



# BRIDGE MAINTENANCE ACADEMY HANDBOOK

Research & Innovation Implementation Program  
Bureau of Planning & Research

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Chapter 1: Introduction

ABOUT THIS HANDBOOK

The purpose of this handbook is to provide a Bridge Maintenance training course and handbook for PennDOT personnel at the District and County levels. The learning objectives of the course are:

- To promote an understanding of the bridge inspection program, regulations and policies and to bridge the gap between the results of a bridge inspection and recommended bridge maintenance;
- To inform participants of Best Practices for structural repairs and preventive maintenance;

- To inform participants of available resources for performing maintenance, including use of PennDOT forms and programs;
- To promote the development of strategic plans for bridge maintenance.

To that end, we have developed a Process Map (see Figure 1) that will guide our path as we work through the learning objectives above.

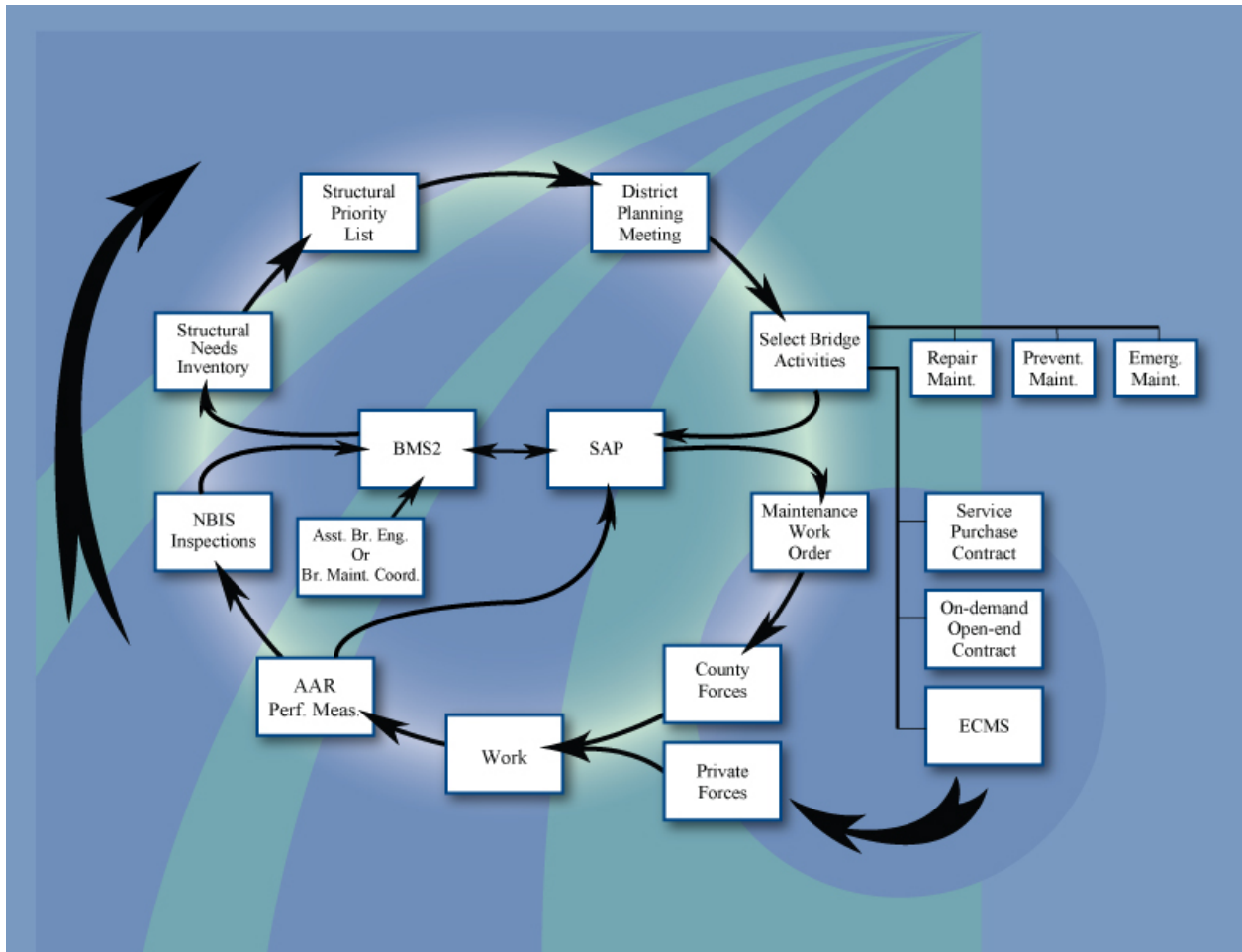


Figure 1 – Process Map

This Process Map is presented as a circle because of the continuity of the bridge

inspection/maintenance process, which becomes a series of cycles across time. As a

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practical matter, the beginning of the Process Map is the place where any user of the Map recognizes his or her place in the process. For the purposes of this handbook, the process will begin with BMS2 because BMS2 is the repository of information about bridge conditions, and from it issues the information used to plan bridge maintenance.

This handbook uses information from a number of PennDOT publications as well as outside sources to outline the pathway to achieving a healthy bridge system, through preventive maintenance and structural repairs. The reader is taken from the point of input (i.e. bridge inspection results and recommendations) through the processes required to manage and resolve these recommendations. The intent of the handbook is that it will serve PennDOT District and County personnel as a desktop reference and guide. It is hoped that the handbook will also expose best practices for use statewide.

### JOB TITLES ASSOCIATED WITH BRIDGE MAINTENANCE

While the job titles listed above represent the personnel most closely involved with bridge maintenance operations, hence their participation in this course, other personnel than these are involved with bridge maintenance. Following is a list of personnel located at County offices who contribute to the processes presented in this handbook, along with brief descriptions of their tasks associated with bridge maintenance.

#### County

##### *County Maintenance Manager (CMM)*

- Coordinates with the District Bridge Unit for generation of a Structure Priority List.
- Meets with the District Bridge Unit and District Maintenance Coordinator to program bridge maintenance.
- Develops an annual plan of work for the upcoming fiscal year, balancing County resources including personnel, equipment, and materials.
- Monitors County Maintenance Measurement Tool 18 (CMMT 18) objectives via monthly reports.

##### *Assistant County Maintenance Manager (ACMM)*

- Receives notifications from the District Bridge Unit through SAP, and develops work orders for maintenance activities.
- Supervises Department Force Bridge Foremen.
- Schedules work for their respective Counties.
- Determines material and equipment needs for maintenance activities and procures those resources as necessary.

##### *Bridge Foreman*

- Supervises Department Forces.
- Percentage of time spent on bridge work measured by CMMT 18, part B.

##### *Department Forces*

- Performs maintenance activities.
- Deck cleaning, typically performed by Department Forces, measured by CMMT 18, Part A.

### Chapter 1 Best Practices

- Maintenance Environmental Planner prepares waterway permits for maintenance work orders.
- Bridge Unit can provide on-the-job Hydraulics and Hydrology training to a Maintenance Engineer so that Maintenance can perform this function for maintenance work/activities.
- Coordinate effort between design and maintenance units.

Chapter 2: BMS2 – How to Get from Inspection to Repairs

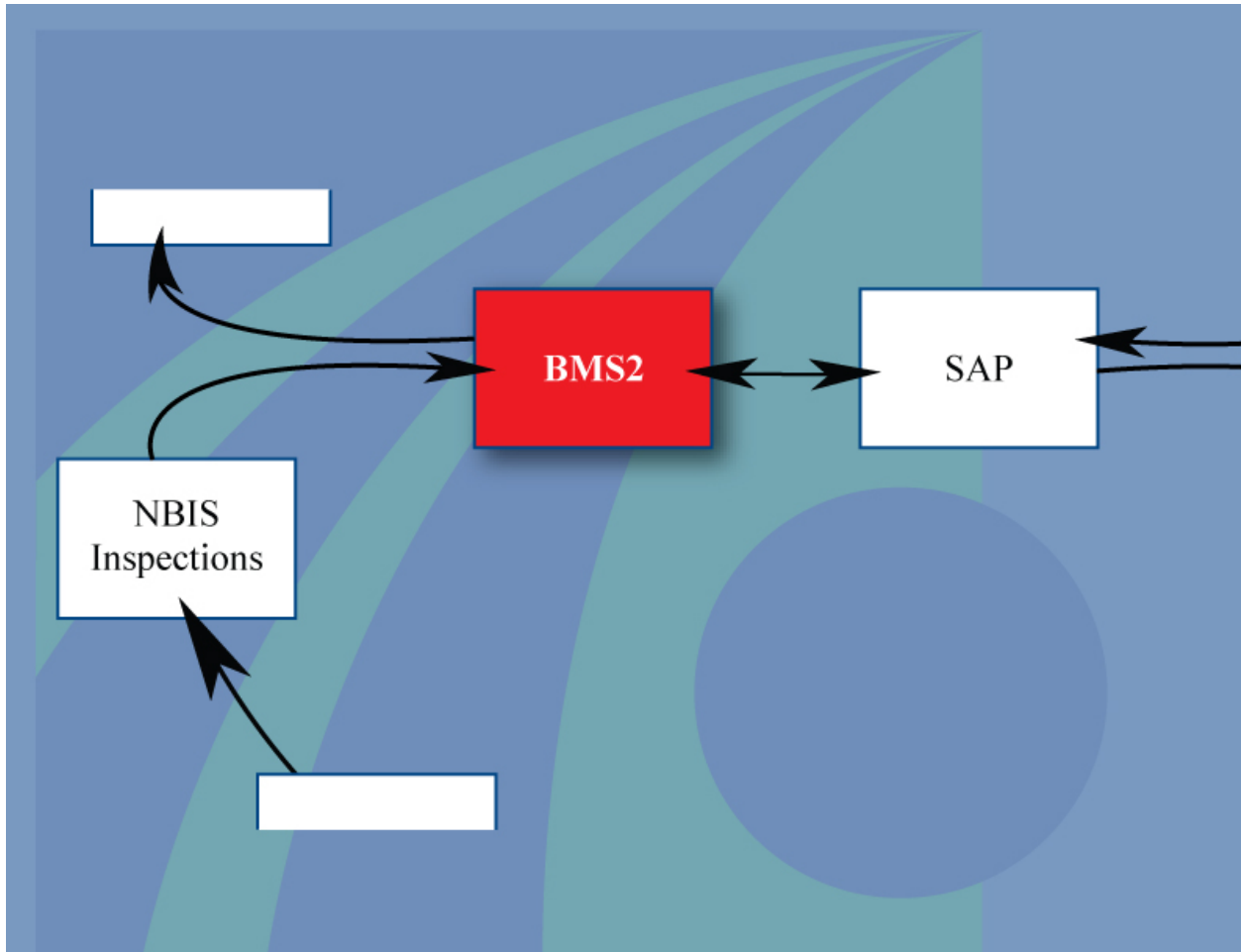


Figure 2 – BMS2 Section of Process Map

**Introduction**

Referring to the Process Map, the major source of data in the Bridge Maintenance Process is BMS2. In essence, BMS2 is a web-based database containing bridge inspection results and recommendations. I-forms data (i.e. inspection data) feeds the Department’s BMS2. The data collected and managed by BMS2 can provide the following assistance to the managers of the bridge maintenance process:

- Bridge planning – determining bridge needs on a network basis.
- Bridge programming – selection of the correct work item for an individual bridge.
- Bridge maintenance management – better use of inspection data for determining maintenance needs and priority for planning and operations.

The information regarding bridge condition, maintenance needs, repair needs, and management of posted or structurally deficient bridges is placed within the database through the collection of inspection data. Because the data from ALL bridge inspections is input into BMS2, future deterioration and corrective bridge costs for various maintenance and improvement options can be better managed. BMS2 uses a planning analysis engine to determine the resources needed on a network basis to achieve and maintain the desired level of performance for Pennsylvania’s bridges.

The process of planning and programming bridge maintenance begins with an inventory of the structural deficiencies found during routine National Bridge Inventory Standards (NBIS) inspections. A report is generated by the District Bridge Unit using BMS2 data showing the

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general condition of the bridges within the District. BMS2 has greatly improved data sharing capabilities with other PennDOT management systems (e.g. RMS, SAP, APRAS, ECMS, and GIS) to assist management decisions.

Let us begin with a discussion on where and how the inspectors get the data going into the BMS2 program.

### BRIDGE INSPECTION BASICS

#### Inspection Frequency

The regular inspection cycle in every contract is two years. Bridges in poorer condition may be inspected annually, with interim inspections of critical elements required semi-annually or annually. Typically, regular safety inspections are performed during the first year of the two-year cycle, with interim inspections of critical elements performed the second year. The second year is often used as a maintenance year, during which the maintenance recommended in the inspection reports is performed.

#### Inspection Report

The product of a bridge safety inspection is a report showing the condition of a bridge on the day it was inspected. These inspection reports contain elements such as narrative descriptions of the bridge components, photographs, and maintenance recommendations. However, the single component that will be common to every Pennsylvania bridge inspection report is a set of Field Sheets, PennDOT D-450 Forms. This set of Forms contains condition ratings representing the inspectors' assessment of the various bridge components at the time of inspection. The Forms also include maintenance recommendations identifying areas of the bridge that require preventive maintenance or structural repairs.

#### Condition Ratings

The NBIS and AASHTO rating codes and their descriptions are shown in the two sections below. It is important to note that the Professional Engineers and Certified Bridge Safety Inspectors that perform bridge inspections are well-trained in the meanings and use of these condition codes, and apply them in their field work according to strict standards.

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**Table 1 – NBIS Component-level Coding**  
(from FHWA's Recording and Coding Guide for the Structural Inventory  
and Appraisal of the Nation's Bridges)

Rating codes	Description
<b>N</b>	<i>Not Applicable</i>
<b>9</b>	<i>Excellent Condition</i>
<b>8</b>	<i>Very Good Condition – No problems noted.</i>
<b>7</b>	<i>Good Condition – Some minor problems.</i>
<b>6</b>	<i>Satisfactory Condition – Structural elements show some minor deterioration.</i>
<b>5</b>	<i>Fair Condition – All primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.</i>
<b>4</b>	<i>Poor Condition – Advanced section loss, deterioration, spalling, or scour.</i>
<b>3</b>	<i>Serious Condition – Loss of section, deterioration, spalling, or scour may have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.</i>
<b>2</b>	<i>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.</i>
<b>1</b>	<i>“Imminent” Failure Condition – Major deterioration or section loss present in critical structural components of obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.</i>
<b>0</b>	<i>Failed Condition – Out of service – beyond corrective action.</i>

The NBIS approach shown above is a consistent standard for collecting bridge data. However, it divides each bridge into only four major parts for condition assessment: superstructure, substructure, deck and culverts. This rating system leads to a number of problems for a state with a significant inventory, such as Pennsylvania. First, it is not comprehensive enough to give the full scope of deficiencies, identify proper repair strategies or estimate costs. Second, the bridge is rated by severity of deterioration, without identifying the deterioration process or extent. Third, the NBIS condition ratings are subjective and are not representative when a bridge exhibits mainly localized problems.

CoRe element ratings were developed to address the shortcomings of NBIS through standardizing the descriptions and adding a greater level of detail. This more generic approach specified the definition of each element, the unit of measurement, and definitions of a set of three to five standardized condition states, and listed typical feasible

actions for each condition state. During AASHTO's Bridge Subcommittee meeting in May 1995, the **CoRe Element Manual** was accepted as an official AASHTO manual.

PennDOT's CoRe element coding is found in Pub 590 "PA CoRe Element Coding Guide", dated December 2006 identifies as Pennsylvania bridge elements all girders, trusses, arches, floorbeams, stringers, abutments, piers, pins and hangers, culverts, joints, bearings, railings, decks and slabs. The element listing includes a description of the element, a definition, condition state language, and a unit of measurement. The element descriptions consider material composition and, where applicable, the presence of protective systems. Condition state language was developed using standard engineering terminology to describe deterioration of the element material. As a result, many of the elements have the same condition state language. Descriptions of bridge elements and Smart Flags are followed by their corresponding condition state language. The condition state



language is geared toward increasing levels of deterioration that relate directly to increasing preventive maintenance through significant structural repair. Thus, the condition state values provide guidance in typical repair strategies and will provide tools to assist Districts in planning and programming work in the future.

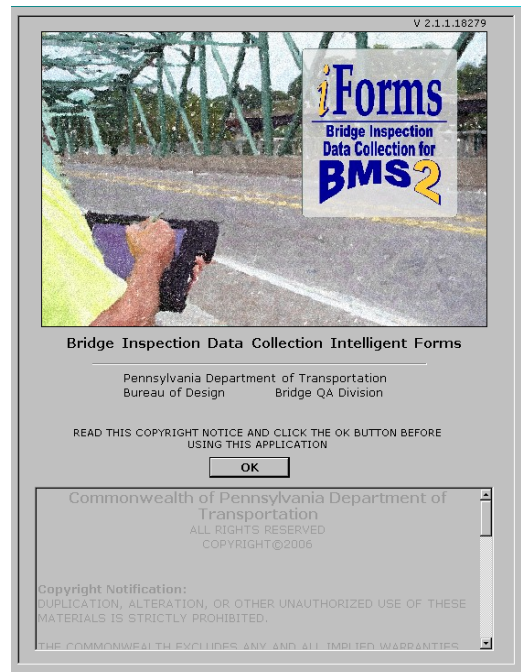
Incorporating the CoRe Elements into the inspection and evaluation of Pennsylvania's bridges will provide more useful data to those who have to plan, schedule and develop maintenance and repair.

How we get from inspection to repairs According to Pub 238, one of the functions of the bridge inspection program is to identify the needs of bridges with regard to structural repairs, preventive maintenance, preservation, reconstruction and replacement. Bridge owners, generally, and the Department, specifically, need this information to respond to those critical deficiencies warranting immediate attention and for the long-term management of these critical infrastructure assets. The data entered into BMS2 will use these major improvement needs and identified maintenance needs to predict future costs to achieve a desired level of service for PA bridges.

BMS2 has a robust software program named "iForms" which supports electronic data collection of bridge inspections for increased efficiency and effectiveness in the electronic collection of bridge data through the use of D-450 Forms (see Figure 3).

The use of the D-450 Forms within iForms allows PennDOT to administer program oversight and to maintain consistency and quality control despite numerous inspectors within PennDOT and with private consultants across the Commonwealth. The D-450 Forms are used to hold the data gathered from bridge inspections, which includes site data, inventory information on the bridge, condition ratings of the bridge components, and the maintenance needs for that particular bridge. This data is brought into BMS2 through the iForms interface.

The inspectors use the NBIS and AASHTO condition ratings (**see Table 1**) to describe and assess the condition of the bridge and bridge members. Deficiencies are located and quantified.



**Figure 3 – iForms Entry Screen**

In addition to the condition of the bridge members, the inspectors will use the D-450M Form to identify needed maintenance items (e.g. on-demand repairs, preventive maintenance, preservation, etc.) for each bridge using the standard list of Maintenance Activities on the D-450M Form. The inspector can edit existing proposed maintenance items or create new items, removing completed structural repairs and updating quantities or adding additional locations for existing maintenance items.

The D-450M Form provides a means to organize the basic major improvement information. Once submitted to BMS2, the current inspection's recommended actions are displayed with all inspections as a cumulative list, displaying current proposed maintenance as well as planned and completed maintenance:

- Planned maintenance items are inspector-recommended or other work items that have been approved, tied to a project and programmed.
- Completed maintenance items are work items for the structure that are associated with a completed project.

Information that appears on the D-450M Form includes the:

- Type of recommended repair

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- Location of a recommended maintenance item (near, far, left, right, entire span, etc.)
- Estimated quantity of a recommended repair
- Priority code of a recommended repair

Maintenance Priority Codes listed on the D-450M Form are:

- 0 – Prompt action required;
- 1 –High Priority, as soon as work can be scheduled;
- 2 – Priority, review work plan, adjust schedule as needed;
- 3 – Add to scheduled work;
- 4 – Routine structural can be delayed until funds are available;  
and
- 5 – Routine non-structural can be delayed until programmed.

Maintenance items coded a “0” or “1” should be considered high priority maintenance items, requiring immediate attention.

All of this discussion was intended to provide an understanding of the BMS2 system as a tool with several uses. The use presented here is the input and recording of information about the conditions and deficiencies of many individual bridges, resulting from the various inspection efforts across the state. Another important use of BMS2, which will be taken up in subsequent chapters of this handbook, is that reports about the aggregate conditions of bridges in a region, District, or County may be produced that guide the planning and programming of maintenance activities.

### Chapter 2 Best Practices

- Maintenance items are extracted from BMS2 with a Crystal report to develop the preservation projects.
- Inspection crews perform notify District Bridge Engineer via cell phone of critical structural items needing repair.
- Timely review of new and outstanding Priority 0 and 1 items by bridge inspection supervisor.
- Timely and effective scheduling to perform critical structural repairs.

## Chapter 3: Annual and Strategic Planning

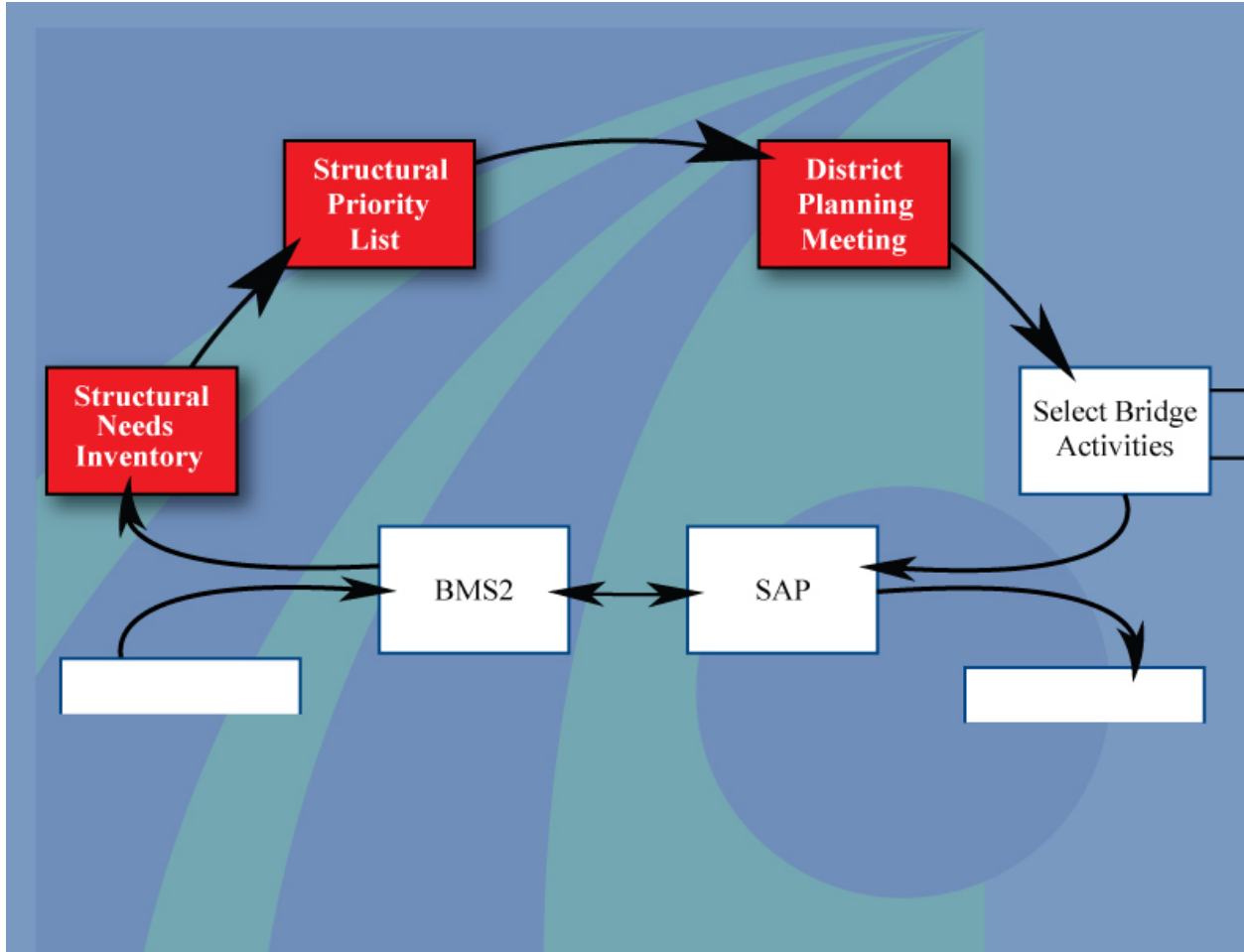


Figure 4 – Annual and Strategic Planning Section of Process Map

**Introduction**

In 2006, FHWA data showed that Pennsylvania's bridges were fifth in the nation in terms of highest percent of Structurally Deficient (SD) deck area at 20.3%. With 20.7 million square feet of total SD deck area, Pennsylvania is second to only California. Across the board, as our bridges age, a higher percentage of them become SD. The volume of bridges in each District that require preventive maintenance and repair is significant. Posted and closed bridges are a drag on the local economy. Local industry, milk, lumber, gas, oil, and agriculture need to get products to markets. Homeowners depend on product and service delivery, garbage removal, and heating oil. Most importantly, closed or restricted bridges hamper emergency services. The ultimate cost to the community is more than just money or inconvenience – it takes TIME and MONEY to replace a bridge.

Long-term, the growth rate for SD bridges in Pennsylvania is to be less than 800,000 SF / year due to an effective preservation program. However, statistics gathered starting in 2003 show a growth of 1.4 million SF / year. The short-term average is heavily influenced by the period 2005-2006, due to the re-inspection and re-rating of noncomposite prestressed concrete adjacent box beam bridges with new guidelines and to a number of large bridges becoming SD. The number of bridges eliminated from the SD category in Pennsylvania as a result of rehabilitation currently exceeds the number of newly designated SD bridges, but only by a small margin. Over time, without a conscientious and coordinated maintenance program, the increase in the number of SD bridges will exceed the number of bridges removed from the SD category.

However, looking at a comparison of total Priority Maintenance 0 and 1 items tallied in 2006 versus those tallied in 2007 for major bridge areas, there is cause for concern. The number of Priority 0 and 1 bridge maintenance activities identified in 2007 on bridge superstructures and substructures exceed those identified in 2006. The number of Priority 0 and 1 bridge maintenance activities for scour also rose in 2007. This upward trend is indicative of the aging of Pennsylvania's bridges and of the increase in the growth of SD bridges across the Commonwealth. Again, the goal is to perform maintenance on bridges *before* bridge conditions require Priority 0 or 1 activities to correct. Critical to turning the tide will be targeted strategic planning of improved efforts in maintenance activities.

It is clear, then that careful planning and programming of bridge maintenance activities is of the utmost importance. *The goal of preventive maintenance is, very simply put, to keep good bridges good.* This goal can be accomplished by developing a **strategic plan** to address bridge maintenance for critical components of the bridge.

A strategic plan is defined as the process of articulating direction and then making decisions on allocating resources. A strategic plan is used as guidance to define functional and divisional plans, which in this case, would be to address the problem of deficient bridges. While an annual plan (also discussed in this chapter) focuses bridge maintenance efforts on immediate needs, the strategic plan looks forward several years, to upcoming and often large-scale needs, as well as routine maintenance items that do not occur every year. If the annual plan can be regarded as a cycle of advancing, yet complementary activities, a strategic plan can be thought of as a cycle of cycles.

### Developing a Strategic Plan

By developing and implementing a strong Strategic Plan, the District can accomplish a major goal, which is to support the reduction of SD bridges by ensuring regularly scheduled maintenance. Developing and maintaining a plan for completing critical preventive maintenance items is a vital step in ensuring continued serviceability of our bridges.

### Pertinent Issues

- Clear, concise document.
- Cycle of cycles.

A well-developed strategic plan does not have to be large or complicated. Four or five pages that address certain components should be sufficient. The components that should appear in a strategic plan are:

- a statement of goals and objectives;
- routine maintenance cycles;
- bridge element life cycles;
- resources;
- funding; and
- performance measures.

Further, a well-developed strategic plan should prioritize the Districts' highway structures using the Business Plan Networks model. Within this model, the roadway network is prioritized by four categories: Network 1 – Interstate highways; Network 2 – NHS highways; Network 3 – Non-NHS highways with ADTs greater than 2,000; and finally Network 4 – Non-NHS highways with ADTs less than 2,000. By focusing on Business Plan Networks 1 and 2, our focus effectively becomes commercial routes, in essence caring for the "trunk of the tree."

As a concept of cycles and activities for critical components, a strategic plan can set the schedule of what work is to be done and at what frequency. The critical components best served by a strategic plan because of their acknowledged life cycle and well-documented costs and impacts include:

- deck overlays,
- joints,
- scour,
- some structural repairs, and
- painting

Along with a maintenance cycle consisting of regularly scheduled cleaning of bridge decks, bearings, and joints and preventive maintenance of stream banks and channel alignments, strategically planned activities such as resealing joints and replacing deck wearing surfaces can significantly extend the service life of bridges and prevent the accumulation of higher priority maintenance items on a County's bridge system. It is essential that management of these activities include tracking and managing the

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repairs and combining maintenance projects for economies of scale.

County Maintenance Managers (CMMs) must work with the District Bridge Unit and District Maintenance Unit in developing a strategic plan that *prioritizes bridge preventive maintenance activities* within the annual county maintenance work plan. The plan should address routine maintenance items such as cleaning decks and scuppers as well as preservation, such as joint repairs, scour mitigation and waterproofing decks (applying membranes, placing latex overlays and filling grid decks, etc).

For each activity in the strategic plan, careful analysis of the required schedule, budget, labor, and equipment is necessary to determine if the work can be completed by the county bridge crew or by contracted forces. Ultimately, development should result in a plan for each critical component that looks like the following:

1. A district has 25 bridges, with a yearly budget equaling \$20,000
2. The cost to reseal the joints on a single bridge is approximately \$4,000, with labor, equipment, water truck rental, and traffic control.
3. A typical joint seal requires replacement every 5 years.
4. Thus, five bridges can be maintained at that yearly budget.
5. The strategic plan is to replace the joint seals on five bridges a year for four years. In the fifth year, the cycle starts again on the first bridge.

### Developing an Annual Maintenance Plan

When developing the annual maintenance plan and schedule, consideration must be given to allowing adequate time in budgets and schedules for developing design details (if necessary), procurement of materials and obtaining Erosion and Sedimentation Control and DEP stream encroachment permits, if necessary.

Additionally, bridges on routes which require significant traffic control (such as Interstates and major arterials) and/or have particular access issues (such as over major rivers, railroads, etc.) will require increased budgets and schedules. If design details cannot be prepared by the District Bridge Unit, additional time should be allotted for

a contract to be executed between the District and a design consultant for the work.

### Pertinent Issues

- The basic planning process.
- Specific improvements?

For bridge maintenance to be efficiently implemented, the county must develop an annual plan that addresses the three major types of bridge maintenance:

1. *Preventive Maintenance Activities*—includes deck and drainage system cleaning, as outlined in Chapter 3A;
2. *Priority Bridge Repairs*—includes structural repairs to bridge components with Priority Codes 0 & 1, as indicated on the bridge inspection report, as outlined in Chapter 3B;
3. *Non-Regular Maintenance*—includes major bridge repairs and bridge rehabilitation projects, as discussed in this chapter.

The CMMs are responsible for coordinating with the District Bridge Unit in establishing a list of projects for each of the three bridge maintenance categories, determining available funding, and determining the amount and type of work that can be accomplished by the county bridge crew or by contractors. Details on preventive maintenance activities are included in Chapter 3A of this handbook, structural repairs are included in Chapter 3B of this handbook, while procurement and contracts details are addressed in Chapters 5 and 6, respectively.

*NOTE: The importance of scheduling and implementing preventive maintenance measures cannot be emphasized enough. Preventive maintenance is considered to be a primary deterrent to premature deterioration of critical structural elements of bridges, and as such, commands high priority in the realm of work planning, scheduling and accomplishment.*

In general, the process for planning annual bridge maintenance activities is as follows:

**Structure Needs Inventory**

The process of planning and programming bridge maintenance begins with an inventory of the structural deficiencies found during the routine NBIS inspections. A report is generated by the District Bridge Unit using BMS2 data showing the general condition of the bridges within the District to develop a picture of what the bridges need within the District.

**Pertinent Issues**

- Assembling your needs inventory
- Use of BMS2 data

**Structure Priority List**

From the Structure Needs Inventory the District Bridge Unit develops a Structure Priority List. This list prioritizes structures requiring work, considering both the needs and sizes of the bridges. This list is developed with communication and cooperation between the District Bridge Unit and the County Maintenance Managers. Work is categorized by work force capabilities, that is, determining work to be performed by Department Forces and work that should be contracted with private firms.

**Pertinent Issues**

- Prioritizing your bridge work
- Work typically done by Department Forces
- Work typically contracted out

1. A series of meetings should take place between the District Bridge Unit, the District Maintenance Unit and the County Maintenance Office. The first meeting should be held in January, and should include:
  - Bridge Engineer;
  - Bridge Inspection Engineer;
  - District Bridge Maintenance Coordinator;
  - Maintenance Programs Engineer.

In this meeting a list of needs based on BMS2 data are identified for all of the County's bridges. The District Bridge Unit will develop the needs based on the bridge inspection reports and feedback from the CMMs. These needs include

preventive maintenance, which is cyclic, and priority bridge repairs.

A list of projects to be completed by the county in the coming year should be prioritized and agreed upon by this group. From this list the CMMs later develop their Annual Work Plan, which is a plan of work to be performed by Department Forces during the fiscal year, beginning July 1. An approximate cost estimate for the project should be developed and compared against the available bridge maintenance funds as well as the available funds in the county maintenance budget.

2. After the budget is approved, a more detailed estimate is developed to determine the personnel and equipment requirements to accomplish the work. This estimate is compared to the personnel and equipment available within the county. The need for certain skills or special equipment must be identified and accounted for.
3. If the Department does not have, or is unable to procure specialized equipment, or if Department Forces do not have the particular specialized skills required, a plan should be developed for contracting these items to private contractors.
4. A second meeting should take place, before April, including the:
  - Maintenance Program Engineer;
  - District Bridge Maintenance Coordinator;
  - Bridge Unit Representative;
  - County Maintenance Manager;
  - Assistant County Maintenance Manager;
  - County Bridge Foreman.

The purpose of this meeting is to develop an Annual Work Plan from the list of bridge projects assigned to the county to complete during the previous meeting(s). The counties should design the work plan to have a minimum of eighty percent (80%) of available bridge crew man-hours in maintenance periods one and three for bridge maintenance activities. This schedule may include

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711-7325-01 activities (Repair or Replacement of structures under 8' in length). This requirement is not intended for counties that do not have a dedicated bridge crew. The Bridge Maintenance Coordinator will develop contracts to complete the remainder of the work by contracted forces.

### **Non-Regular Maintenance**

During the bridge's lifespan, rehabilitation or replacement of certain elements becomes necessary in order to ensure the bridge remains serviceable and to prevent advanced deterioration of critical structural members. In some instances, bridge components become deteriorated to the point that replacement of those components becomes the most cost-effective method to keep a bridge serviceable.

Evaluating bridge inspection reports to determine if a major rehabilitation is warranted plus scheduling of large-scale maintenance activities (such as bridge painting) is an important part of the planning process. The District Bridge Unit will determine the type and scope of non-regular maintenance activities, with input from the District Bridge Maintenance Coordinator and County Maintenance Manager. These activities can be accomplished by either the county bridge crew or by contracted forces; each proposed activity needs to be evaluated to determine if the necessary manpower and equipment are available in the county for the activity and if the work can be effectively scheduled into the county bridge crew's annual work plan.

Because of the larger scope of these projects, completion may be best accomplished by contractors with specialized equipment and resources (such as environmental safety equipment for sandblasting and painting). These contracts are typically prepared by the District Maintenance Unit and completed under the supervision of the District Construction Unit. County Maintenance Managers must consider these contracts when developing the strategic plan and budget for their county's bridge network. Refer to Chapter 6 for details on the contracting process for bridge maintenance work.

Examples of non-regular maintenance include deck replacement, underpinning, joint replacement, steel dam deck joint

rehabilitation/replacement, extensive superstructure painting, pedestal replacement, and stringer/beam replacement. Design details for certain activities may need to be provided by the District Bridge Unit. County Maintenance Managers must allocate adequate budget resources for these activities as part of their annual budgeting process.

In general, non-regular maintenance activities should be prioritized based on the Average Daily Traffic (ADT) of the route; the structural condition/sufficiency rating of the bridge, including the number of high-priority repairs required; the ability to incorporate bridge repairs into upcoming highway restoration or improvement projects; and the anticipated time until replacement of the bridge. Maintenance activities for bridges that have already been programmed for replacement (see Transportation Improvement Plans below) should have the goal of maintaining the bridge's current serviceability level until the date of replacement. However, high-priority maintenance items that can affect the safety of the bridge (Priority 0 and 1 items) need to be addressed as soon as possible regardless of the bridge's rehabilitation or replacement status.

### **Transportation Improvement Plans**

Maintenance projects that may be too large for Department Forces, or which can leverage Federal funding, are sometimes programmed through a regional Metropolitan Planning Organization (MPO) or Rural Planning Organization (RPO) Transportation Improvement Plan (TIP). The TIP is useful to Districts in several ways; as a means of programming large maintenance projects, and as a means to remove smaller maintenance projects from annual planning due to an upcoming rehabilitation or replacement project.

A TIP is a four-year program developed by each MPO, RPO, and one Independent County, that lists all highway, bridge, and public transportation projects that anticipate federal and state capital funds. All the MPO, RPO and Independent County TIPs are incorporated into a Statewide TIP (STIP), which is approved by the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the Environmental Protection Agency (EPA).

*During the District annual planning meeting the TIP should be examined for listings that match the bridge list for that District. If a rehabilitation*

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or replacement project is upcoming, resources for preventive maintenance may be diverted to other priorities. The need for repairs to a bridge programmed for major work should be weighed against the critical nature of the repair and the time until the rehabilitation or replacement is scheduled.

As the Districts update the TIP, the process for prioritization and programming of bridge projects shall be in accordance with SOL 430-07-05, Risk Assessment for PennDOT-Owned Bridges and Structures Report. The Risk Assessment report provides the methodology and factors used to calculate a risk score and rank for all 25,000 state-owned bridges. The key factors include the bridge size and physical condition, importance to the highway system, effects on road user costs and implications to commerce. In addition, the Districts, through the Risk Assessment, can establish scopes of work (i.e. full replacement, superstructure replacement, deck replacement, etc), estimated projects costs and generate a cash flow analysis. As the Department continues to improve bridges by rehabilitation and replacement, the inventory of SD bridges will be reduced and also the risk levels.

The SAFETEA-LU authorization allows the use of federal funds for bridge preservation. The guidelines are listed in Design Manual, Part 4, Section A, Policy and Procedures, Section 5.6. This Section indicates that all highway bridges are eligible to use federal funds for bridge preservation work so long as the bridges meet the NBIS length requirement. Bridges that do not meet the NBIS length requirement must use state funds for preservation. Further, all federal aid projects must be added to the appropriate TIP. See DM-4 for a list of eligible work items for bridge preservation.

### STREAM PERMITTING BASICS

Discussed below is basic stream permitting information. The Bridge Maintenance Coordinator must be familiar with types of permits and methods for obtaining permits, as they often present significant impacts to the schedule. In some districts, the Maintenance Environmental Planner prepares the waterway permits for maintenance work orders.

#### Terminology

*Bog Turtle Habitat Screening*

A screening for bog turtle habitat is required for all projects that impact wetlands in the following counties: Adams, Berks, Bucks, Chester, Cumberland, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Schuylkill and York (PA DEP Document # 3930-PM-WM0550).

#### *Chapter 105*

The rules and regulations of Title 25 (Environmental Protection), Chapter 105 (Dam Safety and Waterway Management) as listed in the PA Code ([www.pacode.com](http://www.pacode.com)). A Chapter 105 Authorization is the Water Obstruction and Encroachment Permit.

#### *Earth Disturbance*

Any activity which disturbs the surface of the land. This includes any excavation or fill within a stream channel. This includes full-depth reconstruction but excludes mill & overlay.

#### *Floodway*

The channel of the watercourse and portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by the Federal Emergency Management Agency (FEMA). In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed, absent evidence to the contrary, that the floodway extends from the stream to 50 feet beyond the top of the stream bank.

#### *GP-3 (General Permit BDWW-GP-3)*

General Permit #3 for Bank Rehabilitation, Bank Protection and Gravel Bar Removal (PA DEP Document # 3930-PM-WM0503).

#### *GP-7 (General Permit BDWM-GP-7)*

General Permit #7 for Minor Road Crossings (PA DEP Document # 3930-PM-WM0507).

#### *GP-8 (General Permit BDWM-GP-8)*

General Permit #8 for Temporary Road Crossings (PA DEP Document # 3930-PM-WM0508).

#### *GP-11 (General Permit BWM-GP-11)*

General Permit #11 for Maintenance, Testing, Repair, Rehabilitation, or Replacement of Water Obstructions and Encroachments (PA DEP Document # 3930-PM-WM0511).



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### *HQ/EV*

High-Quality/Exceptional Value stream as defined in PA Code, Title 25 Environmental Protection, Chapter 93 Water Quality Standards.

### *Joint Permit (Water Obstruction and Encroachment)*

The Water Obstruction and Encroachment Permit issued jointly by PA DEP for the Chapter 105 authorization and US Army Corps of Engineers for the 404 authorization (PA DEP Document # 3930-PM-WM0036).

### *Minor Stream Crossing*

A bridge/road crossing a wetland which disturbs less than 0.1 acre of wetland or crossing a stream where the watershed is less than 1.0 square mile.

### *PNDI*

Pennsylvania Natural Diversity Inventory search (PA DEP Document # 8100-FM-FR0161) for threatened and endangered species. This search and clearance is required for all projects, regardless of permit level.

### *Programmatic Permits (General Maintenance)*

Generic Permits issued by PA DEP to each District to cover minor repairs and maintenance:

- E61-9999 for District 1-0;
- E17-9999 for District 2-0;
- E41-9999 for District 3-0;
- E35-9999 for District 4-0;
- E39-9999 for District 5-0;
- E23-9999 for District 6-0;
- E22-9999 for District 8-0;
- E07-9999 for District 9-0;
- E32-9999 for District 10-0;
- E02-9999 for District 11-0;
- E26-9999 for District 12-0.

### *Regulated Waters of the Commonwealth*

Watercourses, streams or bodies of water and their floodways wholly or partly within or forming part of the boundary of the Commonwealth.

### *Stocked Trout Streams*

Regulated waters of the Commonwealth classified by the PA Fish & Boat Commission as waters approved for trout stocking (TSF).

### *Stream Enclosure*

A bridge, culvert or other structure in excess of 100 feet in length upstream to downstream.

### *Watercourse*

A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

### *Water Obstruction*

A dike, bridge, culvert, wall, wingwall, fill, pier, wharf, embankment, abutment or other structure located in, along or across or projecting into a watercourse, floodway or body of water.

### *Wetlands*

Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. Wetlands must be identified in accordance with the 1987 USACOE Manual for Identifying and Delineating Wetlands.

### **Permit Levels**

Chapter 105 (State authorization) and Section 404 (Federal Waterway) Permits are required for most bridge maintenance projects. The three different levels of Permits, in order of level of impact and effort, which may be required for bridge maintenance projects are:

- Programmatic Permit (General Maintenance);
- General Permit – 11 (Maintenance, Testing, Repair, Rehabilitation or Replacement of Water Obstructions and Encroachments);
- Joint Permit (Standard or Small Project).

Typically, bridge maintenance projects are covered by either a Programmatic Permit, also known as a General Maintenance Permit, or the General Permit – 11 (GP-11). The General Maintenance Permit is an existing authorization issued by PA DEP to each District for preventive maintenance, repair and rehabilitation. The GP-11 authorization is issued for each project individually. The General Maintenance Permit, GP-11, and Joint Permit are exclusive, only one will be required for each project. If the maintenance project does not meet the General Maintenance or General Permit requirements (ie. a Joint Permit is required), the District Environmental Unit should be contacted. Generally, maintenance projects will be covered

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by Maintenance or General Permits. The scope of maintenance projects does not typically require a Joint Permit.

The above permits cover the typical bridge maintenance project. If the maintenance activity includes work outside the immediate footprint of the structure, some or all of the following permits may be necessary:

- Bank Rehabilitation, Bank Protection and Gravel Bar Removal: General Permit – 3 (GP-3);
- Minor Road Crossings: General Permit – 7 (GP-7);
- Temporary Stream Crossing: General Permit – 8 (GP-8).

These permits are separate from and in addition to the authorization for the bridge maintenance. If these conditions apply to the maintenance activity, or if the work will be performed by an outside consultant, contact the District Environmental Unit for assistance.

All permitting levels require a PNDI search and clearance that no threatened or endangered species will be impacted by the proposed activity. The clearance process can take 1-2 months if known species are present. This clearance must be performed in advance of submitting the permit application.

### **General Maintenance (Programmatic) Permit**

For many projects, the District can obtain an authorization for activities under a standing General Maintenance Permit. This District-wide permit allows for minor stream encroachment activities and is intended for use at low-sensitivity, low-impact projects. These projects meet the following criteria:

- No wetlands present in project area;
- No changes to hydraulic openings as part of the activity;
- No HQ/EV (High Quality/Exceptional Value) streams.

### **Applicability**

A General Maintenance Permit is valid for:

- Minor repairs (deck, wingwalls, footings, etc);
- Superstructure replacement;
- Channel cleaning within 50' of bridge.

A General Maintenance Permit is NOT valid for any of the following:

- Pier and abutment replacement;
- Profile adjustments;
- Horizontal and vertical clearance reductions;
- Bridge widening;
- Wetland impacts.

If the General Maintenance Permit is not valid for the proposed maintenance activities, evaluate the applicability of the GP-11.

### **Procedure**

The requests for authorization to use the General Maintenance Permit are generally submitted through a letter of request to the PA Department of Environmental Protection (PA DEP). The request letters are prepared and submitted by the Bridge Maintenance coordinator with support from the District Environmental Unit. This request must include:

- A narrative of the proposed activities;
- A proposed work schedule;
- A simple sketch plan detailing the proposed work (locations of cofferdams, underpinning, streambank restoration, etc.);
- A location map;
- Act 14 Municipal notification letter;
- Current PNDI run and clearances.

Multiple projects can be submitted with one letter of request by using a table or a single page of information with plans, for each project.

A copy of the request letter and plans which were sent to the PA DEP office must also be sent to both the Regional Office of the PA Fish and Boat Commission and the appropriate County Conservation District Office to inform these agencies of the proposed project. For General Maintenance Permits, no Erosion & Sediment Pollution Control plans/authorizations are required to be included with the submission to PA DEP, even if they are required for the project.

Typically, DEP turnaround time for General Maintenance Permit requests is 30 days or less. PennDOT will receive a letter of authorization from the PA DEP with the attached copy of the

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Federal Permit-Pennsylvania State Programmatic Permit. These authorizations are for one time use only by PennDOT. There are no permit application forms for the General Maintenance Permit.

### General Permit – 11

If a project does not qualify for the General Maintenance Permit, the applicability of the GP-11 should be evaluated. The GP-11 differs from the General Maintenance Permit in that it is issued per location (i.e., each project has its own individual permit) rather than issued District-wide. Once a GP-11 permit is issued for a location, future maintenance may be completed without a new permit submission to the PA DEP office as long as the PA DEP office is notified in writing with a reference to the issued GP-11 and also provided that the activity does not substantially change the characteristics of the bridge that were originally permitted. However, this multiple use is limited because of the need for a Federal Permit from the Corps of Engineers. The Corps of Engineers may require a review of the future maintenance and re-issuance of a new Federal permit. Contact should be made with the U.S. Army Corps of Engineers before any future maintenance is completed.

### Applicability

A GP-11 is valid for the following projects:

- Maintenance, testing, repair, rehabilitation or replacement of existing bridges and culverts;
- Minor deviations in the structure's configuration and roadway profile;
- Minor deviations in hydraulic capacity;
- Increases in bridge/culvert length up to 12 feet on each side of the bridge;
- Channel clearing within 50' of bridge.

A GP-11 is NOT valid for any of the following:

- Stream relocations;
- Wetland impacts exceeding 0.05 acre;
- Projects likely to impact historical, cultural or archaeological sites;
- New structures;
- Direct/indirect effects on state/federal species of special concern

If the project does not qualify for the GP-11, a Joint Permit is required. Maintenance projects do not typically require a Joint Permit.

### Procedure

The GP-11 requires the completion of the GP-11 application form, located on the DEP website. Applications are prepared and submitted by the Bridge Maintenance Coordinator. Proposed projects should be reviewed with the District Environmental Unit to determine if GP-11 is suitable for the project. Sample GP-11 submissions are located on the PA DEP website. The GP-11 application includes:

- Signed and completed GP-11 registration request;
- Act 14 Municipal Notification letter;
- Sealed sketch plans and cross sections;
- Current PNDI run and clearances;
- Bog turtle habitat screening (Adams, Berks, Bucks, Chester, Cumberland Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Schuylkill or York Counties only);
- Engineer's seal and signature on the engineering drawings;
- Erosion & Sediment Control Plan;
- Detailed Hydrologic & Hydraulic Study signed and sealed by a licensed Professional Engineer for projects that may increase flooding in the 100-year storm;
- Wetland information data sheets if the project impacts wetlands (temporary or permanent);
- Location Map (USGS Quad Map);
- Photos upstream and downstream of the existing structure.

DEP generally processes a GP-11 application within 60 days of receiving the application as long as no deficiencies are identified concerning the information which is submitted by PennDOT. The Federal Section 404 Permit may or may not be attached by the PA DEP office depending upon the status of PennDOT coordination concerning clearance for the project regarding the bog turtle. Contact with the PennDOT District Environmental Unit is recommended if wetlands are involved with a General Permit Number 11 application.

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### Existing Authorizations

Existing authorizations can be located on the PA DEP eFacts website ([www.dep.state.pa.us/efacts](http://www.dep.state.pa.us/efacts)). Normal repairs and maintenance on encroachments permitted

after July 1, 1979 are authorized under the existing permit. All other activities require new authorization as described in the following table:

**Table 2 – Activities That Require New Authorization**

Date	Type of Maintenance	Permit Requirements
Authorization issued before July 1, 1979 . . .	All repairs and maintenance.	Requires new permit.
Authorization issued after July 1, 1979 . . .	Normal repairs and maintenance.	Authorized under existing permit
	Repairs or maintenance involving modification from its original specifications and a repair or reconstruction involving a substantial portion of the structure.	Requires new permit.

### Emergency Procedures

If it is determined that the condition of a structure poses an immediate threat to health or safety, notification shall be immediately issued to PA DEP and responsible authorities in adjacent and downstream communities, including emergency management authorities. Follow Pub. 550 "Disaster Recovery Manual" for guidance on emergency repairs.

### Chapter 3 - Best Practices

- Develop Strategic Maintenance Plan
- Bridge Maintenance Coordinator attends monthly county manager meetings.
- Bridge Maintenance Coordinator and Assistant DBE-Inspection meet with counties on yearly basis to set work and repair priorities.
- Bridge work orders are reviewed by DBE and ADE-Maintenance prior to meetings with counties.
- District Bridge Engineer meets twice a year with county managers.
- Assistant DBE - Inspection uses Access database or Excel spreadsheet to indicate and track bridges that require preservation, such as scour protection, membrane waterproofing, and painting out 20 years.
- Performance Measure to track spending of preservation funds.
- Leverage Federal funds for preservation activities via the TIP

Chapter 3A: Preventive Maintenance

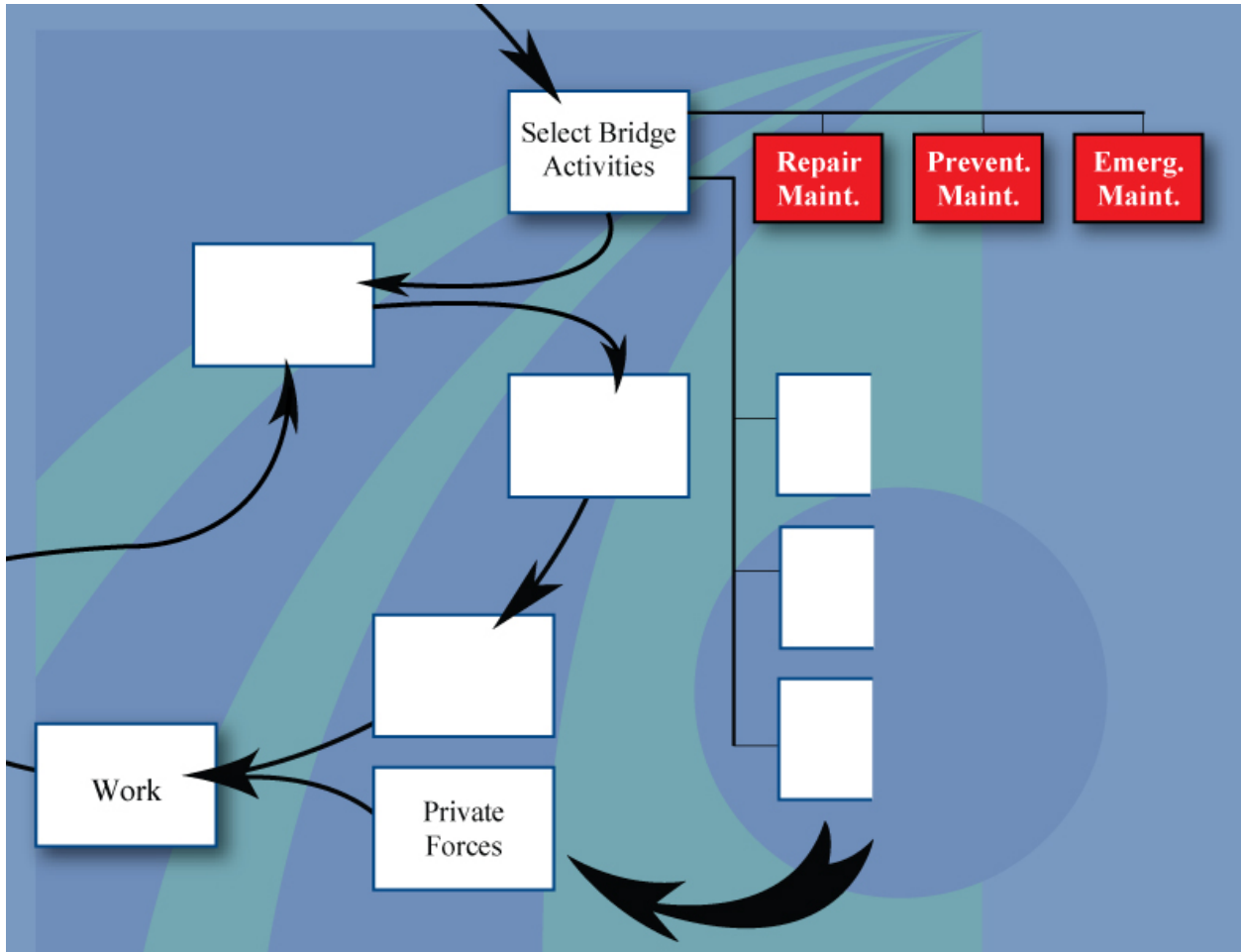


Figure 5 – Preventive Maintenance Section of Process Map

**Introduction**

Deterioration of structures must be minimized to assure the mobility and safety of the traveling public, efficient movement of goods, and appropriate return on the nation’s investment in its bridges. Preventive maintenance is a planned strategy of cost-effective treatments to a structure to preserve it in its present condition and to retard future deterioration. The objective of preventive maintenance is to extend the service life of a bridge before bridge conditions deteriorate to a level requiring corrective maintenance, such as structural repairs. On the other hand, corrective maintenance involves activities or operations applied to fix bridge deficiencies. Preventive maintenance is applying the right treatment, to the right structure, at the right time. Preventive and corrective maintenance are both desirable in a comprehensive bridge preservation program, but

emphasis should be placed on preventive maintenance, since costs associated with corrective maintenance can be significant. Our ultimate goal is to perform activities that will preserve bridge components in their present (or intended) condition as well as forestalling development of a structural deficiency. Each of the preventive maintenance items recommended in D450M Maintenance Needs Data screen contain a BMS activity number that can be used to reference Publication 55 for further guidance.

Typically, we can classify these activities into two groups:

**Scheduled Preventive Maintenance**

Scheduled preventive maintenance activities are regularly performed at a designated frequency:

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**Table 3 – Scheduled Preventive Maintenance**

Maintenance Item	Frequency
Cleaning decks, seats, caps, and salt splash zones	Annually (except in Philadelphia and Allegheny Counties, where it is performed biennially) per CMMT18
Cleaning bridge drainage systems	Annually
Cleaning and lubricating expansion bearing assemblies	Annually

### Response-Type Maintenance

Response-type maintenance activities are performed on an as-needed basis and identified through the inspection process:

- Resealing expansion joints
- Painting structural steel members
- Removing debris from waterway channels
- Replacing wearing surfaces
- Extending or enlarging deck drains
- Repairing impact damage

Repairing impact damage to steel girders requires very careful attention. Unless corrective measures are taken, fracture of the beam can occur due to impact at the original damage location or at another point on the beam. The corrective measure to prevent fracture is to grind the impact damage. The procedure is as follows:

- Grind impact area to bright metal to remove any irregularities and surface defects. Using a sanding disc, smooth area and round over edges. Finish grinding should be done parallel to the stress so this ensures that transverse grind marks are not present.
- If the impact is within the proximity of a welded detail, the weld toes should be smoothed with a die grinder to ensure that no microcracks were introduced during the impact. Using a sanding disc, smooth the area and round over edges. Finish grinding should be done parallel to the stress so this ensures that transverse grind marks are not present.
- The impact area should be faired back to the material edge at not less than a 1 to 10 slope.

- The area should be thoroughly inspected, including any weld toes of details within the vicinity of the impact using ultrasonic or magnetic particle testing as appropriate for the detail.

### Pertinent Issues

- The most common response-type maintenance activities statewide
- The most common response-type maintenance activities regionally

### Introduction to Publication 55

Much of the information regarding Preventive Maintenance is gleaned from Publication 55, titled "Procedures and Standards for Bridge Maintenance," a reference tool for maintaining state-owned bridges. This manual describes the procedures and standards for a multitude of activities related to bridge repair and maintenance. It is organized into eighteen chapters, each chapter considering a different structure element and the repair and/or maintenance activities associated with it. This section will discuss only those activities related to preventive maintenance.

Each activity given in Publication 55 has a rigid outline consisting of seven components. The first component acts to identify the activity. This activity identifier includes a BMS Activity Number, an Activity Title, a Unit of Measurement and a Procedure. The BMS Activity Number is the same number that appears in Form D-450M for a particular maintenance activity.

It is encouraged that any preventive maintenance be scheduled in such a way that it will maximize economies of scale. That is, work that is similar should be applied to as many locations as possible or advantage should be taken of similar work efforts. In addition, response-type efforts should be performed when work of a scheduled nature is underway, such as: when the deck and scuppers on a bridge are being cleaned, the crew should clean the expansion joints and troughs as applicable.

### **Chapter 3A - Best Practices**

- Maintain the vast number of masonry arch bridges through a district-wide masonry repointing contract.
- Reseal all leaking joints on Interstate bridges.
- Bridge Maintenance Coordinator prepares work plans and coordinates with Assistant County Maintenance Manager.
- Bridge Maintenance Coordinator tracks schedules, develops design, performs field surveys and stakeouts, and performs construction inspection for Department Force Projects.
- Preservation work performed by Department Forces can include streambed paving, paving of metal pipes, underpinning, rock protection, joint sealing and installation of waterproofing membranes.

Chapter 3B: Structural Repairs

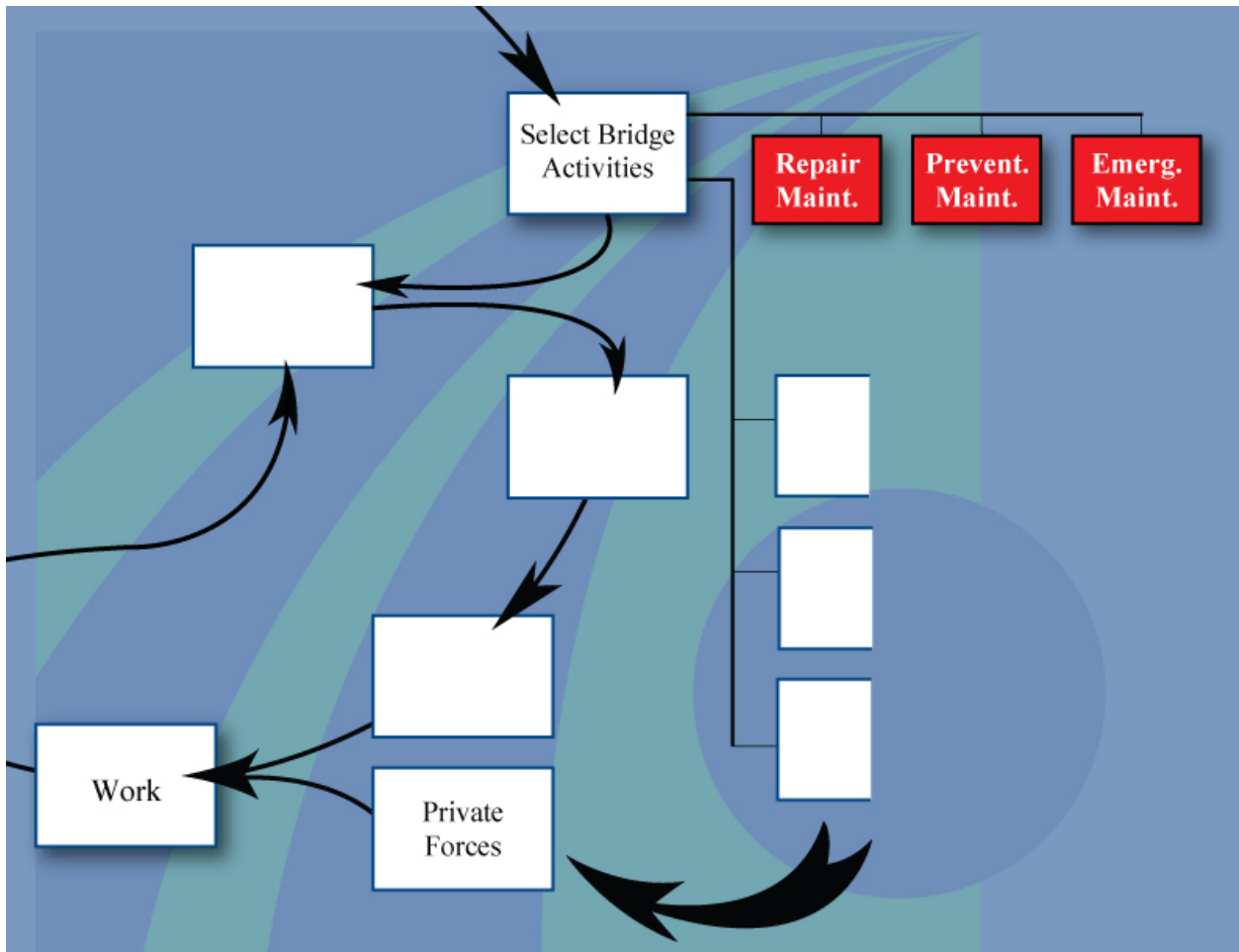


Figure 6 – Strategic Repairs Section of Process Map

**Introduction**

Before discussing structural repairs, it would be best if we start by clearly defining the difference between structural repairs and preventive maintenance as it relates to maintaining state-owned bridges. Structural repairs are defined as those activities that consist of repairing structural deficiencies identified in the bridge inspection report in order to increase or maintain the existing capacity of the structure. Looking back at Chapter 3A, recall that preventive maintenance is defined as those activities that consist of maintaining structural elements of a bridge on a regular or cyclic basis in order to sustain the expected service life of the structure, forestalling development of a structural deficiency. Each of the structural repairs recommended in D450M Maintenance Needs Data screen contain a BMS activity number that

can be used to reference Publication 55 for further guidance.

**Top Structural Repairs**

This section contains a discussion of the top structural repairs that are commonly performed on bridges. Additional information is provided in this section to supplement the information provided in Publication 55.

**Pertinent Issues**

- The most common structural repair activities statewide
- The most common structural repair activities regionally
- Complex repairs



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**Table 4 – Top Structural Repairs**

<b>Activity</b>	<b>BMS Activity No.</b>	<b>Pub 55 Page No.</b>	<b>Pub 408 Section/ Standard Details</b>	<b>Reason for Activity</b>
Steel Stringer or Floorbeam or Girder (Repair/Replace)	A744602 Or B744602 Or C744602	11-1	1060, 1105	Leaking deck joints of steel stringer bridges often result in rusting of the ends of the beams below the joints. When the results of the bridge inspection indicate that significant section loss to the beam webs has occurred, the load carrying capacity of the beams could be compromised. Repairing of the beam webs then becomes necessary. Reducing the water that reaches the beam ends should also be addressed when completing this beam repair.
Galvanized channel repair (damaged web)	---	---	---	Leaking deck joints of steel stringer bridges often result in rusting of the ends of the beams below the joints. When the results of the bridge inspection indicate that significant section loss to the beam webs has occurred, the load carrying capacity of the beams could be compromised. Repairing of the beam webs then becomes necessary. Reducing the water that reaches the beam ends should also be addressed when completing this beam repair.
Doubler Beam (for damaged stringers)	---	---	---	Leaking deck joints of steel stringer bridges often result in rusting of the ends of the beams below the joints. When the results of the bridge inspection indicate that significant section loss to the beam webs has occurred, the load carrying capacity of the beams could be compromised. Adding a supplemental beam is an option to increase the capacity of the member.
Reinforced/Prestressed Concrete Stringer or Diaphragm or Other Members (Repair/Replace)	A744603 Or B744603 Or C744603	12-1	1001, 1003, 1080, 1107, 1091 BC-783M	Leaking deck joints of reinforced concrete and prestressed concrete beam bridges often lead to concrete spalling at the ends of the beams below the joints. When the bridge inspection or other report indicates that significant spalling has occurred that exposes the reinforcement bars or prestressing strands, repairing of the beam webs then becomes necessary. Reducing the water that reaches the beam ends should also be addressed when completing this beam repair.
Bearing Pedestal Repair	---	---	---	Cracking or spalling of the bearing pedestal will result in the need to perform a spall repair. Spalls are caused by

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<b>Activity</b>	<b>BMS Activity No.</b>	<b>Pub 55 Page No.</b>	<b>Pub 408 Section/ Standard Details</b>	<b>Reason for Activity</b>
				reinforcement bars that have expanded due to rusting and water freezing in cracks.
Resetting Bearings	---	---	---	Bearings become frozen as a result of lack of regular lubrication in addition to rusting from water intrusion thru the joints, as well as debris from the deck. A frozen bearing cannot rotate in response to the expansion and contraction of the structure. In the worst case, the bearing will be pushed or pulled over, ratcheting the bearing and allowing movement in only one direction as a result of the expansion/contraction forces.
Concrete Deck (Repair)	D744303	8-7	1040 BC-783M	Deterioration of the top surface of a cement concrete deck will result in the need to perform a concrete deck repair. Rusting of the top layer of reinforcement bars, accelerated by the penetration of chlorides to the reinforcement bars, could lead to the formation of concrete spalls, due to rusting reinforcement bars expanding and water freezing.
Abutments (Spall Repair) and Bearing Seats (Repair)	B744802 And D744503	14-5	1001, 1002, 1003, 1017 BC-783M	Spalling of the exposed surface of a concrete abutment backwall, cheekwall, stem, or wingwall will result in the need to perform a spall repair. Rusting of the top layer of reinforcement bars, possibly accelerated by the penetration of chlorides to the reinforcement bars due to water leaking through deck expansion joints could lead to the formation of concrete spalls. Spalls are caused by reinforcement bars that have expanded due to rusting and water freezing in cracks.
Pier Repairs	---	---	BD-629M (Sheet 15 of 15), Special Provision 97080600	Spalling of the exposed surface of a concrete pier will result in the need to perform a spall repair. Rusting of the top layer of reinforcement bars, possibly accelerated by the penetration of chlorides to the reinforcement bars due to water leaking through deck expansion joints could lead to the formation of concrete spalls. Spalls are caused by reinforcement bars that have expanded due to rusting and water freezing in cracks.

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<b>Activity</b>	<b>BMS Activity No.</b>	<b>Pub 55 Page No.</b>	<b>Pub 408 Section/ Standard Details</b>	<b>Reason for Activity</b>
Abutments (Crack Repair)	B744802	14-5	1001, 1002, 1003, 1017, 1091, Special Provision 97080600	<p>Settlement of an abutment can lead to a crack. Concrete shrinkage due to curing, or movement due to temperature change, can also cause cracking.</p> <p>The cause of the crack should be determined first. A crack could be a symptom of a larger structural problem that should be addressed. It is important to determine if the crack is static, or is active. If the crack is static, then performing only the crack repair will be sufficient. However, if the crack is changing in width over time, the cause for the movement, such as abutment settlement, needs to be addressed or the crack will reappear.</p>
Masonry (Repoint)	B744804	14-38	1017	<p>Stone masonry mortar pointing can deteriorate over time due to water penetration and freeze/thaw, resulting in a need for repointing. The mortar bonds the stones together into a solid unit and protects the wall from water penetration. Because a stone masonry abutment also serves as a retaining wall there is often saturated backfill behind the wall. Therefore, in some instances it is advantageous to have some open joints without mortar in the wall to act as weep holes to allow water to drain from behind the wall, in which case repointing all of the joints can be detrimental to the wall unless weep holes are provided.</p>
Footing (Underpin)	E744803	14-34	1001, 1002, 1003, 205, 850	<p>High velocity stream flow during a high water event, an undersized bridge hydraulic opening, and/or an unstable stream bed can result in scour of the stream bed. If the scour depth extends below the bottom of footing elevation, a void could form in the soil or erodible rock on which the footing is founded.</p>

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Activity	BMS Activity No.	Pub 55 Page No.	Pub 408 Section/ Standard Details	Reason for Activity
Scour Hole	C745301	16-10	703, 205, 850	High velocity stream flow during a high water event, an undersized bridge hydraulic opening, and/or an unstable stream bed can result in scour of the stream bed. If the scour depth extends below the bottom of footing elevation, a void could form in the soil or erodible rock on which the footing is founded.
Repair/Reseal Deck Joints and Compression Seal Deck Joints (Repair/Rehabilitate)	A744101 and B744102	4-1	521, 705, Special Provisions 97050102, 97050101, 90080101, 97050201	Leaking deck joints often lead to deterioration to beam ends, bearings, and substructure units. Therefore, minimizing water penetration is a very important cost effective maintenance repair goal.
Structure Mounted Railing (Repair/Replace)	RLGSTRM	5-3	1001, 1002, 1003, 1013, 1014 BD-600M BC-700M	Many older bridges were constructed with structure mounted metal railings or other styles of railings such as open rail concrete barriers. These railings can be damaged from vehicle collision damage or have section loss due to steel corrosion or concrete spalling. Bridge inspection reports may also recommend railing replacement to improve safety features.

### Other Topics for Consideration

Although Publication 55 covers a multitude of standard structural repairs, there are other structural repairs that are fairly common in maintaining today's bridges. These other structural repairs require a design by a District Bridge Engineer as well as project specific supervision. In some instances, Publication 55 does address these other structural repairs, however, it is necessary to clarify that they are more complex repairs requiring careful consideration, design and supervision. For example:

- Non-composite prestressed concrete adjacent box beam bridges present a number of structural repairs that require careful consideration. The December 2005 collapse of a fascia beam on the bridge carrying S.R. 1014 over

Interstate 70 highlighted the need for special considerations in maintaining this structure type. For non-composite prestressed concrete adjacent box beam bridges the tops of the beams serve as the structural deck with a bituminous wearing surface applied. A cement concrete deck slab is not used. The lack of a concrete deck slab can result in an increase in water penetration especially if a membrane waterproofing is not present.

- This type of structure relies on only the shear keys and transverse tie rods or post tensioning strands, for the beams to act together. Longitudinal cracks in the bituminous wearing surface often form above the beam joints due to independent beam deflections, resulting

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in more water penetration. No concrete deck also increases fascia beam web cracking below concrete barrier open joints due to an abrupt change in beam stiffness at the barrier open joints. This abrupt change in stiffness is caused by the concrete barriers acting compositely with the fascia beams, except at the barrier joints. These fascia beam web cracks are therefore located in the water path below leaking barrier joints thereby compounding the problem.

- Structural repairs include concrete barrier retrofitting to eliminate open joints that cause cracks in the beams below these joints, and shear key re-grouting. In combination with shear key re-grouting, removing the existing bituminous wearing surface, installing a concrete wearing surface or composite concrete deck can extend the life of the structure.
- One other related item is cleaning the drain holes in the bottom of the box beams. Although this falls under preventive maintenance and should be a part of all bridge inspections, as applicable, it takes on a unique relevance for non-composite prestressed concrete adjacent box beams. With only a bituminous wearing surface, water is more likely to infiltrate the shear keys and curb areas, eventually entering the beam voids. If the drain holes are not open, the contained water is then subject to freezing and expansion, resulting in potential cracking of the sides and bottom of the box beams. This water adds deadload to the structure. Therefore, it is of high importance that all drain holes be cleaned during inspection, documenting which holes contain moisture/water as necessary.

Modular expansion dam repair warrants special consideration as well. Regarding this type of repair, the Engineer's design and plans as well as the Contractor's method of construction should be coordinated closely with the actual manufacturer of the proposed modular expansion dam to ensure proper preparation and installation.

Bridge painting due to lead based paint removal also warrants special consideration. Most older steel bridges contain lead based paint that results in the need for strict environmental control. Prior to starting a bridge painting project, the paint should be tested for lead and other hazardous materials under the supervision of the District Bridge Engineer. A project specific lead abatement program must be designed for the removal and proper disposal of lead based paint and blast material.

Truss or girder repairs involving a non-redundant structure load path clearly warrant special consideration. By definition, a non-redundant structure is one that the failure of one member could result in the collapse of the structure (usually a structure with only two lines of trusses or girders). Therefore, repairs of this nature should always include a design and procedure supplied by the District Bridge Engineer. Furthermore, the District Bridge Engineer should work closely with the Contractor to ensure the procedure is being satisfactorily implemented.

Bearing replacement warrants special consideration because it entails beam jacking and bearing design. An adequate beam/girder jacking scheme needs to be developed. This scheme should satisfy the design requirements (supporting the applicable bridge loads) and construction requirements (feasible to construct). In addition, this scheme should be closely coordinated with the maintenance and protection of traffic activities. In addition, if bearings are to be replaced, these replacement bearings should be designed as well, considering all applicable movements and rotations.

Formwork is not in itself a structural repair, nonetheless, it deserves mentioning. Formwork, including prebuilt forms, is an important part of most structural repair work and some preventive maintenance of a bridge. In the past, there has been no clear direction or guidelines provided for whether formwork needs to be designed or can simply be provided by Department Forces or a Contractor, partly because of its wide variety of applications. Many foremen learned to build formwork using standard tables and guides from the tie rod manufacturers or they use metal forms with

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their own guidance. The sales rep for the tie system has tables that make it easy for the foreman to build safe vertical formwork.

- If the work is to be completed by Department Forces, the District Bridge Maintenance Coordinator and the Bridge Unit should carefully consider the formwork necessary to complete the given repairs/maintenance for the specific bridge. Safety is the most important consideration when determining if formwork needs to be designed or can simply be provided. If it is apparent that a given formwork will present a safety concern, due consideration should be given to designing that formwork. Deflection is another consideration that may prompt a formwork design. For instance, in arch or box top slabs, the formwork may need to be designed due to deflection concerns. Finally, the location of the formwork should be considered. This includes the overall area to be formed and whether it is horizontal and/or vertical construction. If the formwork becomes too complex or extensive, consideration should be given to designing the formwork. If standard formwork is to be used, it can be designed by an Engineer. If prebuilt forms are to be used, most manufacturers provide representatives that can assist in checking over the design or provide an Engineer to design the prebuilt formwork. The District Bridge Maintenance Coordinator should work with the Bridge Unit to evaluate, review and design (if necessary) any formwork to be completed by Department Forces.

If the work is to be completed by a Contractor, it is the Contractor's responsibility to determine whether the necessary formwork needs to be designed. The structural repairs to be completed by the Contractor include the formwork, thus, the Contractor is responsible for determining if standard formwork would be adequate. If not, the Contractor can choose to call a manufacturer (for a prebuilt form) or obtain a design by an Engineer. If a prebuilt form is utilized, the Contractor should consider all aspects of the formwork (including safety) and if they are uncomfortable with the formwork, they can call the manufacturer and ask them to send a representative out to check over or design the formwork before they place the concrete, if necessary. Whether standard formwork is constructed or prebuilt forms are used, it is the Contractor's responsibility to consider the formwork associated with the necessary repairs or maintenance.

### Chapter 3B - Best Practices

- Utilize design squad to prepare maintenance, preservation projects and Interstate work.
- Repair sketches are developed by the Bridge Maintenance Coordinator in the Bridge Unit
- County bridge crews with substantial capabilities perform emergency type of structural repairs and routine repairs.
- Districts can develop, bid and award bridge maintenance contracts to focus on Priority 1 activities with some bridge replacements.
- Focus maintenance activities on scour, pedestal repairs and beam ends.
- Repair leaking deck joints with two-part silicone system such as XJS deck joint systems.

