A Systematic Process for Using Federal Aid to Support Bridge Preventive Maintenance

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16. Abstract

Preventive maintenance (PM) is recognized as a cost-effective way to preserve the investment in and service life of highway bridges. State agencies, including Wisconsin, are performing bridge PM projects. SAFETEA-LU 23 U.S.C. 144(d) made States eligible to use Federal Highway Bridge Program (HBP) funds to support bridge preventive maintenance provided they demonstrate a systematic process for the PM program. Each State is to work with their Federal Highway Administration (FHWA) Division Office to document and approve the systematic process. Some State's applications are successful and others are not.

This report discusses concepts and essential characteristics of a systematic process for bridge PM with examples. The information presented herein was prepared based upon conversations with the FHWA Offices of Asset Management and Bridge Technology and by review of documents describing the successfully approved bridge PM programs of eight State transportation agencies.

To assist WisDOT and other State agencies, examples from several States are organized into a template for preparing a bridge PM plan that includes the essential features of a systematic process. The results are expected to help State agencies understand and apply the concepts when establishing bridge PM programs and prepare proposals to obtain approval to use HBP funds for bridge preventive maintenance projects.

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EXECUTIVE SUMMARY

SAFETEA-LU 23 U.S.C. 144(d) made States eligible to use Highway Bridge Program (HBP) funds to support bridge preventive maintenance provided they demonstrate a systematic process for the PM program. In 2002, the Federal Highway Administration (FHWA) announced that HBP funds are eligible for bridge preventive maintenance (PM) activities provided the preventive maintenance activities are identified using a systematic process that ensures the activities are cost-effective in extending the service life of bridges.

A clear set of characteristics for defining a systematic process can help the States prepare and the FHWA Division Offices review the systematic process plans. This report presents and discusses essential characteristics of a systematic process for defining a bridge preventive maintenance program and presents examples from the application documents of eight State agencies: Colorado, Hawaii, Michigan, Minnesota, New York, Texas, Virginia, and Washington. The result should be useful to State agencies for establishing a bridge PM program and for gaining approval to use Federal HBP funds for bridge preventive maintenance projects.

Among the States reviewed, the PM activities that have been approved for Federal aid are:

- Bridge Deck
  - Joint Replacement or Repair
  - Minor Deck Rehabilitation or Repair including Deck Overlay
  - Drainage System Repair
  - Crack Sealing or Patching
  - Approach Slab Replace or Repair
  - Bridge Washing
  - Deck Replacement (to current Width)
  - Cathodic Protection (CP), Electrochemical Chloride Extraction (ECE) Treatment
- Superstructure
  - Bearing Area Restore or Replace / Bering Lubrication
  - Damage Girder Replace or Repair
  - Seismic Retrofit
  - Concrete Sealing
  - Broken Timber Replacement
  - Cathodic Protection System / Retrofit of Fracture Critical Members / Retrofit of Fatigue
- Substructure
  - Encase Deteriorated Piles
  - Replace or Repair Damaged Substructure
  - Scour Remediation / Scour Countermeasures
  - Cathodic Protection / Electrochemical Chloride Extraction (ECE) Treatment
- Painting
- Miscellaneous

- Movable Bridge Operation System
- Cable Replacement

The work was conducted by the University of Wisconsin-Madison. To gain a better understanding of a systematic process, the research team teleconferenced with experts at the FHWA Offices of Asset Management and Bridge Technology to review each step of a draft process proposed by FHWA but has not been promulgated as official policy.

Consistent with the FHWA draft process, there are several common overarching and essential programmatic elements of the State PM programs:

- Preventive maintenance projects are identified using objective criteria that are applied statewide.
- A consistent project prioritization strategy and process insure effectiveness outcomes of expenditures.
- Preventive maintenance projects get underway in timely manner so that the predicted long-term cost-effectiveness benefits are achievable.
- The preventive maintenance program goal is a sustainable, steady-state expenditure plan for that maximizes long-term cost avoidance.
- A multi-year flow of dedicated funds are identified to achieve the long term goal.

Some steps of FHWA's process appear to be missing from some State documents. The broad program goals and targets are not always clearly apparent in the documents. The documents present the overall process for cost-effective preventive maintenance and focus on indentifying maintenance needs and selecting projects but without a long-term, ongoing plan. The role of the agency's bridge maintenance system for supporting the preventive maintenance program may not be explicitly defined. In addition, some documents fail to clearly describe the State resources to support the PM program and the business process for getting PM projects into the construction program.

A proposal was submitted by the Wisconsin Department of Transportation (WisDOT) in 2003 to use HBP but was not successful. The research team reviewed that proposal relative to the essential characteristics and our understanding of the FHWA's systematic process. The WisDOT proposal addresses the bridge preventive maintenance activities that would be eligible for Federal aid as well as activities that would not. The proposal does not, however, describe methods to identify the preventive maintenance needs nor to select bridge PM projects. Moreover, WisDOT's proposal does not present the long-term goal of the State's bridge PM program nor does it identify a dedicated funding stream to support the State's contribution to the program. This report includes recommendations for modifying WisDOT's draft agreement. The recommendations are comprehensive of all steps in the FHWA draft of a systematic process and meant to be a reference for WisDOT in revising and improving its proposal in the future.

Agreements for using Federal HBP funds are to be prepared cooperatively by the State and the FHWA Division Office working together. Again, since there is no Federal policy, the set of characteristics of a systematic process described in this report is a guideline.

To assist the agency in implementing the results of this research, the report includes a draft proposal that may be used by WisDOT for defining a systematic process for bridge PM. Though the template was created for WisDOT it may be useful to other State agencies as they establish bridge PM program and apply for Federal aid.

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INTRODUCTION

Motivation

Research suggests that preventive maintenance (PM) is a cost-effective way of extending the service life of highway facilities *(1)*. Case studies conducted by Baladi et al. show that PM programs require relatively small budgets and are more cost-effective when compared to rehabilitation maintenance. For every dollar spent on the PM program, $4 to $10 was saved in the rehabilitation program *(2)*.

These and similar findings have led to the eligibility of Federal assistance. In response, FHWA published memorandums in 2002 and 2004 interpreting the Federal Statutes. The 2002 memo (HBRRP Funds for Preventive Maintenance) from the Office of Bridge Technology announced that Highway Bridge Replacement and Rehabilitation Program funds may be obligated for PM on Federal-aid highway bridges *(3)*. HBRRP was renamed the Highway Bridge Program (HBP) in 2008 by passage of the SAFETEA-LU technical correction bill (Public Law No. 110-244, 122 Stat. 1572). FHWA's memo on Preventive Maintenance Eligibility *(1)*, allows many activities previously considered routine to be considered preventive for purposes of eligibility of Federal funding. The 2004 memos (Preventive Maintenance Eligibility and Preventive Maintenance Questions and Answers) from the FHWA Office of Asset Management allows flexibility to use Federal funds for activities such as pavement seal coats and patching as well as crack sealing and joint repair on bridges.

The primary purpose of these memos was to provide guidance to assist the FHWA Division Offices as they work with State Department of Transportation (DOT) to develop a systematic process for Federal funds for bridge preventive maintenance. The intents of the FHWA memos are to encourage States to identify goals for their PM programs and create plans to achieve those goals through on-going PM. The FHWA recommends collaboration between FHWA Division Offices and the State in defining the systematic process for PM decision making and programming. The FHWA Division Offices are responsible for assessing the States systematic PM programs, determining PM activities, and approving their program.

Objectives

The goal of this project is to assist WisDOT in preparing its application for Federal aid to support a bridge PM program. To achieve the goal, the objectives of this study were threefold:

1) To identify bridge preventive maintenance activities for Federal aid. To accomplish this objective, the Researchers identified the PM activities referenced in the memos issued by the FHWA and the activities approved by FHWA Division Offices for other States. For the State of Wisconsin, some PM activities are already in use at the regions. The Researchers explored the feasibility of analyzing the effectiveness of these activities,

2) To recommend a systematic process for WisDOT's bridge PM program. Concepts for a systematic process were drafted by FHWA and illustrated as a draft flowchart without narrative explanation or examples. To accomplish this objective the Researchers prepared descriptions for the FHWA concepts and collected illustrative examples from the State documents to demonstrate the key concepts, and

3) To create a template for defining an effective preventive maintenance program and preparing a successful proposal to the FHWA to establish the program.

Research Approach

The impact of preventive maintenance actions on extending the service life of bridges is very difficult to quantify. Hence, the research team focused on obtaining information through expert elicitation from the practitioners. The following actions were recommended by the project advisory committee:

- Collect the documents submitted by States to the FHWA Division Offices to get approval for using HBP funds. Documents were obtained from Colorado, Hawaii, Michigan, Minnesota, Montana, New York, Oregon, Tennessee, Texas, Virginia Washington, and Wisconsin.
- Analyze the documents to identify key features and examples of the systematic process.

The documents describing the systematic processes of eight States agencies were reviewed for this study. The eight States have approval to use Federal aid for bridge PM activities. These States include Colorado (CDOT), Hawaii (HDOT), Michigan (MDOT), Minnesota (Mn/DOT), New York (NYSDOT), Texas (TxDOT), Virginia (VDOT), and Washington (WSDOT). The research process was to first analyze the State documents relative to the FHWA memos. Next the team discussed the essential characteristics of a systematic process with staff at the FHWA Office of Bridge Technology and Asset Management. The State documents were then analyzed relative to the essential characteristics. Finally, a summary of documents delivered from other States was prepared.

In addition, the Research team attempted to quantify the effectiveness of bridge preventive maintenance activities using historic maintenance data provided by a regional office in Wisconsin. Due to time and budget limitations, one activity, bridge deck washing was studied. The conditions of bridges with and without deck washing were compared over a period of approximately ten years. Based on this comparison, recommendations for future monitoring of PM activities are given.

BRIDGE PREVENTIVE MAINTENCE WITH FEDERAL AID

This section reviews the definition of preventive maintenance used to guide the development of a systematic process. The FHWA Division Offices are responsible for evaluating the State process as well as the proposed program. The section also lists the preventive maintenance activities that have been approved for Federal funding.

Definitions of Bridge Preventive Maintenance Eligible for Federal Aid

In 1999, PM was defined by the American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Highways Preventive Maintenance *(4)* as follows:

> *"A planned strategy of cost-effective treatment to an existing roadway system and its appurtenances that preserves the system, retards future deterioration and maintains or improves the functional condition of the system without increasing structural capacity."*

That definition has been widely adapted. Individual DOTs have modified or built upon this basic definition. For example, VDOT's definition emphasizes preventive maintenance activities as being performed in advance of a need for repair or accumulated deterioration *(5)*. ODOT defines PM as keeping a structure in its as-built condition *(6)*.

PM has been described as being cyclic in nature *(7)*. NYSDOT describes preventive maintenance as actions performed on a regular scheduled basis using a set of procedures to preserve the intended working condition of the system *(8)*. There are two categories of preventive maintenance

actions in NYSDOT: corrective and cyclic. The former are repairs to deteriorated elements of bridges that are otherwise in good structural condition and the latter, such as bridge washing, are performed regularly. Table 1 lists three States' definitions for bridge PM.

Table 1 Definitions of Bridge Preventive Maintenance at State DOTs

Agency	Definition
VDOT	Planned activities that are performed in advance of a need for repair or in advance of accumulated deterioration, so as to avoid such occurrences and reduce or arrest the rate of future deterioration *(5)*
ODOT	The acts of keeping a structure in its as-built condition and/or protecting it from inevitable deterioration due to environment, traffic vibration and deicing chemicals *(6)*
NYSDOT	- Corrective action: fundamentally repairs deteriorated or damaged elements of bridges that are otherwise in good structural condition *(8)*. - Cyclic action: actions performed on a regularly scheduled basis such as bridge washing, sealing concrete surfaces, lubricating bearings and paintings *(8)*.

Use of HBP Funds for Bridge Preventive Maintenance

The FHWA allows Federal aid for bridge maintenance if the primary purpose is to preserve the system. Some routine maintenance activities may qualify. Activities that address structural deficiencies or increase capacity are not eligible nor are more substantial treatments such as replacement or rehabilitation, which restore the serviceability or add structural capacity.

Table 2 shows the status of the use of Federal funding in 2005 (unpublished data, the FHWA Office of Bridge Technology). The table lists States known to have obtained or applied for approval.

Table 2 States using Federal Funds for Bridge PM in 2005

State	Status
Alabama	One project approved and others are planned.
Arkansas	The Department hired a consultant to provide training on the use of Pontis for bridge preservation activities, and then expects to submit a request.
Colorado	Approved
Delaware	Approved
D.C.	Approved
Idaho	Approved
Indiana	State requested, but not approved
Iowa	Approved
Maryland	Approved
Massachusetts	Approved
Michigan	Approved
Montana	Not fully implemented yet.
New Mexico	Approved
New York	Approved
North Carolina	Requested
Pennsylvania	Approved
Rhode Island	Approved
Virginia	The FHWA Division Office and VDOT have agreed on a list of PM activities.
Washington	Approved
Wisconsin	State requested, but request was denied

According to the documents provided by MDOT, Michigan requested flexibility to use HBRRP funds for bridge preservation maintenance projects in 2001 *(9)*. The 2002 FHWA memo (HBRRP Funds for Preventive Maintenance) from the Office of Bridge Technology made Federal funds eligible for PM on the condition of cooperation between the FHWA Division office and the State.

The dollar amount of HBP being used for PM varies among the States surveyed in this study. The amount is 5% (CDOT) to 30% (NMDOT) of the State's HBP funds. TxDOT defined a limit on the amount to not exceed 5% of HBP funding in a Fiscal Year *(12)*. TxDOT wants to ensure the HBP funding remains primarily for the rehabilitation and replacement of deficient bridges.

Scope of Bridge PM Activities Approved for Federal Aid

The research team surveyed the FHWA Division offices on preventive maintenance activities that have been approved for Federal aid. The response rate was low.

The research team worked with the FHWA and the chair of the AASHTO Subcommittee on Maintenance Bridge Task Force, Peter Weykamp to collect State documents. The FHWA Division Offices were contacted by survey, email and telephone. Documents from 12 States were collected.

From these documents, the preventive maintenance activities that have been approved for Federal aid are listed in Table 3. For comparison, the last column lists the bridge preventive maintenance activities currently conducted in Wisconsin according to the Southwest Regional Office. For decks, joint repair and minor deck overlay are the most common preventive maintenance activities. Crack sealing or patching is also frequently accepted for Federal aid. Three of the States reviewed have approved for repairing bearings including bearing lubrication. Scour remediation and scour countermeasures are the commonly accepted PM for substructures. In addition, painting considered eligible at most of States. This includes full, zone, and spot painting.

The eligible preventive maintenance activities for Federal aid vary depending on each State's needs and budget. The eligible activities range from what might be considered routine to minor rehabilitation. MDOT requested using Federal aid for both scheduled and preventive maintenance, but obtained approval for preventive maintenance only (*9*). CDOT already had a State program to support bridge PM and then obtained approval to use Federal aid for urgent minor rehabilitation (*11*).

Many maintenance activities may be considered Federal-aid eligible on system-wide basis *(1)*. The FHWA memos give some latitude for determining eligible PM activities in each State. However, the FHWA division offices and State DOTs need to consider the primary intent of the activity that would be eligible for Federal funds *(10)*. Litter pick up, for example, is not eligible for Federal funds because the primary intent is to make the road safe and passable not to preserves the structure.

Table 3 Preventive Maintenance Activities Approved for Federal Aid

Element	Activity	CDOT	HDOT	MDOT	Mn/ DOT	NYS DOT	VDOT	WS DOT	Wis DOT[1]
Deck	Joint Replace or Repair	√	√	√	√	√	√	√	√
	Minor Deck Rehabilitation or Repair including Deck Overlay	√	√	√	√	√	√	√	
	Drainage System Repair	√		√			√		√
	Crack Sealing or Patching	√		√		√	√		√
	Approach Slab Replace or Repair		√	√					√
	Bridge Washing					√	√		√
	Deck Replacement (to current width)				√				
	Cathodic Protection (CP), Electrochemical Chloride Extraction (ECE) treatment						√		
Superstructure	Bearing Area Restore or Replace / Bearing Lubrication	√	√			√			√
	Damaged Girder Replace or Repair	√							
	Seismic Retrofit		√						
	Concrete Sealing			√					
	Broken Timber Stringer Repair	√							
	Pin and hanger replacement			√					
	Cathodic protection system / Retrofit of fracture critical members / Retrofit of fatigue						√		
Substructure	Encase deteriorated piles	√							
	Replace or repair damaged substructure	√	√		√	√	√		√
	Scour remediation / Scour countermeasures	√	√	√			√	√	
	Cathodic protection / Electrochemical Chloride Extraction (ECE) treatment						√		
Painting	Bridge Painting (full, zone, and spot)		√	√	√	√	√	√	√
Miscellaneous	Movable bridge operation system / Cable replacement for highway bridges							√	

[1]WisDOT does not have approval to use HBP funds for PM. These activities were suggested by the WisDOT Southwest Regional office.

STATE PROPOSALS TO USE HBP FUNDS FOR BRIDGE PM

The FHWA's Systematic Process

According to the FHWA memo *(1)*, to obtain Federal aid each State should develop a systematic process capable of updating bridge condition data, tracking bridge condition, predicting bridge condition, and estimating the impact of a maintenance project. The FHWA Offices of Bridge Technology and Asset Management drafted a flowchart of these essential characteristics for defining a systematic process for preventive maintenance (unpublished data, Wade Casey and Tom Everett in the FHWA Office of Bridge Technology and Asset Management). The purposes are to assist States in defining a systematic process and to provide consistency among the FHWA Division Offices as they review State programs and determine the funding eligibility. As of this report writing, the flowchart has not been promulgated to policy and therefore not included in the report.

In this study, the essential characteristics in the draft process were used as the basis for analyzing the documents collected from the FHWA Division Offices. The analysis had 6 tasks:

1. Teleconference with FHWA Offices of Bridge Technology and Asset Management to discuss the essential features.
2. Prepare a narrative description of each essential characteristic.
3. Identify and summarize illustrative examples of the practices from the successful State documents.
4. Have the narrative descriptions and illustrative examples reviewed by FHWA. This was done through review of a TRB paper submitted in August 2008. All reviewers' comments were incorporated in to this report. The TRB paper was considered premature since the FHWA flowchart has not been promulgated to policy.
5. Use the essential characteristics to identify missing features in WisDOT's unsuccessful application.
6. Develop a template for preparing a successful application.

This section of the report deals with Tasks 1 to 4. (Tasks 5 and 6 are presented in the next section). The research process was to first analyze the State documents using only the FHWA memos and the draft flowchart. Next the researchers discussed the flowchart with the FHWA Office of Bridge Technology and Asset Management. Finally the researchers prepared a summary of how the States are reflecting the steps in their documents. The goal was to provide an objective review of how the States' systematic processes reflect the FHWA's intent. The Researchers interpreted the process and present a brief description of the intent for each step along with examples from the State documents. The purpose is to assist States and the FHWA Division Offices with comparative examples for preparing and reviewing applications for Federal aid to support PM.

Define Outcome or Goal

Obviously, the primary goal of a PM program is to extend the service life of bridges by applying cost-effective maintenance. This characteristic deals with defining a specific outcome for the PM program. The outcome for each State's bridge PM program may be a target to be accomplished over time and then sustained in the long term. Whatever the timeline, each state should define a target value for a specific goal so the State can track and monitor the progress of its PM program.

Some States define the goal of their bridge PM program in their documents. In 2001, MDOT set a strategic investment plan to have 90% of its bridges in "good" condition by 2008 and established an ongoing goal to maintain 90% of its bridges in good to fair condition. According to the Bridge Inspection Manual for MDOT, an NBI rating of 5 or more is considered "good to fair" condition *(16)*. Scheduled maintenance and preventive maintenance are the main elements of a comprehensive bridge strategy *(9)*. The overall goal in Mn/DOT is to preserve 84% of bridges in good repair, which means Mn/DOT contracts PM on bridges with NBI rating of 6 or greater (unpublished data, Gary Peterson in Mn/DOT). The goal of NYSDOT bridge preventive maintenance program is to prevent bridges from becoming deficient as defined by NYSDOT criteria. Deficient is defined as having a NYS condition rating of 5 or less.

Objective Criteria for Determining Necessity of PM

This step has two important impacts on the overall systematic process. First, it describes the engineering criteria used to determine the State's need for Federal assistance in bridge PM. This is the underlying motivation for the application. Second, the metrics used to quantify the need become the measures for the program goal.

The method for identifying needs should be objective and consistent statewide. States may use their BMS to identify the maintenance demands. Pontis is the most widely used tool in State DOTs. CDOT, HDOT, MDOT, TxDOT and WSDOT are using or plan to use Pontis as BMS. Though each State may have a different index to measure bridge performance, NBI ratings and Pontis condition states are the most commonly used. State-specific indexes are developed and applied to track bridge performance in NYSDOT.

Various threshold values are used to identify specific maintenance activity needs depending on the type of bridge element. The documents from Minnesota and New York have good examples of threshold values for identifying maintenance needs as shown in Table 4 *(8, 13)*. Mn/DOT uses the project selection criteria based upon Pontis element condition ratings. NYSDOT has its own condition rating system, different from Pontis or National Bridge Inventory (NBI) rating. NYSDOT's condition rating scale ranges from 1 to 7 with 7 being in new condition and NYSDOT defines a deficient bridge as one with a state condition rating less than 5.0. *(14)*.

Table 4 Examples of Bridge Preventive Maintenance Project Selection Criteria (*8, 13*)

Element	Condition Criteria (Mn/DOT) [1]	Selection Criteria (NYSDOT)
Deck and Slab elements	Element in condition state 3, 4 or 5	Deck Sealing: Concrete wearing surface rated >5 on structure rated 4.5 to 7
Reinforced concrete elements	More than 10% in condition state 3 or 4	Bearing Lubrication: Steel bearings on structures rated 4.5 to 7
Expansion joints	More than 1% in condition state 3	Structure average condition rating between 4.8 and 6 with joints rated <5
Painted steel elements	More than 25% in condition state 3 to 5	Painted Structures on structures rated 4.5 to 7

[1] Guideline only. Actual field conditions may warrant preservation projects at other levels of deterioration

Prioritize the Need

A systematic process should include a procedure to prioritize among all bridges in need of maintenance. A well defined procedure for prioritizing leads to a consistent and effective budget allocation plan. Most of the States have a prescriptive procedure for manipulating various

conditions and inventory information contained within their bridge management data to develop a first cut of the prioritized list of candidate projects. The ranking process includes decentralized input from engineers at the districts.

The most commonly used bridge data are from each State's bridge inventory database, NBI inspection records, and data contained in the State's Bridge Management System (BMS) software like Pontis. Mn/DOT uses Pontis data and manipulates the data outside of Pontis to develop a first cut (unpublished data, Gary Peterson in Mn/DOT). HDOT selects and then prioritizes candidate projects using the bridge preservation program evaluation criteria in the Pontis *(15)*. NYSDOT has a Bridge Needs Assessment Model (BNAM), to prepare a list of candidate projects. Bridge inspectors are also encouraged to recommend projects at CDOT.

Details vary among the States but usually, the recommended projects are reviewed by a bridge maintenance committee that consists of district engineers, bridge inspection engineers, and bridge engineers at the central office. Projects get prioritized based on cost-effectiveness, serviceability, the structure's age, safety, other available funding, and whether any rehabilitation or replacement work are scheduled.

A well prepared procedure to prioritize projects is required for the State DOTs that use Federal aid for bridge PM projects. The projects are selected using the procedure and then approved by the FHWA Division Office.

Program Remedy to Address the Need

The objective of this characteristic is to have an administrative process for getting PM projects underway in a timely manner. States should describe the internal procedures and communication mechanisms in place for getting PM projects into the ongoing maintenance program.

This essential characteristic deals with having an implementation procedure to administer the State's PM program without delay so as to maximize the cost-effectiveness of PM. TxDOT schedules approved projects into its Statewide Preservation Program (SPP) of the following year. If the project is determined to be of vital important, a special minute order is requested to add the project to the current SPP *(12)*.

Identify Resources to Achieve Goal

This characteristic deals with the estimating cost and funding feasibility of the State's PM plan. States should estimate the resource requirements over time to achieve and maintain the program goal and then identify the available State and Federal resources. The objective is to ensure a funding stream and success of the PM efforts.

Some State documents cite the State's resources to support the PM program. For example, CDOT's Maintenance Level of Service program funding, HDOT's Bridge Preservation Program, and Mn/DOT's Bridge Improvement and Repair Program. TxDOT lists two State programs for bridge PM: district Preventive Maintenance and Rehabilitation funding and the centralized Bridge Preventive Maintenance Program funds. TxDOT uses Federal aid when these two resources are either not available or are insufficient.

Define Timelines and/or Timeframe

The FHWA wants States to prepare a schedule for achieving their PM program goal. This includes a plan and timeline for addressing the maintenance backlog and then an estimate of the ongoing effort for maintaining the goal condition in steady-state.

Some State plans include estimated steady-state maintenance cycles and associated resources. NYSDOT's plan for cyclic bridge maintenance is shown in Table 5 as an example.

Table 5 Guidelines for Bridge Cyclical Maintenance (*8*)

Activity	Selection Criteria	Cycle
Wash Bridge	All functional structures, priority to structures over highway	2 yrs
Seal Deck	Concrete wearing surfaces rated >5.0 on structure rated 4.5 to 7	4 yrs
Lubricate Bearings	Steel bearings on structures rated 4.5 to 7	4 yrs
Paint Bridge	Painted structures rated 4.5 to 7	12 yrs
Deck Overlay	Wearing surfaces on structures rated 4.5 to 7	12 yrs

Demonstrate Cost-Effectiveness with Extension of Service Life

The States need a way to assess and quantify the impact of PM and to predict bridge condition. The FHWA encourages States to use a BMS. Pontis has embedded functions in its preservation maintenance modules that can compare the costs and effectiveness of preventive maintenance activities by evaluating and projecting bridge conditions. The usefulness of these modules depends upon the quality of the input data. Agencies may need to input costs and condition transition matrices. The candidate PM projects are also prioritized according to cost-effectiveness and service life extension.

States using their own BMS will need a process to assess the impact of the proposed work. The Bridge Needs Assessment Model (BNAM) at NYSDOT shows the impact of a PM project by forecasting the bridge condition. BNAM is capable of tracking progress, demonstrating cost-effectiveness, and extension of service life. TxDOT defined project cost-effectiveness using the following formula. The smaller the cost-effectiveness is, the higher the priority of the project *(12)*.

$$Cost\ Effectiveness = \frac{Cost\ of\ the\ project}{Number\ of\ Months\ of\ Extended\ Service\ Life \times ADT}$$

Some States compare the total cost of PM to the cost of improvement or replacement. Mn/DOT has a rule that if bridge PM cost exceeds 30% of the cost of a new bridge, bridge improvement should be considered instead of PM. The project study report must include information on the type of improvements considered and the cost of such improvement *(13)*.

Dedicate Adequate Resources

This characteristic deals with issues of agency commitment to the PM program. States should define a decision process for dedicating resources over the long-term to achieve the PM maintenance goal. States also may consider a plan to allocate the PM funds and predict budget requirements to meet maintenance needs statewide.

States PM program documents should include a description of programmatic features to ensure agency commitment to providing staff for on-going operation and management of the PM program. This includes monitoring the condition of the structures as well as the use of the Federal funds. On-going performance evaluation and continuous performance measures assure the benefit of PM projects and long-term agency support for investment for PM program.

PM program may be monitored and controlled by specific field and office procedures including procedures for quality control and quality assurance of the bridge PM projects. For example, HDOT

updates NBI data within 90 days after completion of preventive maintenance projects *(15)*. TxDOT is preparing a Bridge Management Information System (BMIS) to support its bridge asset management. The full range of BMIS includes bridge inspection, routine and preventive maintenance needs and schedules, rehabilitation and replacement threshold and funding needs.

The FHWA District Office monitors the use of Federal funds including the condition of treated structures. NYSDOT prepares an annual report on the status of the program along with any adjustments that has been made. At HDOT the bridge design branch prepares an overall evaluation of the program and the FHWA District Office conducts a biennial review.

Summary

This section presented a discussion of the FHWA's concepts for a systematic process and examples of the concepts from the State documents. There are several common overarching and programmatic elements of the State PM programs:

- Preventive maintenance projects are identified using objective criteria applied statewide.
- A consistent project prioritization strategy and process insure effectiveness outcomes of expenditures.
- Preventive maintenance projects get underway in a timely manner so that the expected long-term cost-effectiveness benefits are achievable.
- The preventive maintenance program goal is a sustainable, steady-state expenditure plan that maximizes long-term benefits.
- A multi-year flow of dedicated funds are identified to achieve the long term goal.

Some characteristics of a systematic process appear to be missing from the State documents. The broad program goal and target are not always clearly apparent in the documents. The documents present the overall process for cost-effective preventive maintenance, but they focus more heavily on indentifying maintenance needs and selecting projects than on the long-term ongoing plan. The role of the agency's bridge maintenance system for supporting the preventive maintenance program may not be explicitly defined. In addition, some documents fail to clearly describe the available State resources to support the PM program and the business process for getting PM projects into the construction program.

There is no standard guideline or list for what PM activities are eligible for Federal funding. The activities range from routine maintenance and minor rehabilitation. The funding eligibility depends on the preventive maintenance need in each State and the systematic process for selecting and implementing a Federal aid program.

WISDOT'S PROPOSAL TO USE HBP FUNDS FOR PM

This section presents a review of the WisDOT's 2003 draft proposal that was not successful. The essential characteristics of a systematic process are the basis for identifying missing features in WisDOT's application. Comparison of the draft proposal and the essential characteristics leads to recommendations for improving the proposal. Based on results of the analysis, the research team prepared a new draft proposal for WisDOT.

Analysis of the WisDOT's Current Draft Proposal

WisDOT's Bureau of Structures prepared a 5-page agreement for using Federal HBP funds for bridge PM projects in 2003. The agreement was not signed by the FHWA Wisconsin District Office. WisD'T's 2003 draft addresses the bridge preventive maintenance activities that would be eligible for Federal aid as well as activities that would not be allowed. The proposal does not, however, describe a process to identify the preventive maintenance needs nor to select bridge PM projects. Moreover, also missing from the proposal are the long term goal of the State's bridge PM program and the availability of State resources to support the program.

Acceptance of the agreement for using Federal HBP funds is expected to be the outcome of the State and the FHWA Division Office working together. Table 6 lists our recommendations for modifying WisDOT's agreement proposal. The recommendations are comprehensive of all of the essential characteristics of a systematic program for bridge PM. The table is meant to be a reference guideline for WisDOT in revising and improving its proposal in the future. Following these recommendations will improve WisDOT's PM program plan.

Table 6 Recommendations for WisDOT Draft Proposal

Essential Characteristic	In the Draft?	Recommendation
Define outcome / goal	No	Make long term goal with target values of the metrics
Define how the needs are identified	No	Establish thresholds using engineering value to identify the maintenance need
Prioritize the need	Briefly	Prepare systematic process to describe how to select the projects
Program remedy to address the need	No	Create process to get the selected project implemented in the on-going maintenance plan
Identify resources to Achieve goal	No	Discover supportive in-State maintenance program for bridge PM project
Identify timelines / timeframe	No	Establish Schedule for achieving long term goal
Demonstrate cost-effectiveness	No	Quantify the impact of PM and to predict bridge condition with maintenance cost
Demonstrate extension of service life	No	
Dedicate adequate resources	No	Build programmatic features of agency commitment to the bridge PM

Draft Sample Agreement for WisDOT

The following pages contain a draft template that can be used by WisDOT to prepare its agreement for use of Federal funds for preventive maintenance of structures.

AGREEMENT FOR THE USE OF FEDERAL FUNDS FOR PREVENTIVE MAINTENANCE OF STRUCTURES

This agreement between the Wisconsin Department of Transportation (WisDOT) and the Wisconsin Division of the Federal Highway Administration (FHWA), is intended to implement the use of Federal-aid Highway Funding for Preventive Maintenance activities as authorized in 23 USC 116 (d), "Preventive Maintenance" on all eligible structures in the State of Wisconsin.

The criteria used to develop this agreement is based on the FHWA guidance issued by the FHWA on October 8, 2004 ("ACTION: Preventive Maintenance Eligibility", issued by the Associate Administrator for Infrastructure), and current AASHTO guidance on Preventive Maintenance.

This agreement is limited to Preventive Maintenance (PM) activities on Structures. It does not cover PM activities on Roadways. A separate agreement has been developed for PM activities on Roadways.

By signing this agreement, WisDOT and the FHWA incorporate by reference the laws, regulations, policies, standards, and procedures which govern or are applicable to Federal-aid projects. WisDOT certifies that it will comply with all provisions of 23 USC 133, "Surface Transportation Program", for non-National Highway System PM projects.

Nothing in this agreement shall be construed to relieve WisDOT from ultimate accountability for compliance with Federal Laws and regulations with respect to the expenditure of Federal-aid highway funds for PM activities in the State of Wisconsin, including those funds passed through to local governments.

This agreement shall become effective January 1, 2009. It may be canceled or modified at any time by mutual agreement of WisDOT and the FHWA.

Wisconsin Department of Transportation

_____ _____

Kevin Chesnik, Administrator Date
Division of Transportation Infrastructure Development

Federal Highway Administration

_____ _____

Bruce E Matzke, Division Administrator Date
Wisconsin Division

AGREEMENT FOR THE USE OF FEDERAL FUNDS FOR PREVENTIVE MAINTENANCE OF STRUCTURES

I. SCOPE AND GOAL OF BRIDGE PREVENTIVE MAINTENANCE

Definition: Preventive maintenance (PM) is the planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without increasing structural or operational capacity.

Preventive maintenance activities should extend the useful life of the existing structure without degrading safety or roadway geometrics. The evaluation of geometric features and accident information, in order to determine if geometric or safety enhancements are warranted is encouraged, but is usually beyond the scope of most preventive maintenance work.

WisDOT established the long term goal to maintain structures in State: Provide bridges which are cost-effective, maximize service life with minimal maintenance and meet the overall expectations of the traveling public with respect to comfort, convenience and safety. To meet the goal, WisDOT is having a strategic investment plan to maintain 90 percent of our bridges in "fair or good" condition by 2015. NBI rating of 5 or more is considered as fair or good condition in Wisconsin. WisDOT expects this agreement can assist us to meet the goal for our State bridges.

II. CRITERIA FOR BRIDGE PREVENTIVE MAINTENANCE

The National Bridge Inventory (NBI) inspection report and the respective bridge condition ratings in Highway Structure Information System (HIS) along with WisDOT's Bridge Management System (BMS) will be used as the basis for identifying preventive maintenance demands. Bridges are recommended and prioritized using predetermined evaluation criteria established in BMS. Regional bridge engineers, bridge inspection engineers and bridge engineers from Bureau of Structures on central office are also authorized to recommend the projects. For objective and consistent decision making, the criteria apply statewide.

The following types of works are examples of preventive maintenance to structures eligible for the use of Federal. The works are shown with thresholds by Pontis rating scale to identify maintenance needs depending on the element.

Table A. Bridge PM Activity Eligible for Federal Aid

Element	Activity	Criteria
Deck	Joint Replace or Repair	More than 1% in condition state 3 or 4
	Minor Deck Rehabilitation or Repair including Deck Overlay	Element in condition state 3,4 or 5
	Crack Sealing or Patching	Surface in condition state 4 or 5
	Bridge Washing	All functional structures (every 2 years)
Super-structure	Bearing Area Restore or Replace / Bearing Lubrication	Steel bearings in condition state 3, 4 or 5
	Seismic Retrofit	Bridge in a Seismic Acceleration Zone of 0.10 (10%) or greater by the 1996 USGS
	Replace or repair damaged substructure	Element in condition state 3, 4 or 5
	Scour remediation / Scour countermeasures	Scour code of 3 or less
Painting	Bridge Painting (full, zone, and spot)	More than 25% in condition state 3,4 or 5

III. PROJECT SELECTION PROCESS

The projects are prioritized and selected by a predetermined process. Once the maintenance demands are indentified, the projects are evaluated by bridge preventive maintenance committee. The committee made up of the Director in Bureau of Structures in central office, bridge engineer in regional office, and inspection engineers (e.g., in TxDOT, the Bridge Division Director of Project Development and the three senior project managers and Director of Field Operations). During evaluation, the following criteria may be considered by committee to select the projects.

- Useful service life extension of the structure from maintenance
- Bridge Age
- Average Daily Traffic
- Safety enhancement
- Scheduled maintenance rehabilitation / replacement plan within 3 years
- Other available funding sources

If work needed on an individual structure is not sufficient to justify a separate contract, packaging bridge maintenance projects or inclusion with roadway work should be considered to provide cost-effectiveness. The necessity for packaging work may result in an increased priority for work on a particular bridge which would otherwise not be considered. Packaging of bridge work to provide for efficient project administration should also be considered in establishing priorities.

The selected projects were delivered to the FHWA Division Offices and implemented with approval from the FHWA.

IV. IMPLEMENTATION OF THE PROJECTS

WisDOT has a plan to implement the approved projects into the current maintenance program. With communication to programming and administering division, predefined administrative process gets approved projects underway in timely manner. The selected projects are incorporated into the "Meta-Manager" system, which was developed for evaluating programming options, and placed in the ongoing bridge maintenance programs next year. The projects can be implemented with Bridge Preventive Maintenance Program (BPMP), General Transportation Aid (GTA) or Local Bridge Improvement Assistance Program (Local Bridge Program). If the project is determined to be of vital important, a special minute order will be requested to add the project to the current BPMP.

WisDOT created the limitation of using Highway Bridge Program (HBP) funds for bridge preventive maintenance projects. In order to ensure Highway Bridge Program (HBP) funding remains enough for rehabilitation and replace of deficient bridges, however, no more than 5% of yearly expected HBP funding should be designated for preventive maintenance projects in WisDOT.

V. TIMELINES FOR IMPLEMENTATION

Once the deficient elements are repaired or replaced, routine maintenance should be performed to maintain the bridge in good condition. The cycle of certain maintenance activity may be assigned after the elements of brides reach at the certain level. Though routine maintenance activities should be funded by maintenance programs in regional offices (district) such as the General Transportation Aid (GTA), Federal funds are also available for routine maintenance depending on the primary purpose of the activity. The primary intent of the activity should be to preserve the structure. Litter pick up, for example, may extend bridge service life by removing material from clogging the drainage system. But the activity is not eligible for Federal funds because the primary intent is to make the road passable not to preserve the structure. Guidance for bridge cyclical maintenance activities is shown in Table B.

Table B. Specific Guidance for Bridge Cyclical Maintenance

Activity	Selection Criteria	Cycle
Bridge Washing	All functional structures, priority to structures over highway	2 years
Deck Sealing	Surface in condition state 4 or 5	4 years
Bearing Lubrication	Steel bearing in condition state 4 or 5	4 years
Crack Sealing	Surface in condition state 4 or 5	5 years
Bridge Painting	Painted structures in condition state 4 or 5	12 years
Deck Overlay	Wearing surfaces in condition state 4 or 5	12 years

VI. COST-EFFECTIVENESS AND EXTENSION OF SERVICE LIFE

Bridge Management System (BMS) in WisDOT is able to assess and quantify the impact of PM activities to predict the bridge condition. Pontis, which WisDOT is considering to employ, has embedded functions in the preservation maintenance modules that can compare the cost and effectiveness of preventive maintenance activities by evaluating and projecting bridge conditions. Initially, WisDOT had planned to use the default cost and transition matrices in Pontis but the values appropriate for Wisconsin will be researched and embedded in the system. Until the BMS is fully operational, the selected project will be evaluated by cost-effectiveness considering the key factors such as cost of the project, number of months of extended service life, and ADT on the bridges.

VII. DEDICATED ADEQUATE RESOURCES

To achieve long term bridge preventive maintenance goal in Wisconsin, programmatic features to provide ongoing monitoring and controlling of the complete work need to be granted. Depending on the project requirements, bridge PM projects may be constructed using in-house bridge maintenance crews or by competitive bid contract forces. But quality control and quality assurance of the PM activities will be monitored and controlled by respective regional bridge inspection personnel. Element level inspection condition states should be updated within 90 days after completion of the PM work. Moreover, a biennial periodic review of the program will be done by the FHWA and the Bureau of Structures to determine the overall effects of the program and to evaluate how well the program is reflecting the established objectives and needs.

Recommendation for Monitoring Effectiveness of PM Activities in Wisconsin

As a part of this project, the research team collected data on bridge preventive maintenance activities currently being practiced in the WisDOT regions. To identify the activities and collect suitable data, a survey was sent to the regional offices throughout the State (see Appendix A). The survey included questions about detailed bridge preventive maintenance activities, unit cost and benefits (estimated service life extension with or without preventive maintenance). Though the survey responses were poor and there were minimum data-supportive responses, the Researchers identified one regional office had historical data on preventive maintenance activity, i.e., the Southwest Regional office at Madison (SW-Madison).

The research team discussed with bridge engineers in SW-Madison about how they have conducted bridge maintenance and how they collect the cost data related to the activities. Essentially, the regional office asked bridge engineers in each county to deliver the cost information associated with conducted preventive maintenance. The maintenance data had been reported as activity codes, with dates and detailed cost with material, labor, machinery, and administration. The data has been collected since 1997 and stored in an Access database.

Some studies based on transition probability have suggested that bridge deck washing can extend the service life of bridges (*18*). In this study, actual field maintenance data obtained from SW-Madison were used in an attempt to quantify the effectiveness of bridge preventive maintenance activities. Due to time and budget limitation, only one activity was selected in this study. This PM activity was bridge deck washing, coded as 61a. The study was also limited to 237 bridges with prestressed girders and decks with epoxy coated rebars. Of these, 94 have been washed and 143 have not. In addition, the bridges were categorized by bridge age and ADT on deck for this analysis. Table 7 shows the data sources for the analysis.

Table 7 Data Sources Used to Quantify Effectiveness of Bridge PM Activity

Data	Source
Bridges with Prestressed girders an decks with epoxy coated rebar	SW-Madison office at WisDOT
Traffic volume on Bridges	
Bridge age	
Historical PM data	
Bridge condition data / Bridge inspection data	Bridge Management Database at WisDOT (Highway Structures Information System)
Failure cost to calculate bridge Health Index	Spreadsheet developed by Adel Al-Wazeer *(17)*

Since deck washing is not a repair activity, it cannot improve the condition of the structure but it may delay deterioration. Thus, the long term impact of this activity was the main intent of this study. For analysis, two approaches were attempted to show the effectiveness of deck washing:

1. Compare the condition of the bridges over time with and without deck washing
2. Compare the condition of bridges over time with deck washing yearly, every other year, every 4 years, and so on.

In the analysis of the data, the bridge Health Index (HI) was used to quantify the effect of deck washing on the condition of the bridge. HI was initially developed by the California Department of Transportation (Caltrans) *(19)* and is used in Pontis as a bridge performance measure (*20*). To compute the bridge HI, the failure cost parameter suggested by Al-Wazeer of B.D. Systems for the Federal Highway Administration *(17)* was applied. In an attempt to isolate the effect of deck washing from other maintenance actions, the study focused on the rate of change of the HI with time. Data points that showed a sudden increase in the bridge HI due to a rehabilitation or replacement activity were excluded from the analysis. Example plots of the HI with time for selected bridges are shown in Appendices B.1 and B.2. Each plot includes examples of the data that were excluded in this analysis.

Analysis of the data showed no clear distinction in the service life of the bridges with or without bridge deck washing. Most of the bridge conditions varied between 96 and 100 in HI and there was no significant difference between bridges with deck washing and bridges without deck washing. To investigate the rate of change of the HI with time, an average annual deterioration rate was calculated instead. The Two-sample T test was applied to compare average annual deterioration rates from two groups of bridges. However, analysis of the data in this form did not show any advantages of bridge deck washing in decreasing deterioration rate either.

Based on the assumptions made in this analysis, the data suggest that bridge deck washing has no significant effect on extending the service life of the bridges. It is recognized, however, that there exist other factors that may influence the results of the analysis. For example, the values of failure cost are not unique and they could be estimated in a different manner. Here, the suggestions from Al-Wazeer were used; however, other values have been suggested in the literature (*21*). Also, the

data included other maintenance actions such as patching, deck or crack sealing which were not considered in this study but that could affect the bridge service life.

For future use, the research team recommends that bridges of similar characteristics (structure type, location, ADT, environment) be selected and carefully monitored over time. PM activity such as deck washing can be applied to only some decks while no washing would be done to the rest of them. Each year, bridge performances of each deck can be monitored and compared to each other for 5 years. Element level inspection would be recommended to measure bridge performance such as deck, column, and abutment. This type of experiment would show the effectiveness of certain bridge PM activity on each bridge element. Effectiveness can be presented by how much the activity make deterioration rate slow on certain element with the cost information of the maintenance activity. A similar approach may be followed for other PM activity.

SUMMARY AND RECOMMENDATION

There are no standard criteria for State applications to use Federal HBP funds for bridge preventive maintenance and the States' agreement documents vary widely. To assist the States in preparing a bridge PM program and FHWA Division Offices in reviewing the agreements, the FHWA drafted concepts of the systematic process without narrative explanation or examples. The concepts have not been promulgated to policy.

This report presents an interpretation of the systematic process along with a review of eight successful State DOT proposals. Several overarching common elements of the States' PM programs make them consistent with the intent of the FHWA's interpretation of the SAFETEA-LU provision:

- Preventive maintenance projects are identified using objective criteria applied statewide.
- A consistent project prioritization strategy and process insure effectiveness outcomes of expenditures.
- Preventive maintenance projects get underway in a timely manner so that the predicted long-term cost-effectiveness benefits are achievable.
- The preventive maintenance program goal is a sustainable, steady-state expenditure plan for that maximizes long-term cost avoidance.
- A multi-year flow of dedicated funds are identified to achieve the long term goal.

This analysis was prepared to help State agencies as they establish bridge PM program and apply for Federal aid. It is recommended that WisDOT incorporate these features into its application. To assist them in their effort, this report includes a draft template for WisDOT. Though the template was created for WisDOT, the template could be used other States.

REFERENCES

1. Gee, K. Associate Administrator for Infrastructure. *ACTION: Preventive Maintenance Eligibility.* October 8, 2004. http://www.fhwa.dot.gov/preservation/100804.cfm. accessed June 31, 2008
2. Baladi, G. Y., Svasdisant, T., Van, T., Buch, N., and Chatti, K. Cost-effective preventive maintenance: Case studies. In *Transportation Research Record: Journal of the Transportation Research Board, No.* 1795, Transportation Research Board of the National Academies, Washington, D.C., 2002, pp. 17-26.
3. Gee, K. Program Manager, Infrastructure. *INFORMATION: HBRRP Funds for Preventive Maintenance (23 U.S.C. 116(d))*. FHWA, January 11, 2002. http://www.fhwa.dot.gov/preservation/011102.cfm. accessed June 31, 2008
4. Federal Highway Administration (FHWA). *Pavement Preservation: A Road Map for the future*. Publication FHWA-SA-99-015. FHWA, U.S. Department of Transportation, 1999.
5. Sprindel, M., Brown, M., and Thompson, P. *Preventive Maintenance for Concrete Bridge Deck, http://www.virginiadot.org/business/resources/bu-mat-OPT7S-CBCPreventMaintConcDecks.pdf.* assessed Oct, 2008
6. Ohio Department of Transportation (ODOT). *On-Line Bridge Maintenance Manual.*, undated. http://www.dot.state.oh.us/preventivemaintenance/defines/defines.htm. accessed May, 2008
7. O'Brien, L. G., Evolution and Benefits of Preventive Maintenance Strategies. National Cooperative Highway Research Program Synthesis of Highway Practice 153, Washington D.C., 1989.
8. New York State Department of Transportation (NYSDOT). Funding Preventive Maintenance within the HBRRP, 2005 (NYSDOT internal document delivered by State agency)
9. Michigan Department of Transportation (MDOT). HBRRP for Preventive Maintenance, 2002 (MDOT internal document delivered by State agency).
10. Newman, C. Office of Asset Management. *Preventive Maintenance Questions and Answers*. December 16, 2004. http://www.fhwa.dot.gov/preservation/100804qa.cfm accessed June 31, 2008
11. Colorado Department of Transportation (CDOT). HBRRP Funds for Preventive Maintenance, 2002 (CDOT internal document delivered by State agency)
12. Texas Department of Transportation (TxDOT). Plan for the Systematic Assessment of Preventive Maintenance Projects for Bridges using Highway Bridge Replacement Funding. 2006 (TxDOT internal document delivered by State agency)
13. Minnesota Department of Transportation (Mn/DOT). Bridge Improvement and Replacement Guidelines, 2002 (Mn/DOT internal document delivered by State agency)
14. New York State Department of Transportation (NYSDOT). *New York State's Bridge Program in Brief*. https://www.nysdot.gov/portal/page/portal/main/bridgedata. accessed August 28, 2008
15. Hawaii Department of Transportation (HDOT), FHWA HAWAII DIVISION. Bridge Preservation Program Guidelines, 2005 (HDOT internal document delivered by State agency)

16. Michigan Department of Transportation (MDOT), *Pontis Bridge Inspection Manual.* 2007. http://www.michigan.gov/documents/mdot/MDOT_PontisManual_2007_195365_7.pdf. accessed August 28, 2008

17. Adel Al-Wazeer , *Spreadsheet Method of Minimum Failure Cost Calculation*, *http://assetmanagement.transportation.org/tam/aashto.nsf/docs/E5D2A9F0532369118525 6B3A004E0632?opendocument&CurrentCategory=c.%20Management%20Systems,* accessed October 7, 2008

18. Rhode Island Department of Transportation (RIDOT), *Bridge Inspection / Washing Program Bridge Drainage Program*, 2002. www.pavementpreservation.org/library/getfile.php?journal_id=1087. Accessed November 10, 2008

19. Shepard, R. W., and Johnson, M. B. California Bridge Health Index: A Diagnostic Tool to Maximize Bridge Longevity, Investment., Washington, D.C., In Transportation Research Board of the National Academies, *TR News*, Number 215, 2001, pp. 6-11.

20. Pontis Technical Manual Release 4.4. AASHTO, Washington, D.C. 2005, pp. 4-2 – 4-6.

21. Sobanjo, J. O., and Thomson, P. D. *Development of Agency Maintenance, Repair & Rehabilitation (MR&R) Cost Data for Florida's Bridge Management System.* Prepared for State Maintenance Office Florida Department of Transportation, 2001.

APPENDICES

A. Survey of WisDOT Regional Offices

Bridge Preventive Maintenance at WisDOT Regions

Survey of Regional Offices
Conducted by

University of Wisconsin-Madison

Please help us collect information that will be useful to WisDOT as they prepare a proposal to FHWA for using HBRRP funds for preventive maintenance (PM) of highway bridges by completing this survey. The survey focuses on the preventive maintenance activities performed at your region. We appreciate your time and assistance on this project. If you have questions, please contact MK Kang at (608) 262-3729 (myungook@cae.wisc.edu) or Professor Jose Pincheira at (608) 262-7239 (jpin@engr.wisc.edu). THANK YOU!

Think about all of the activities of your region for bridge preservation. Please indicate the activities typically performed, and then estimate their frequency, total direct cost, the service life without PM (if no maintenance is done, the number of years until the condition of the element deteriorates to the point that major improvement is needed), and the increase in service life due to the preventive maintenance activity if known. *Indicate all that apply. Please skip the activities your region does not perfor*m. Extra lines are for activities not listed.

Activity	Frequency or Cycle					Total direct cost per unit*	Estimated life without PM(years)	Estimated life increase due to PM (years)
	Yearly	2 years	5 years	Other	As needed (please indicate the trigger for action)			
Bridge Deck								
Remove salt, dirt and debris on deck.	☐	☐	☐	☐ _____				
Sweep and flush deck with water.	☐	☐	☐	☐ _____				
Remove dirt and debris from joint opening.	☐	☐	☐	☐ _____				
Flush dirt and debris from drainage system with water, air blast, or other devices.	☐	☐	☐	☐ _____				
Strip seal joint patching.	☐	☐	☐	☐ _____				
Spot paint under joint.	☐	☐	☐	☐ _____				

Activity	Frequency or Cycle					Total direct cost per unit*	Estimated life without PM(years)	Estimated life increase due to PM (years)
	Yearly	2 years	5 years	Other	As needed (please indicate the trigger for action)			
Repair pourable Joint Sealant.	☐	☐	☐	☐ _____				
Seal deck cracks (Black bar, no overlay).	☐	☐	☐	☐ _____				
Seal deck cracks (Black bar, with overlay).	☐	☐	☐	☐ _____				
Seal deck cracks (Green bar, no overlay).	☐	☐	☐	☐ _____				
Seal deck cracks (Green bar, with overlay).	☐	☐	☐	☐ _____				
Seal cracks on Curbs.	☐	☐	☐	☐ _____				
Seal cracks on Sidewalks.	☐	☐	☐	☐ _____				
Seal cracks on Parapet.	☐	☐	☐	☐ _____				
Seal concrete on Deck.	☐	☐	☐	☐ _____				
Seal concrete on Curbs.	☐	☐	☐	☐ _____				
Seal concrete on Sidewalks.	☐	☐	☐	☐ _____				
Seal concrete on Parapet.	☐	☐	☐	☐ _____				
Patching with asphalt	☐	☐	☐	☐ _____				
Patching with concrete	☐	☐	☐	☐ _____				
Asphalt overlay to exiting deck.	☐	☐	☐	☐ _____				
Concrete overlay to exiting deck.	☐	☐	☐	☐ _____				
Chloride extraction	☐	☐	☐	☐ _____				
Paint Rail.	☐	☐	☐	☐ _____				

Activity	Frequency or Cycle					Total direct cost per unit*	Estimated life without PM(years)	Estimated life increase due to PM (years)
	Yearly	2 years	5 years	Other	As needed (please indicate the trigger for action)			
	☐	☐	☐	☐ _____				
	☐	☐	☐	☐ _____				
Superstructure								
Remove salt, dirt and debris on steel/concrete members.	☐	☐	☐	☐ _____				
Sweep and flush steel/concrete members with pressurized water.	☐	☐	☐	☐ _____				
Remove debris from bearings and flush them with pressurized water.	☐	☐	☐	☐ _____				
Remove debris from bridge seats and flush them with pressurized water.	☐	☐	☐	☐ _____				
Jack structure and clean, lubricate and paint bearings.	☐	☐	☐	☐ _____				
Paint girders.	☐	☐	☐	☐ _____				
	☐	☐	☐	☐ _____				
	☐	☐	☐	☐ _____				
Substructure								
Seal concrete abutments	☐	☐	☐	☐ _____				
Refill Riprap	☐	☐	☐	☐ _____				
Scour Mitigation (excavate or fill in the riverbed)	☐	☐	☐	☐ _____				
Paint steel piers.	☐	☐	☐	☐ _____				

Activity	Frequency or Cycle					Total direct cost per unit*	Estimated life without PM(years)	Estimated life increase due to PM (years)
	Yearly	2 years	5 years	Other	As needed (please indicate the trigger for action)			
Seal concrete piers.	☐	☐	☐	☐ _____				
	☐	☐	☐	☐ _____				
	☐	☐	☐	☐ _____				

* Direct cost includes material, labor and equipment excluding mobilization/demobilization and traffic control.
* Please indicate the unit (e.g., per mile, per sq ft, etc.)

Bridge Preventive Maintenance Manual

Please complete the following.

Check	
☐	My region has standards/guidelines for preventive maintenance of bridges. A copy of the document can be obtained from Name: _____ Phone:_____ email:_____
☐	I am willing to discuss the bridge preventive activities in my region with a member of the research team. I can be contacted at Phone:_____ email:_____

Contact Information

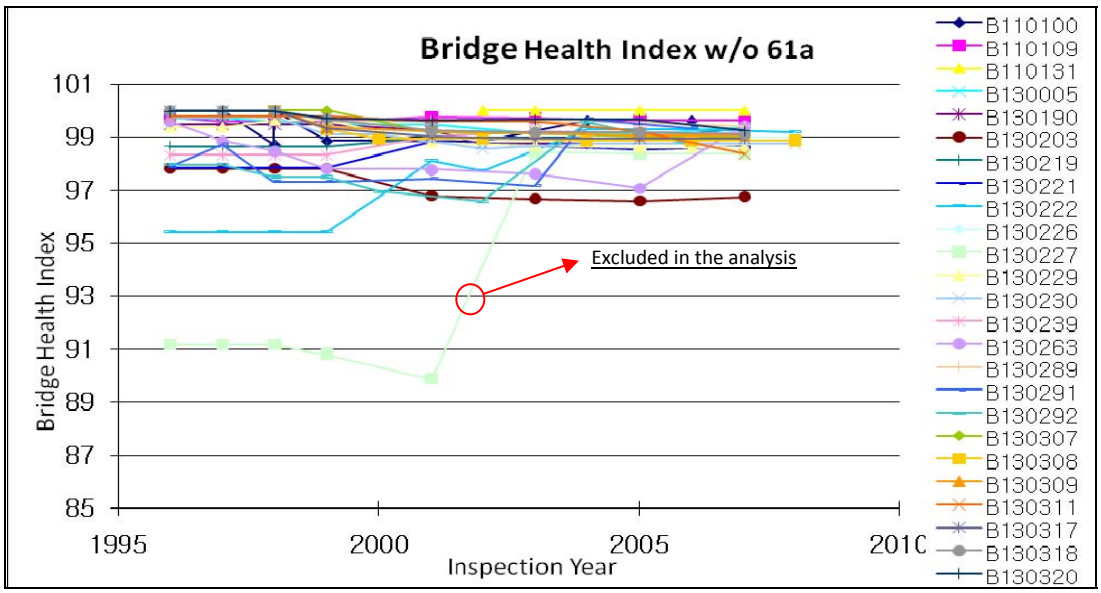
Name of person completing the survey: _____
Title: _____
Region: _____

****

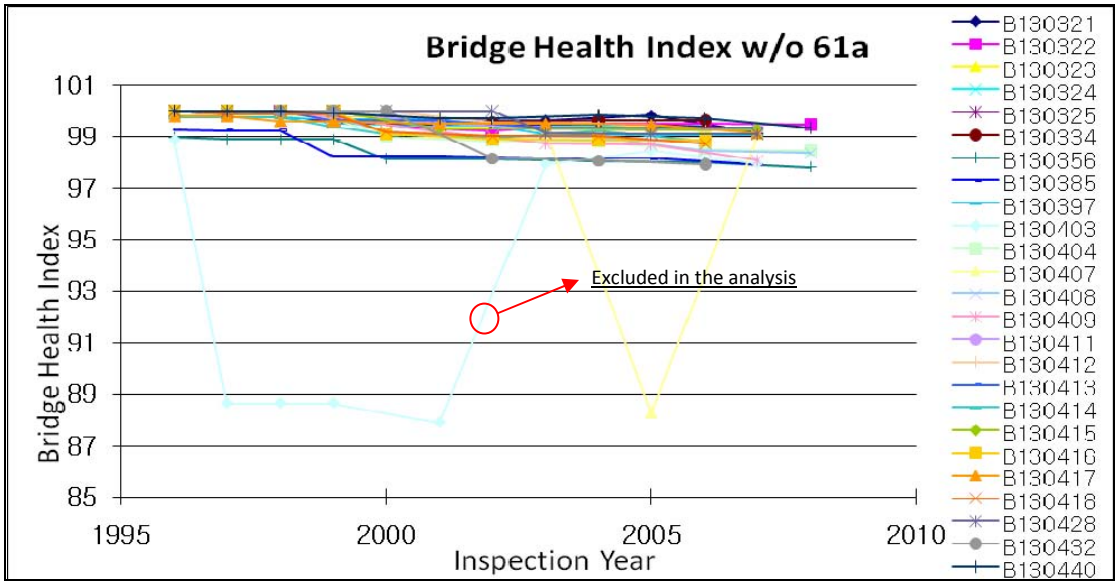
THANK YOU FOR PARTICIPATING IN OUR SURVEY!

B. Data Analysis for Effectiveness of Bridge Deck Washing

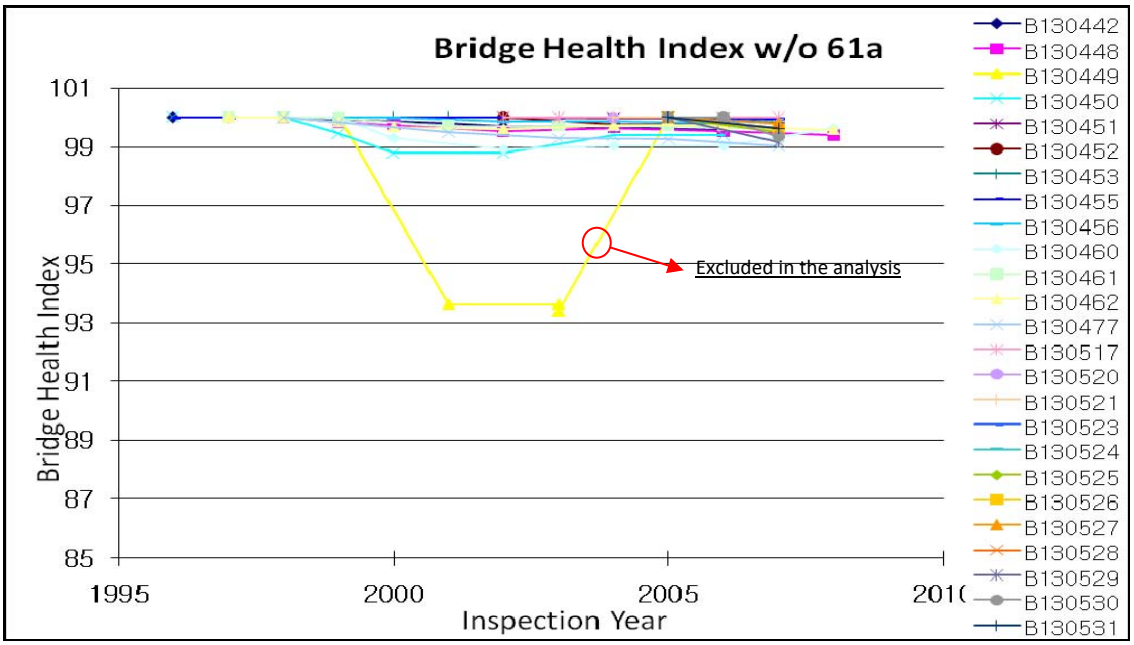
B.1. Bridge Performance presented by Bridge Health Index without deck washing, 61a



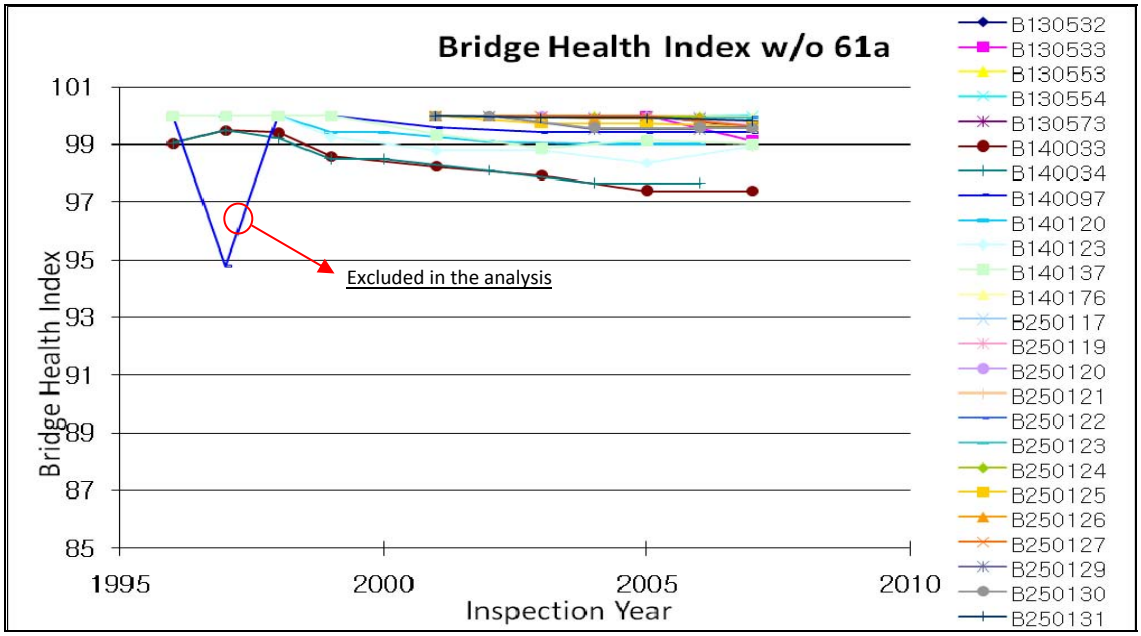
a) Bridge Performance presented by HI without deck washing (B110100-B130320)



b) Bridge Performance presented by HI without deck washing (B130321-B130440)



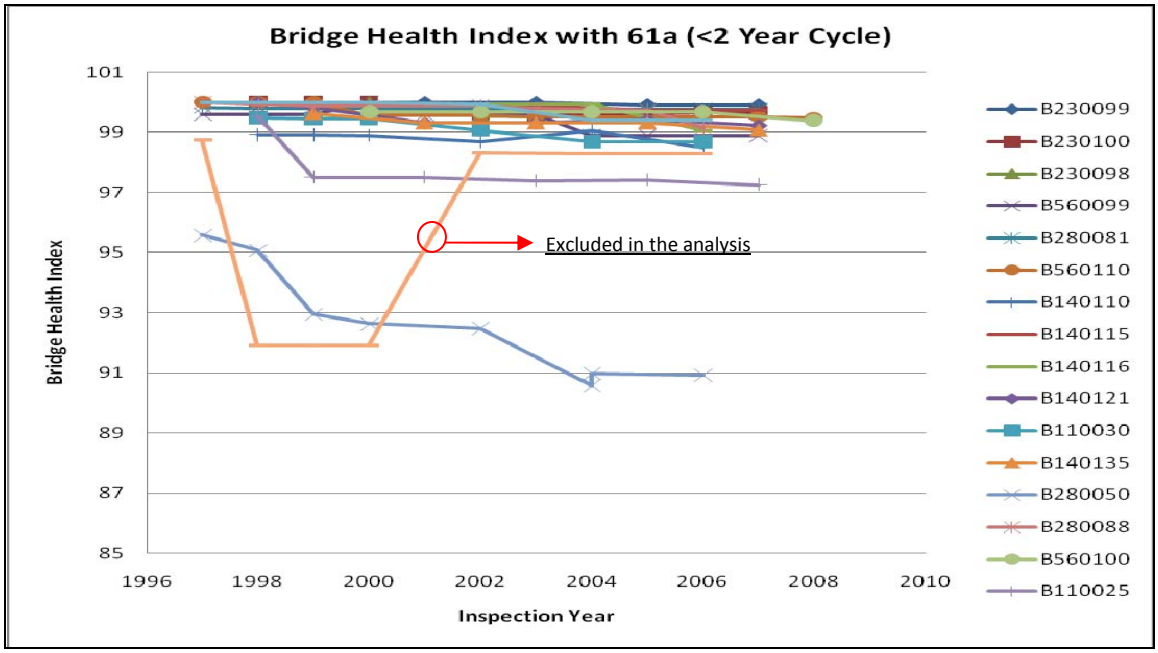
c) Bridge Performance presented by HI without deck washing (B130442-B130531)



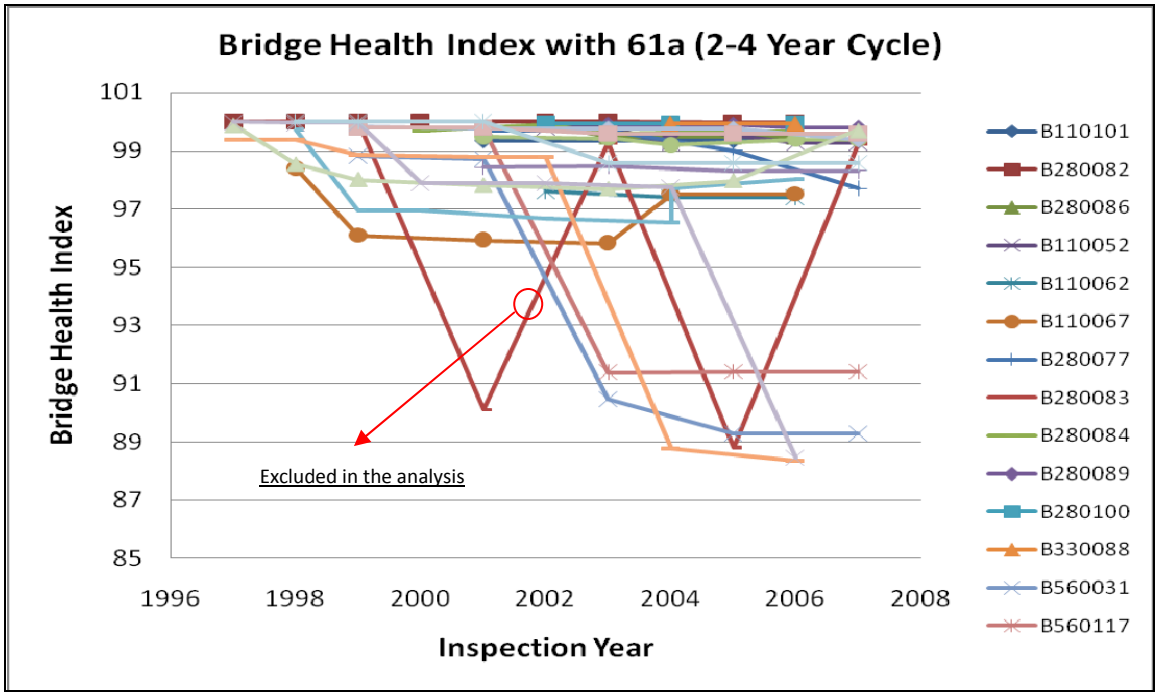
d) Bridge Performance presented by HI without deck washing (B130532-B250131)

Figure B.1. Bridge Performance presented by Bridge Health Index without deck washing, 61a

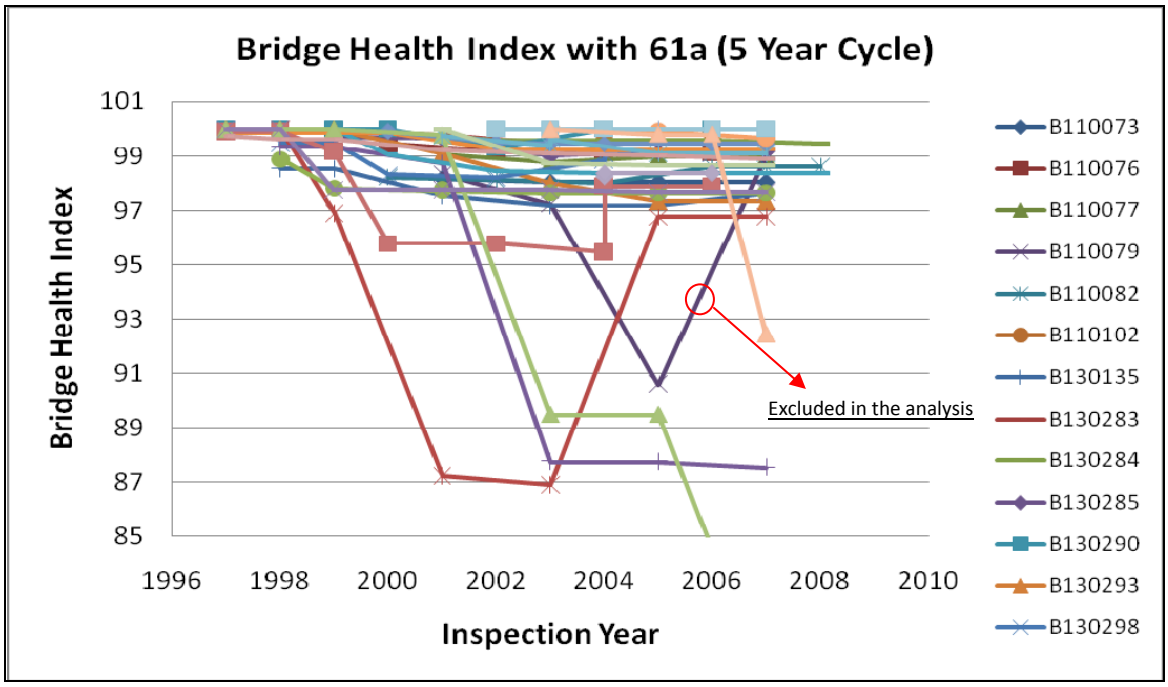
B.2. Bridge Performance presented by Bridge Health Index with deck washing, 61a - Cycle shows that how often the selected bridges have been washed. For example, 5 year cycle means the bridges have been washed every 5 years.



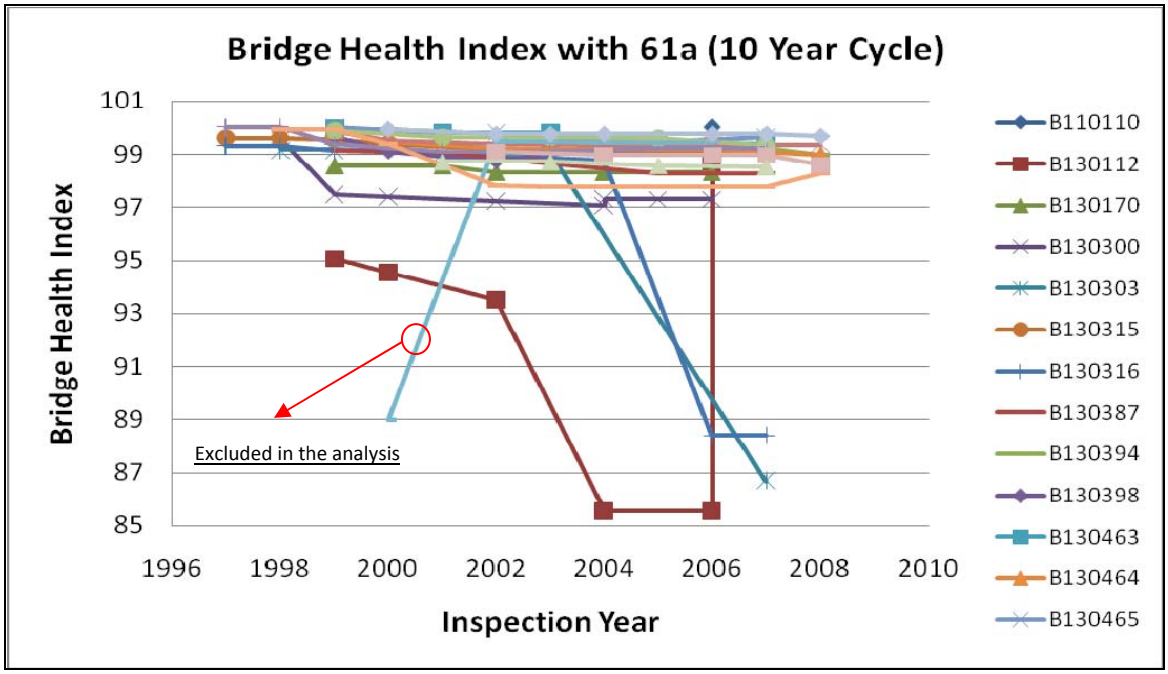
a) Bridge Performance presented by HI with deck washing (<2 Year Cycle)



b) Bridge Performance presented by HI with deck washing (2-4 Year Cycle)



c) Bridge Performance presented by HI with deck washing (5 Year Cycle)



d) Bridge Performance presented by HI with deck washing (10 Year Cycle)

Figure B.2 Bridge Performance presented by Bridge Health Index with deck washing, 61a