitation
	03 Rehabilitation - Steel Bridge - Immediate Structural Repairs
	04 Replacement - Steel Bridge - Condition-Driven
	05 Replacement - Steel Bridge - Capacity-Driven
	06 Rehabilitation - Steel Bridge - Structural Rehabilitation & Painting
	07 Rehabilitation - Steel Bridge - Structural Repairs & Painting
	08 Rehabilitation - Steel Bridge - Capacity-Driven
	09 Preservation - Steel Bridge - Rehabilitation & Painting
	10 Preservation - Steel Bridge - Repairs & Painting
	11 PM - Steel Bridge - Painting Restoration
Culvert	01 Replacement - Culvert - Immediate Temporary Repairs
	02 Rehabilitation - Culvert - Immediate Structural Rehabilitation
	03 Rehabilitation - Culvert - Immediate Structural Repairs
	04 Replacement - Culvert - Condition-Driven
	05 Replacement - Culvert - Capacity-Driven
	06 Rehabilitation - Culvert - Structural Rehabilitation
	07 Rehabilitation - Culvert - Structural Repairs
	08 Rehabilitation - Culvert - Capacity-Driven
	09 Preservation - Culvert - Rehabilitation
	10 Preservation - Culvert - Repairs

Where there are instances of multiple projects of the same Subprogram Action, projects are further prioritized. These projects are further prioritized by structural risk. Metrics of structural risk include Bridge NBI Rating, Paint Condition NBI Rating (when Bridge is GOOD or FAIR), Deck Overlay NBI Rating (when Bridge is GOOD or FAIR), and by duration in which the element has been in the triggering condition. Duration is currently considered when identifying condition-driven preservation repairs (i.e. repairs to keep GOOD bridges GOOD). Subsequent of structural risk, projects are then prioritized based on community risk. Metrics of community risk include ADT and Detour Length. Using this scheme, Subprogram Project Priority Lists are produced.

5.2 Program Level Project Prioritization

Recognizing general strategic similarities between the Subprogram Actions, the Subprogram Actions are grouped into Primary Actions. These Primary Actions are prioritized considering risk to the Bridge Program.

Primary Actions		
Rank	**Primary Action**	**General Strategic Impact**
0	Data Collection, Monitoring, and Processing	Supports data-driven decision making
1	Bridge Safety Restoration	Eliminates Immediate Safety Hazard
2	Replacement	Addresses POOR bridge
3	Rehabilitation – Structural Rehabilitation	
4	Preservation – Scour – Repairs	Prevents FAIR bridges from becoming POOR
5	Preservation – Steel Bridge – Rehabilitation & Painting	
6	Preservation – Rehabilitation – Bridge	
7	Preservation – Rehabilitation – Culvert	
8	Preservation – Steel Bridge – Repairs & Painting	Maintains GOOD bridges
9	Preservation – Repairs – Bridge	
10	Preservation – Repairs – Culvert	
11	PM – Steel Bridge – Painting Restoration	
12	PM – Concrete Deck – Overlay Restoration	
13	PM – Scour - Countermeasures	Improves Bridge resiliency
14	Rehabilitation – Strengthening (Capacity-Driven)	
15	Rehabilitation – Seismic Retrofit (Capacity-Driven)	

The Subprogram Actions are ranked within each Primary Action. This is illustrated below.

Primary Action	Rank	Subprogram Action
00 Data Collection, Monitoring, and Processing	00.1	Bridge Inspection
00 Data Collection, Monitoring, and Processing	00.2	Scour Evaluation
00 Data Collection, Monitoring, and Processing	00.3	Scour Monitoring
01 Bridge Safety Restoration	01	Rehabilitation - Scour - Immediate Repairs
01 Bridge Safety Restoration	02	Replacement - Steel Bridge - Immediate Temporary Repairs
01 Bridge Safety Restoration	03	Replacement - Immediate Temporary Repairs
01 Bridge Safety Restoration	04	Replacement - Culvert - Immediate Temporary Repairs

Primary Action	Rank	Subprogram Action
01 Bridge Safety Restoration	05	Rehabilitation - Steel Bridge - Immediate Structural Rehabilitation
01 Bridge Safety Restoration	06	Rehabilitation - Immediate Structural Rehabilitation
01 Bridge Safety Restoration	07	Rehabilitation - Culvert - Immediate Structural Rehabilitation
01 Bridge Safety Restoration	08	Rehabilitation - Steel Bridge - Immediate Structural Repairs
01 Bridge Safety Restoration	09	Rehabilitation - Immediate Structural Repairs
01 Bridge Safety Restoration	10	Rehabilitation - Culvert - Immediate Structural Repairs
01 Bridge Safety Restoration	11	PM - Bridge Safety Restoration - Deck Joint Replacement
01 Bridge Safety Restoration	12	Rehabilitation - Bridge Safety Restoration - Railing Structural Rehabilitation
01 Bridge Safety Restoration	13	Rehabilitation - Bridge Safety Restoration - Railing Replacement
02 Replacement	01	Replacement - Steel Bridge - Condition-Driven
02 Replacement	02	Replacement - Condition-Driven
02 Replacement	03	Replacement - Culvert - Condition-Driven
02 Replacement	04	Replacement - Steel Bridge - Capacity-Driven
02 Replacement	05	Replacement - Capacity-Driven
02 Replacement	06	Replacement - Culvert - Capacity-Driven
03 Rehabilitation - Structural Rehabilitation	01	Rehabilitation - Scour - Repairs
03 Rehabilitation - Structural Rehabilitation	02	Rehabilitation - Strengthening - Condition-Driven
03 Rehabilitation - Structural Rehabilitation	03	Rehabilitation - Steel Bridge - Structural Rehabilitation & Painting
03 Rehabilitation - Structural Rehabilitation	04	Rehabilitation - Structural Rehabilitation
03 Rehabilitation - Structural Rehabilitation	05	Rehabilitation - Culvert - Structural Rehabilitation
03 Rehabilitation - Structural Rehabilitation	06	Rehabilitation - Concrete Deck - Structural Rehab, Full Depth Recon, & Overlay Con
03 Rehabilitation - Structural Rehabilitation	07	Rehabilitation - Steel Bridge - Structural Repairs & Painting
03 Rehabilitation - Structural Rehabilitation	08	Rehabilitation - Structural Repairs
03 Rehabilitation - Structural Rehabilitation	09	Rehabilitation - Culvert - Structural Repairs
03 Rehabilitation - Structural Rehabilitation	10	Rehabilitation - Steel Bridge - Capacity-Driven
03 Rehabilitation - Structural Rehabilitation	11	Rehabilitation - Capacity-Driven
03 Rehabilitation - Structural Rehabilitation	12	Rehabilitation - Culvert - Capacity-Driven
04 Preservation - Scour - Repairs	01	Preservation - Scour - Repairs
05 Preservation - Steel Bridge - Rehabilitation & Painting	01	Preservation - Steel Bridge - Rehabilitation & Painting

Primary Action	Rank	Subprogram Action
05 Preservation - Steel Bridge - Rehabilitation & Painting	02	Preservation - Concrete Deck - Partial Full Depth Reconstruction & Overlay Construction
06 Preservation - Rehabilitation - Bridge	01	Preservation - Rehabilitation
06 Preservation - Rehabilitation - Bridge	02	Preservation - Concrete Deck - Partial Full Depth Reconstruction & Overlay Construction
07 Preservation - Rehabilitation - Culvert	01	Preservation - Culvert - Rehabilitation
08 Preservation - Steel Bridge - Repairs & Painting	01	Preservation - Steel Bridge - Repairs & Painting
08 Preservation - Steel Bridge - Repairs & Painting	02	Preservation - Concrete Deck - Repairs & Overlay Construction
08 Preservation - Steel Bridge - Repairs & Painting	03	Preservation - Concrete Deck - Repairs / Repairs & Overlay Construction (Capacity-Driven)
09 Preservation - Repairs - Bridge	01	Preservation - Repairs
09 Preservation - Repairs - Bridge	02	Preservation - Concrete Deck - Repairs & Overlay Construction
09 Preservation - Repairs - Bridge	03	Preservation - Concrete Deck - Repairs / Repairs & Overlay Construction (Capacity-Driven)
10 Preservation - Repairs - Culvert	01	Preservation - Culvert - Repairs
11 PM - Steel Bridge - Painting Restoration	01	PM - Steel Bridge - Painting Restoration
12 PM - Concrete Deck - Overlay Restoration	01	PM - Concrete Deck - Overlay Restoration
12 PM - Concrete Deck - Overlay Restoration	02	PM - Concrete Deck - Overlay Repairs / Overlay Restoration (Capacity-Driven)
13 PM - Scour Countermeasures	01	PM - Scour - Countermeasures
14 Rehabilitation - Strengthening (Capacity-Driven)	01	Rehabilitation - Strengthening - Capacity-Driven
15 Rehabilitation - Seismic Retrofit (Capacity-Driven)	01	Rehabilitation - Seismic Retrofit - Capacity-Driven

Bridge Program Project Rank is prioritized by the rank of the Primary Action, rank of the Subprogram Action within the Primary Action (PA SA Rank), and, lastly, the Subprogram Project Rank.

5.3 Project Scope, Scheduling, and Cost Determination

Project scope, scheduling, and cost determinations primarily occur at two major junctions in the project delivery process – at the planning (programming phase) and in the design phase.

Scope, scheduling, and costs represented in this manual are intended to be planning (programming) level.

Scope, especially for preventative maintenance and preservation repair projects, are further defined through Work Candidates and inspection notes provided by inspectors.

In general, PE1, PE2, ROW, and CON are anticipated to be 2-year, 1-year, 1-year, and 2-year long durations.

The unit costs represented in this manual will need to be updated periodically as new cost data becomes available.

5.4 Programming Projects

Projects that exceed $250,000 and can be federalized are programmed by completing a Mid-Range Transportation Plan (MRTP) Project Programming Request (PPR). The Statewide BAMP Manager, with the assistance of the Subprogram Managers, prepares and submits PPRs during the call for projects that occurs at or near the start of the State Fiscal Year. PPRs submitted at or near the start of State Fiscal Year 2023 are for projects that require funding in 2024 and beyond.

After a determination has been made to federalize the project, the Statewide BAMP Manager coordinates with the STIP manager to ensure the project is properly represented on the STIP. There are two scheduled opportunities for projects to be added to the STIP, at the start of Federal Fiscal Year and mid Federal Fiscal Year.

6.0 MODELING & 10 YEAR FORECAST of BRIDGE CONDITIONS

Using the policies and procedures described in the previous sections, the performance of the Bridge Program is modeled to present a 10-year forecast of bridge conditions. For the purposes of the TAMP, for each year, the percentage of NHS bridges classified in GOOD condition and the percentage of NHS bridges classified in POOR condition are forecasted.

6.1 Recommended Funding to Meet Bridge Program Requirements

The recommended average annual funding, for the next 10 years, to meet Bridge Program requirements are tabulated below.

Recommended Annual Average Funding			
Bridge Type	**Total**	**Federal**	**Local**
NHS	$100.2M	$77.8M	$22.4M
Non-NHS	$22.9M	$17.7M	$5.1M
NHS & Non-NHS	$123.0M	$95.5M	$27.5M

This recommended funding amount enables the Bridge Program to achieve and sustain a desired state of good repair over the life cycle of bridge assets at minimum practicable cost, considering resiliency and risk, in accordance with the TAMP. Furthermore, this funding amount supports the Bridge Program in achieving State Act 100 goals of improving safety, fostering system preservation, and improving resiliency.

The vital costs that support data-driven decision making are included in the recommended funding amount above.

Using FHWA's FMIS codes, the recommended average annual Federal-aid funding for NHS bridges are as follows.

FMIS Recommended Annual Average Funding for NHS Bridges		
FMIS Code	**FMIS Name**	**Federal**
49	**Bridge Inspections and Related Trainings**	$2.32M
10	**Bridge Replacement**	$8.29M
13	**Bridge Rehabilitation**	$34.45M
47	**Bridge Preservation**	$24.73M
48	**Bridge Protection**	$8.00M
	Total	$77.79M

Using FHWA's FMIS codes, the recommended average annual Federal-aid funding for Non-NHS bridges are as follows.

FMIS Recommended Annual Average Funding for Non-NHS Bridges		
FMIS Code	**FMIS Name**	**Federal**
49	**Bridge Inspections and Related Trainings**	$1.14M
10	**Bridge Replacement**	$0.65M
13	**Bridge Rehabilitation**	$1.49M
47	**Bridge Preservation**	$12.55M
48	**Bridge Protection**	$1.87M
	Total	$17.70M

6.2 Funding Scenarios and Forecast of Bridge Conditions

Funding scenarios are ran to describe the delicate relationship between funding and Bridge Program performance. Subsequently, funding scenarios also provide justification for Bridge Program funding, given other Programs also compete for funding. Utilizing a risk-oriented approach to aggressively address Bridge Needs (i.e. an *Aggressive Needs* Approach), five scenarios are considered for the current performance period. The amounts shown are the average annual federal-aid funding amounts to address TPM-related Structural Needs for NHS bridges. Average annual federal-aid funding amounts for bridge inspections and related trainings and projects to improve resiliency for NHS bridges are excluded. These funding amounts, respectively, are $2.3M and $8.0M.

Scenario 1: Bridge Needs Baseline ($67.4M/YR) – This Needs-driven scenario establishes the baseline of funding required to address all the needs identified through the Bridge Subprograms. This Baseline is the Recommended Funding.

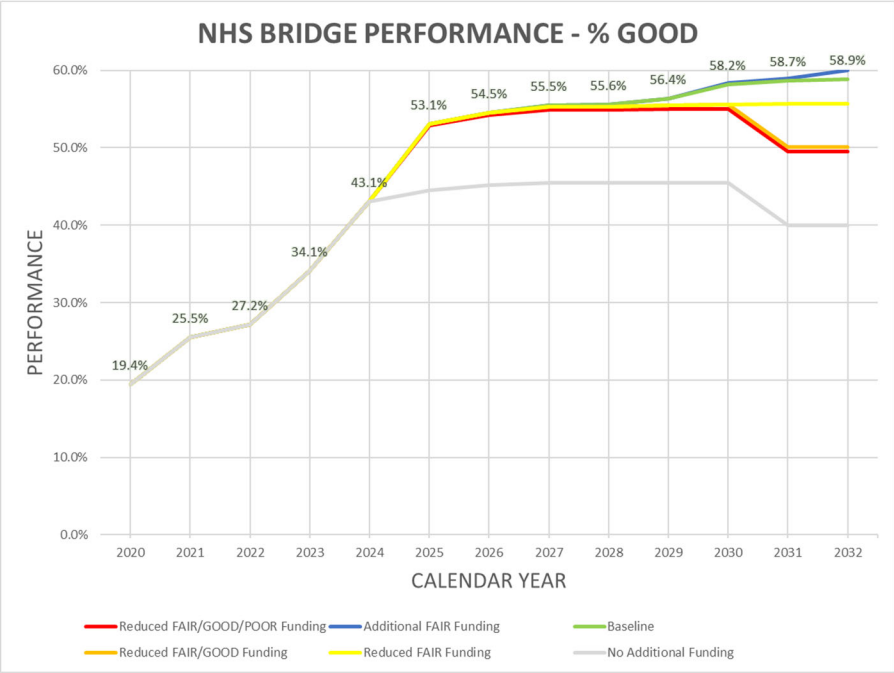
Scenario 2: Reduced Funding for FAIR Bridge Needs ($52.9M/YR) – This scenario assumes risk of FAIR bridges potentially deteriorating to POOR condition.

Scenario 3: Reduced Funding for FAIR and GOOD Bridge Needs ($50.4M/YR) – This scenario assumes risk of FAIR and GOOD bridges potentially deteriorating to POOR and FAIR, respectively.

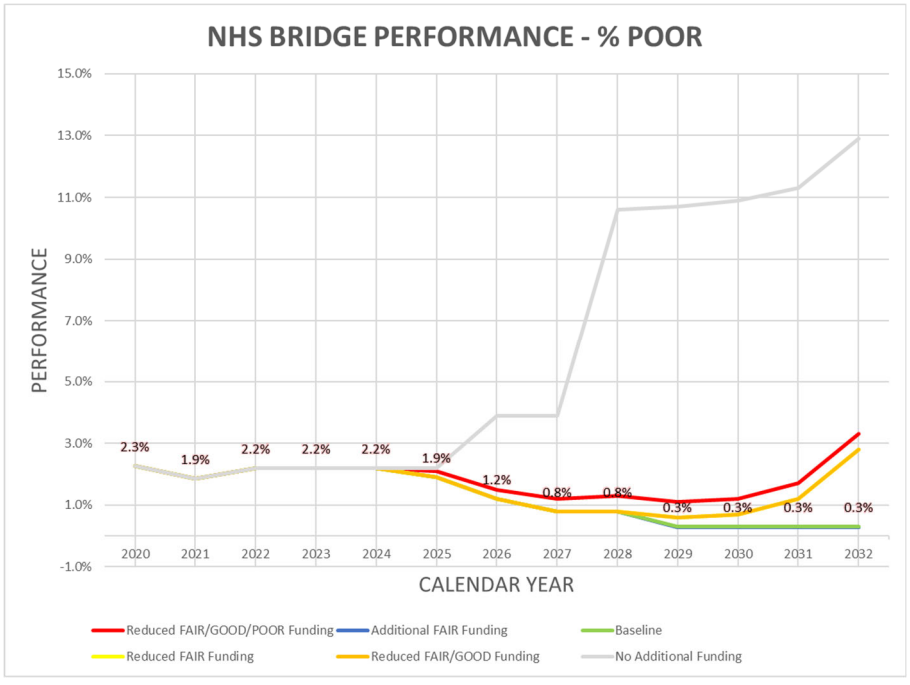
Scenario 4: Reduced Funding for POOR, FAIR, and GOOD Bridge Needs ($43.7M/YR) – This scenario assumes risk of FAIR and GOOD bridges potentially deteriorating to POOR and FAIR, respectively. It also assumes risk of not timely addressing lower priority POOR bridges.

Scenario 5: Additional Funding for FAIR Bridge Needs ($75.2M/YR) – This scenario advances preservation rehabilitation projects on FAIR bridges, proactively restoring them to GOOD condition.

The corresponding performance of percent GOOD and percent POOR for NHS bridges, using the five scenarios, are shown below respectively.



Percentage of NHS bridges classified in GOOD condition over 10-years



Percentage of NHS bridges classified in POOR condition over 10-years

7.0 BRIDGE PROGRAM GAP ANALYSIS

The BAMP acknowledges that areas of improvement exist. To improve the effectiveness of the BAMP, a comprehensive gap analysis was conducted. The results from the analysis are tabulated below.

Area	Preservation	Rehabilitation	Replacement	Steel Bridge	Culvert	Concrete Deck	Strengthening	Scour	Seismic Retrofit	Safety Rest	Gap	Actions Identified to Help Close Gap
Bridge Condition Data	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	• Element Condition States and NBI Condition Rating data inconsistencies adversely affect condition data quality and, also, the effectiveness of the data-driven asset management decision making processes. • The bridge condition data inconsistencies create forecasting and modeling challenges.	• Continue QA process of monitoring bridge, component, and element deterioration on a monthly basis to ensure deterioration is properly evaluated, located, and quantified. • Continue monthly BIP QC meetings with the BAMP and inspectors to go over recent reported deterioration to ensure consistency. • Provide additional BIP element evaluation criteria in the BIP Manual to help inspectors evaluate elements consistently. • Periodically evaluate and, as needed, update the Bridge Element to NBI Conversion Table.
Cost data	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	• Historical unit cost data to support actions of subprograms can be further developed.	• Update the Payment section of the Bridge Program Standard Specifications to provide a proper measurement statement for each pay item, explaining how each pay item is measured for contract payment. • Specify proper work types with each pay item. • Develop a division-wide unit cost database to ensure consistency the agency.

Area	Preservation	Rehabilitation	Replacement	Steel Bridge	Culvert	Concrete Deck	Strengthening	Scour	Seismic Retrofit	Safety Rest	Gap	Actions Identified to Help Close Gap
												• Update Work Candidate unit costs.
Subprogram Actions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	• Subprogram actions can be further developed.	• Develop a centralized catalog of subprogram actions. • Utilize past and future design and construction data to develop additional subprogram actions, as required.
Standard Drawings and Specifications	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	• Standard drawings and specifications to support subprogram actions can be further developed.	• Develop standard drawings and specifications to support each subprogram action in the centralized catalog.
Modeling and forecasting	✓	✓	✓	✓	✓	✓					• Modeling and forecasting can be further developed.	• Subsequent of improving condition and unit cost data quality, periodically update and expand modeling assumptions. • Perform further analysis, with temporal considerations, to verify the effectiveness of the range of Element States used to identify the structural needs of FAIR bridges that are expected to deteriorate to POOR condition.
Subprogram Action Delegation	✓			✓	✓	✓				✓	• The degree and quality of preventative maintenance and preservation actions executed by the Districts varies significantly. • Districts are more familiar with routine maintenance strategies than preventative maintenance or preservation strategies.	• Continue and increase coordination between the BAMP and the Districts, delegating subprogram actions. • Centralize the management of preventative maintenance and preservation action priorities to the BAMP. • Improve methods to document scope, cost, and

Area	Preservation	Rehabilitation	Replacement	Steel Bridge	Culvert	Concrete Deck	Strengthening	Scour	Seismic Retrofit	Safety Rest	Gap	Actions Identified to Help Close Gap
												durations in which preventative maintenance and preservation actions are performed.
PCCA			✓	✓	✓						• Ability to perform accurate PCCA is limited.	• Subsequent of improving unit cost data quality and frequency of preservation subprogram activities, periodically update PCCA assumptions.
Steel Bridge Subprogram Effectiveness				✓							• The Steel Bridge Subprogram may be more effective as a Paint Subprogram.	• Subsequent of the completion of steel bridge projects within the next 10-years and the development of data quality, unit costs, and paint specifications, consider reorganizing the Steel Bridge Subprogram into the Paint Subprogram. A Paint Subprogram reorients the focus from addressing high-risk steel bridge needs to *proactively* ensuring paint system needs are addressed.
Programmatic Agreements	✓			✓	✓	✓		✓		✓	• Programmatic Agreements to support streamlining preventative maintenance and preservation actions can be further developed. • Programmatic Agreements to support the construction of scour countermeasures can be further developed.	• Coordinate with Federal and State Environmental Review Agencies to develop Programmatic Agreements to the fullest extent possible to support preventative maintenance and preservation actions. • To support the scour subprogram actions, especially the construction of scour countermeasures, programmatic agreements with the State Historic

Area	Preservation	Rehabilitation	Replacement	Steel Bridge	Culvert	Concrete Deck	Strengthening	Scour	Seismic Retrofit	Safety Rest	Gap	Actions Identified to Help Close Gap
												preservation Division, FHWA, Army Corps of Engineers will enhance the ability of the HDOT to respond to threats. Consultation with FEMA and local agencies will also help.
Concrete Deck Data to Support Deck Management						✓					• Current concrete deck element condition data collected does not discern Top Surface from Soffit (Bottom Surface) and limits deck management capabilities	• Create ADEs to obtain Deck Soffit (Bottom Surface) condition data • Subsequent of creating Deck Soffit (Bottom Surface) ADEs, this condition data will need to be joined with the condition data of the Top Surface of the Concrete Deck element for the NBI annual submittal. Utilize Service Units with AASHTOWare BrM Contractor to customize a feature to consolidate the data into the NBEs.
Limited Element-to-NBI Conversion Functionality in BrM to Support Deck Management						✓					• Current Element-to-NBI Conversion Functionality in BrM does not allow for the exclusion of select defects (e.g. Cracking on the Top Surface) when performing the conversion. This can skew the conversion.	• Utilize Service Units with AASHTOWare BrM Contractor to customize the Element-to-NBI Conversion to allow for the exclusion of select defects (e.g. Cracks on the Top Surface). This will allow Inspectors to collect condition data of elements in accordance with the MBEI and the HDOT's Supplemental Element Evaluation Criteria and will allow the utmost flexibility asset management policies. In particular, top surface cracking, while required to

Area	Preservation	Rehabilitation	Replacement	Steel Bridge	Culvert	Concrete Deck	Strengthening	Scour	Seismic Retrofit	Safety Rest	Gap	Actions Identified to Help Close Gap
												be collected in accordance with the MBEI, should not considered in the Element-to-NBI Conversion.
Load Rating Data Consistency							✓				• The Load Rating data often contains inconsistencies or omissions which may interfere with proper assessment of structural capacity • Structure Load Ratings are not routinely updated as required when inspections find significant change in bridge component conditions (ex. from good to fair or fair to poor).	• Continue the current QA process of Load Rating data. • Increase frequency of overall data QA to quarterly. • Improve QA process by including additional criteria for data validation. • Update BIP Manual to make it clearer when Load Ratings must be updated with respect to changes in inspection data.
Identifying Strengthening Candidates							✓				• The Strengthening Program is still in relatively early stages of development. Criteria for identifying candidates for strengthening can be improved.	• Continue to current process of selecting strengthening candidates. • Analyze data to identify additional relevant criteria. (For example: structures along frequently used freight routes.)
Scour Critical Data								✓			• The quality of scour critical data can be improved.	• The HDOT is currently performing scour evaluations for all bridges over water. Completion of these will aid in the evaluation of Scour Defect 6000 in terms of assessments of threats and urgency to complete repairs. • The HDOT began taking cross section measurements for all bridges over water in 2019. As more bridge inspection cycles are completed, the accuracy of

Area	Preservation	Rehabilitation	Replacement	Steel Bridge	Culvert	Concrete Deck	Strengthening	Scour	Seismic Retrofit	Safety Rest	Gap	Actions Identified to Help Close Gap
												historical comparisons will improve.
Seismic Retrofit Screening									✓		• The lack of as-built plans for many older bridges in the HDOT's inventory creates difficulty in screening for vulnerabilities to seismic events.	• Execute effort to make field measurements of bridge seat widths, and using NBE methods accurately determine the size, location, and number of reinforcing bars in bridge columns and connections.

A. APPENDIX

A.1 Identification of Condition-Based Needs

Bridge condition-based needs are detected using a range of Element Condition States. These ranges vary, depending on the element type. The table below depicts the Element Condition States and, for convenience, the corresponding NBI Condition Rating for Non-Primary and Protective System elements.

***Condition-Based* Needs**					
Element Type	**CS2 %**	**CS3 %**	**CS4 %**	**NBI**	**Need**
Approach Slab	≤ 10%	≤ 5%	Not permitted.	7	Repair
Approach Slab	> 10%	≤ 60%	≤ 5%	6 thru 5	Rehabilitation
Approach Slab		> 60%	> 5%	4 thru 2	Replacement
Bridge Rail		≤ 100%	Not permitted.	7 thru 5	Repair
Bridge Rail			≤ 5%	4	Structural Rehabilitation
Bridge Rail		≤ 5%	> 5%	3 thru 2	Replacement
Joints		≤ 30%	Not permitted.	7 thru 6	Repair
Joints		> 30%	≤ 100%	5.5 thru 2	Replacement
Bearings		≤ 100%	Not permitted.	7 thru 5	Repair
Bearings			≤ 100%	4 thru 2	Structural Rehabilitation / Replacement
Steel Protective Coating		≤ 5%	Not permitted.	7	Spot Paint
Steel Protective Coating		> 5%	≤ 100%	6 thru 2	Repaint
Wearing Surface	≤ 5%	≤ 5%	Not permitted.	7	Patch Wearing Surface
Wearing Surface	> 5%	≤ 95%	≤ 95%	6 thru 2	Replace Wearing Surface

A.2 Identification of Cyclic-Based Needs

Bridge *cyclic-based* needs are identified on a scheduling basis and through work candidates issued by bridge inspectors. These needs are shown below.

***Cyclic-Based* Needs**	
Need	**Description**
Bridge Cleaning	Clean all components of the bridge. Remove dirt, debris, and other material by scraping, brushing, sweeping, flushing, or by using other hand or mechanical means. Open and clean all bridge drainage systems: scuppers, drainage pipes, troughs, and catch basins. Remove debris from deck expansion joints. Clean abutment areas, pier areas, and bridge members. Remove vegetation. Perform other cleaning as required.
Culvert Cleaning	Clean entrances and interior of culverts. Remove debris, vegetation, silt, and large rocks using a skid loader, hand tools, or high-pressure water as appropriate.
Channel Cleaning	Maintenance of natural drainage or stream channels and side slopes, including removal of debris and rock slides, to ensure proper flow.
Steel Bridge Painting	Provide containment for surface preparation and painting. Using solvent and blast cleaning methods, prepare steel element surfaces. Apply coating(s) meeting coating thickness and application method requirements.

A.3 Connecting Subprogram Actions to Work Types

Subprogram actions are categorized into the following work types.

Subprogram Action	Work Type
01 PM - Bridge Safety Restoration - Deck Joint Replacement	Preventative Maintenance
04 PM - Scour - Countermeasures	
05 PM - Concrete Deck - Overlay Restoration	
06 PM - Concrete Deck - Overlay Repairs / Overlay Restoration (Capacity-Driven)	
11 PM - Steel Bridge - Painting Restoration	
01 Preservation - Repairs	Preservation
02 Preservation - Concrete Deck - Partial Full Depth Reconstruction & Overlay Construction	
03 Preservation - Concrete Deck - Repairs & Overlay Construction	
03 Preservation - Scour - Repairs	
04 Preservation - Concrete Deck - Repairs / Repairs & Overlay Construction (Capacity-Driven)	
06 Preservation - Rehabilitation	
09 Preservation - Culvert - Rehabilitation	
09 Preservation - Steel Bridge - Rehabilitation & Painting	
10 Preservation - Culvert - Repairs	
10 Preservation - Steel Bridge - Repairs & Painting	
01 Rehabilitation - Concrete Deck - Structural Rehab, Full Depth Recon, & Overlay Con	Rehabilitation
01 Rehabilitation - Immediate Structural Rehabilitation	
01 Rehabilitation - Scour - Immediate Repairs	
01 Rehabilitation - Strengthening - Condition-Driven	
02 Rehabilitation - Bridge Safety Restoration - Railing Replacement	
02 Rehabilitation - Culvert - Immediate Structural Rehabilitation	
02 Rehabilitation - Immediate Structural Repairs	
02 Rehabilitation - Scour - Repairs	
02 Rehabilitation - Seismic Retrofit - Capacity-Driven	
02 Rehabilitation - Steel Bridge - Immediate Structural Rehabilitation	
02 Rehabilitation - Strengthening - Capacity-Driven	
03 Rehabilitation - Bridge Safety Restoration - Railing Structural Rehabilitation	
03 Rehabilitation - Culvert - Immediate Structural Repairs	
03 Rehabilitation - Steel Bridge - Immediate Structural Repairs	
03 Rehabilitation - Structural Rehabilitation	
04 Rehabilitation - Structural Repairs	
05 Rehabilitation - Capacity-Driven	
06 Rehabilitation - Culvert - Structural Rehabilitation	
06 Rehabilitation - Steel Bridge - Structural Rehabilitation & Painting	
07 Rehabilitation - Culvert - Structural Repairs	
07 Rehabilitation - Steel Bridge - Structural Repairs & Painting	

Subprogram Action	Work Type
08 Rehabilitation - Culvert - Capacity-Driven	
08 Rehabilitation - Steel Bridge - Capacity-Driven	
01 Replacement - Culvert - Immediate Temporary Repairs	Replacement
01 Replacement - Immediate Temporary Repairs	
01 Replacement - Steel Bridge - Immediate Temporary Repairs	
02 Replacement - Condition-Driven	
03 Replacement - Capacity-Driven	
04 Replacement - Culvert - Condition-Driven	
04 Replacement - Steel Bridge - Condition-Driven	
05 Replacement - Culvert - Capacity-Driven	
05 Replacement - Steel Bridge - Capacity-Driven	
00 Bridge Inspection	-
00 Scour Evaluation	
00 Scour Monitoring	

A.4 Connecting Subprogram Actions to FMIS Codes

Subprogram actions are categorized into the following FMIS Codes.

Subprogram Action	FMIS Code	FMIS Name
01 Replacement - Culvert - Immediate Temporary Repairs	10	Bridge Replacement
01 Replacement - Immediate Temporary Repairs		
01 Replacement - Steel Bridge - Immediate Temporary Repairs		
02 Replacement - Condition-Driven		
03 Replacement - Capacity-Driven		
04 Replacement - Culvert - Condition-Driven		
04 Replacement - Steel Bridge - Condition-Driven		
05 Replacement - Culvert - Capacity-Driven		
05 Replacement - Steel Bridge - Capacity-Driven		
01 Rehabilitation - Concrete Deck - Structural Rehab, Full Depth Recon, & Overlay Con	13	Bridge Rehabilitation
01 Rehabilitation - Immediate Structural Rehabilitation		
01 Rehabilitation - Scour - Immediate Repairs		
01 Rehabilitation - Strengthening - Condition-Driven		
02 Rehabilitation - Bridge Safety Restoration - Railing Replacement		
02 Rehabilitation - Culvert - Immediate Structural Rehabilitation		
02 Rehabilitation - Immediate Structural Repairs		
02 Rehabilitation - Scour - Repairs		
02 Rehabilitation - Steel Bridge - Immediate Structural Rehabilitation		
02 Rehabilitation - Strengthening - Capacity-Driven		
03 Rehabilitation - Bridge Safety Restoration - Railing Structural Rehabilitation		
03 Rehabilitation - Culvert - Immediate Structural Repairs		
03 Rehabilitation - Steel Bridge - Immediate Structural Repairs		
03 Rehabilitation - Structural Rehabilitation		
04 Rehabilitation - Structural Repairs		
05 Rehabilitation - Capacity-Driven		
06 Rehabilitation - Culvert - Structural Rehabilitation		
06 Rehabilitation - Steel Bridge - Structural Rehabilitation & Painting		
07 Rehabilitation - Culvert - Structural Repairs		
07 Rehabilitation - Steel Bridge - Structural Repairs & Painting		
08 Rehabilitation - Culvert - Capacity-Driven		
08 Rehabilitation - Steel Bridge - Capacity-Driven		
01 PM - Bridge Safety Restoration - Deck Joint Replacement	47	Bridge Preservation
01 Preservation - Repairs		

Subprogram Action	FMIS Code	FMIS Name
02 Preservation - Concrete Deck - Partial Full Depth Reconstruction & Overlay Construction		
03 Preservation - Concrete Deck - Repairs & Overlay Construction		
03 Preservation - Scour – Repairs		
04 Preservation - Concrete Deck - Repairs / Repairs & Overlay Construction (Capacity-Driven)		
06 Preservation - Rehabilitation		
09 Preservation - Culvert - Rehabilitation		
09 Preservation - Steel Bridge - Rehabilitation & Painting		
10 Preservation - Culvert - Repairs		
10 Preservation - Steel Bridge - Repairs & Painting		
11 PM - Steel Bridge - Painting Restoration		
02 Rehabilitation - Seismic Retrofit - Capacity-Driven	48	Bridge Protection
04 PM - Scour - Countermeasures		
00 Bridge Inspection	49	Bridge Inspections and Related Trainings
00 Scour Evaluation		
00 Scour Monitoring		
05 PM - Concrete Deck - Overlay Restoration	59	Bridge Resurfacing
06 PM - Concrete Deck - Overlay Repairs / Overlay Restoration (Capacity-Driven)		

A.5 Annualized Costs

Annualized costs in the Subprogram sections used in Least Life Cycle Cost (LLCC) analysis utilize the following formulas.

When $r \neq 0$:

$$Annual\ Cost_{Action} = \frac{rCost_{Action}}{(1+r)^t - 1}$$

Where $r = 0$:

$$Annual\ Cost_{Action} = \frac{Cost_{Action}}{t}$$

Where:

$Annual\ Cost_{Action}$ = Annualized Cost of $Action$

$Cost_{Action}$ = Cost of $Action$

t = Anticipated interval for $Action$

r = Discount Rate*

*Discount Rate used is based on 2021 Discount Rates for OMB Circular No. A-94.