Guideline for Implementing Quality Control and Quality Assurance for Bridge Inspection

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By

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The undersigned, appointed by the Dean of the Graduate School, have examined the thesis entitled

GUIDELINE FOR IMPLEMENTING QUALITY CONTROL AND QUALITY ASSURANCE FOR BRIDGE INSPEPCTION

Presented by Adam Ross Alexander,

A candidate for the degree of Master of Science,

And hereby certify that, in their opinion, it is worthy of acceptance.

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ABSTRACT

The bridge inspection process is critical to ensuring the safety of highway bridges, identifying repair and maintenance needs, and determining the appropriate allocation of funds. As a result, the quality of the data produced during the inspection process is paramount. Previous studies on the reliability of highway bridge inspection have indicated that there can be variability in the processes and results of visual inspections. Variations can arise from inspector characteristics (education, training, experience, etc.), inconsistency in the inspection procedures and practices, understanding of inspection program requirements, and other factors. Reliability and consistency in load rating procedures are also needed to ensure bridge safety and identify repair and rehabilitation needs.

Given the importance of the quality inspection results to successful bridge management, both in terms of resource allocation and safety, the need to improve the quality level of inspections and broaden the implementation of effective Quality Control (QC) and Quality Assurance (QA) procedures has been recognized. The goal of this document is to improve highway bridge safety by providing guidelines for implementing QC/QA procedures within existing bridge inspection programs. The document is intended to provide a resource that describes methodologies and practices for QC and QA, to improve the quality of the existing programs and allow owners to consider practices that best fit their programmatic needs.

The report documents both QC and QA practices that are presently implemented in the United States. A review of available literature, a series of discussions with bridge owners and experts, and investigation of current practices and procedures was conducted to develop the information included in the report. The fundamental tenants of quality systems are discussed, and quality dimensions for highway bridge inspection and load rating are described. The elements of a quality program, including documentation of inspector qualifications and roles and responsibilities within a quality program are discussed. Several models for different aspects of the QC process have been developed and described. These include characteristics of QC review processes, corrective actions, sampling approaches for QC and QC for load rating.

Several models that generalize procedures for implementing QA procedures have also been developed and described. These models describe different approaches to measuring quality for bridge inspection programs, and examples of implementation of the models is provided based on current practices in State Departments of Transportation. Methods of measuring quality and approaches to sampling for QA are discussed. Sample forms from various State DOTs that can be utilized in the bridge inspection QC/QA process have been included.

The purpose of the report is to provide a resource for bridge owners that are developing, improving and/or implementing QC/QA practices. The report provides key information that can be practically applied and implemented to assure systematic QC and QA for the purpose of maintaining a high degree of accuracy and consistency in bridge inspection programs.

1: Introduction

1.1. Overview

The National Bridge Inspection Standards (NBIS) were implemented in 1971 as a response to the tragic collapse of the Silver Bridge over the Ohio River at Point Pleasant, West Virginia on December 15, 1967. The NBIS established requirements for 1) inspection procedure, 2) frequency of inspections, 3) qualifications of inspectors, 4) inspection reports and 5) inventory. The purpose of the NBIS is to set the national standards for the proper safety inspection and evaluation of all highway bridges in the United States.

The bridge inspection process is critical to ensuring the safety of highway bridges, identifying repair and maintenance needs, and appropriate allocation of funding. As a result, the quality of the data produced during the inspection process extremely important. Methods for ensuring that quality are typically described as quality control (QC), activities intended to ensure quality is maintain at a certain level, and quality assurance (QA), methods intended to assure the effectiveness of QC. These methods can vary widely, and many different formats and structures have been used to fill the need for ensuring the quality of bridge inspection results.

1.2. Goals and Objectives

The objectives of the research presented in this thesis are to first define Quality Control and Quality Assurance and how they relate to bridge inspection. While most people have a general idea of what quality control and quality assurance are, they are unable do give a good description or definition about what they actually are. Once defined it is the goal of this project to explore and document current quality programs, describe what makes a good quality program and characterize essential elements of a QC/QA that will help states with well established programs to improve as well as help the other states create a program. It is the overall goal of this research to produce a document which will provide the tools needed to improve a QC/QA programs in bridge inspection.

2: Background

2.1. QA/QC defined

The terms quality control (QC) and quality assurance (QA) times get used interchangeably, and while often times QA and QC go hand in hand they are two different parts of a quality system designed to ensure the quality of a product or effort.

According to the AASHTO or CFR 650 quality control or QC is defined as "procedures that are intended to maintain quality of a bridge inspection and load rating at or above a specified level." Quality Assurance or QA is defined as "the use of sampling to verify or measure the level of the entire bridge inspection and load rating program."

To put it in simpler terms quality control is conducted within a specific work group for the purpose of correcting or deterring errors and omissions from specific bridge inspection reports. Quality assurance is conducted from outside the work group for the purpose of evaluating the quality level of the program overall, verifying the effectiveness of QC, and identifying deficiencies that can be corrected by changes to the program such as different training, or changes to guidelines. Figure 2-1 shows how QC and QA are related and how they fit into the hierarchy of a quality program.

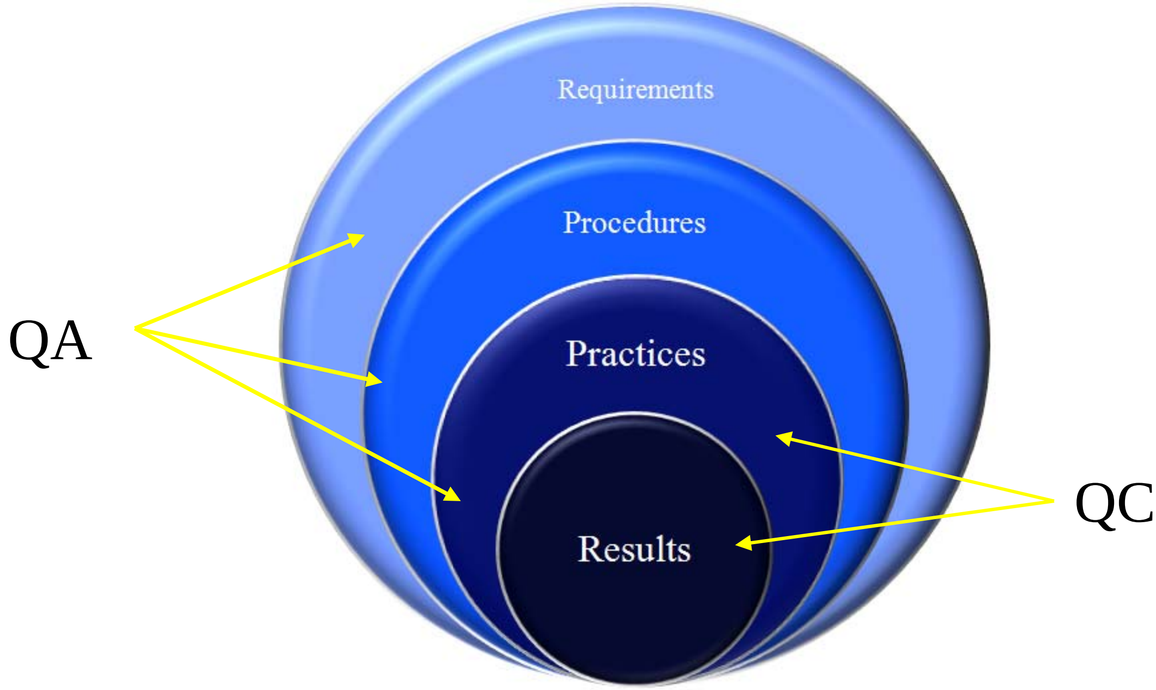

Figure 2-1: QC vs. QA Venn Diagram

2.2. Important definitions

This section provides several important definitions associated with QC/QA and Bridge inspection.

- *Work Group:* Organizational unit responsible for conducting or overseeing bridge inspection, such as a State district, county, township, or inspection consultant.
- *Corrective action:* Corrective actions are steps that are taken to remove the causes of an existing nonconformity or undesirable situation.

- *Quality Control Officer (QCO):* An individual responsible for conducting QC activities.
- *Quality Assurance Engineer (QAE):* An individual responsible for conducting QA activities.
- *Quality Report:* A document that reports the outcome of a QC or QA review.
- *Inspection Requirements:* A requirement is a need, expectation, or obligation. It can be explicitly stated, such as the NBIS requirements, or implied. A specified requirement is one that has been stated (in a document for example), whereas an implied requirement is a need, expectation, or obligation that is common practice or customary.
- *Procedures:* A procedure is a way of carrying out a process, activity or function. A detailed procedure defines and controls the work that should be done, and explains how it should be done, who should do it, and under what circumstances. In addition, a procedure may explain what authority and what responsibility has been allocated, which inputs should be used, and what outputs should be generated.
- *Practices:* The realized implementation or application of the procedures.
- *Expert Team:* A defined group of individuals with advanced or special knowledge of procedures, programs and/or practices.
- *Quality Dimension:* A characteristic that provides a measure of quality. For example, conformance of an inspection to established procedures is dimension of quality

- *Control Inspection:* An inspection conducted to provide a reference or standard for the assessment for other inspections of the same bridge. Typically conducted by an expert team.

2.3. History of QA/QC inspection.

Quality programs have existed in industry for many years. They grew out of the necessity to meet consumers' needs. Perhaps some of the first quality control took place on early civil engineering projects. The pyramids for instance, have four sides that are within 3.5 arc seconds of being perpendicular.

In the Middle Ages royal governments appointed people to oversee the purchasing of materials to ensure their quality (Godfrey 1999). However, the greatest advancement of quality programs was seen during the industrial revolution, where large numbers of products were produced by machines. This was further advanced during the war where mass production became standard. It was common for factory workers to be paid on quantity produced, which led to mistakes and products of poor quality. To remedy this full time quality supervisors or inspectors were hired. Through the years quality programs were perfected and expanded, but it remained primarily a tool of the manufacturing industry. However, in 1980 "company quality" was introduced. For the first time quality programs were applied to areas such as job management, departmental responsibilities, as well as documentation of records and personnel qualifications. It was realized that quality programs could be applied to not only a product, but processes as well (Godfrey 1999).

2.4. What is Bridge Inspection

This section provides an overview of the current schemes utilized for the condition evaluation of highway bridges in the United States. Presently, all States are required to provide data on the condition of their bridges under the NBIS scheme of rating primary components of the structure. However, States have developed individual inspection programs that meet or exceed the Federal requirements, some utilizing a more detailed, element – level inspection of primary bridge elements. This section describes briefly the NBIS and element level schemes.

Inspections conducted under the NBIS guidelines report on the overall condition of three primary components in a bridge structure. Condition ratings are assigned to reflect both the severity of deterioration and the extent to which it is widespread[2]. The general condition ratings are assigned according to the following guidance:

N NOT APPLICABLE

9 EXCELLENT CONDITION

8 VERY GOOD CONDITION – no problems noted.

7 GOOD CONDITION – some minor problems.

6 SATISFACTORY CONDITION – structural elements show minor deterioration.

5 FAIR CONDITION – all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.

4 POOR CONDITION – advanced section loss, deterioration, spalling, or scour.

3 SERIOUS CONDITION – loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.

2 CRITICAL CONDITION – advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.

1 "IMMINENT" FAILURE CONDITION – major deterioration or section loss present in critical structural components, or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put bridge back in light service.

0 FAILED CONDITION – out of service; beyond corrective action.

The condition descriptions provide the basis for all States to report to the FHWA the condition of their bridges. Obviously, there is a fair amount of subjectivity to the condition ratings, and localized deterioration can be difficult to assess for the inspector. States that rely on the NBIS ratings for evaluation of their bridges may include more specific definitions of the various ratings to meet localized needs, for example, defining the portion of a deck (%) that would be deteriorated for a condition 4 to apply.

Limitations to the application of the NBIS rating include that each bridge is divided into only three main components, superstructure, substructure, and deck, or defined as a culvert. The level of detail resulting from the rating would not then be adequate to define appropriate maintenance actions or repair strategies. Additionally, the specific mode of deterioration or damage is not defined, such that the underlying cause cannot be identified from the condition ratings. The ratings are very subjective, and when properly applied describe an overall condition of the component being rated, such that localized damage modes are grouped into one overall rating. This makes it difficult to identify the mode of damage and assess appropriate actions to address the deterioration. These details are commonly maintained in inspection notes that support the assigned condition rating, but are not reported in uniform manner across States.

The AASHTO Commonly – Recognized Bridge Elements (CoRE) Guide provides an alternative system for the condition assessment of a bridge. Under this guide, elements of a bridge are specifically identified (e.g. bare concrete deck, concrete deck protected with asphalt overlay, etc.). The specific elements are then rated on a scale that reflects the most common processes of deterioration and the effect of deterioration on serviceability. The scale can be specified for specific elements, under the general pattern of [3]:

1. Protected: The element's protective materials or systems (e.g. paint or cathodic protection) are sound and functioning as intended to prevent deterioration of the element.
2. Exposed: The element's protective materials or systems have partially or completely failed (e.g. peeling paint or spalled concrete), leaving the element vulnerable to deterioration.

3. Attacked: The element is experiencing active attack by physical or chemical processes (e.g. corrosion, wood rot) but is not yet damaged.
4. Damaged: The element has lost important amounts of material (e.g. steel section loss) such that its serviceability is suspect.
5. Failed: The element no longer serves its intended function (e.g. the bridge must be load posted.

These ratings can be utilized as Condition States (CS), in which quantities of the bridge in each condition state can be described. For example, a bridge beam with peeling paint over 10% of its surface might be described as 10% in CS 2 and 90 % in CS 1. The individual elements can be modified, or other elements added as necessary to meet the needs of individual States. States utilizing the element-level inspection approach typically develop an inspection manual that indicates the elements utilized within that State, descriptions of the elements and the applicable condition states to be used. The elements and condition states can be modified over time to address needs. For example, in Oklahoma, analysis of the bridge inspection consistency utilizing a control bridge concept has resulted in adjustments to the number of elements used within their inspection process, eliminating 50 out of the 200 elements defined for inspectors to rate[4]. Oklahoma’s control bridge testing provides some of the only measurements known relating to the reliability of element level inspections. Results from Oklahoma’s control bridge testing have revealed subjectivity and variability in the assignment of condition states and the assignment of appropriate elements. This is consistent with the results of the 2001 FHWA study on visual inspections, which found variability in the assignment of element descriptions and condition states in a series of tasks intended to evaluate inspection practices from different States participating in the study(although the focus of the study was component (NBI ratings), certain tasks addressed element level inspections)[5].

The CoRE guide provides a common nucleus for the development of element-level inspection schemes that provide more detail than the NBIS rating scheme. The AASHTO core elements have been implemented by many States, some using the PONTIS bridge management software, some developing their own systems for implementing element-level inspection data within a bridge management system (BMS). Some States collect both NBIS data and element level data, the element level data to be used in local BMS functions and the NBIS data for reporting to the FHWA.

Still other States, such as New York, have developed their own, independent methodology for assessing and reporting the condition of bridge. In New York State, bridge inspectors assess all of a bridge's individual parts. They are required to evaluate, assign a condition score, and document the condition of up to 47 structural elements, including rating 25 components of each span of a bridge, in addition to general components common to all bridges. The NYSDOT condition rating scale ranges from 1 to 7, with 7 being in new condition and a rating of 5 or greater considered as good condition.

NYSDOT also computes an overall New York State condition rating for each bridge by combining the ratings of individual components using a weighted average formula. This formula assigns greater weights to the ratings of the bridge elements having the greatest structural importance and lesser weights for minor structural and non-structural elements. If a bridge has multiple spans, each element common to the spans is rated and the lowest individual span element rating is used in the condition rating formula.

Although element-level inspections provide detailed data on the condition of specific bridge elements, there is varying implementation of that scheme, and the limited data available on the reliability of the approach indicate variation exists in the assignment of condition states and consistent element selection. Additionally, not all States are collecting data systematically at that level. Essentially, there exist 52 different inspection systems for highway bridges, which are all related but have individual characteristics that vary. As a result, maintaining consistency in inspection results is problematic, both within particular states and nationwide.

2.5. History of QA/QC in Bridge Inspection

Since the National Bridge Inspection Standards (NBIS) were implememted in 1971 the inspection programs and quality programs have grown and become better defined. FHWA has standards put in place for bridge inspections as well as recommendations for a bridge inspection QA/QC program, which they require all states to have.

Even with all the improvements in the inspection standards since 1971 an evaluation of the reliability of visual inspection conducted by the FHWA in 2001 indicated that the condition ratings normally assigned through the routine inspection process can vary significantly(Moore 2001). In the study, it was found that only 68% of inspection results vary within +/- 1 from the average based on a statistical analysis. A tolerance of +/- 1 for condition ratings is generally accepted as characteristic of the inspection system utilized in the U.S., but the study found that a portion of inspection results would be outside that tolerance. Figure 2-1 shows the typical distribution of routine inspection results for a particular test bridge that was part of the study. The figure indicates a broad distribution of condition ratings were assigned by the inspector population, with each component having 4 or 5 different condition ratings. This distribution of condition ratings was found throughout out the study, with an average of between 4 and 5 different condition ratings assigned to each primary component in the study. Other inspection variables, such as a comparison of the time required for different teams to inspect the same bridge, were also studied. It was found that significant variability existed in the time required for executing inspections of the same bridge. This evaluation was conducted using inspectors from across the U.S., and provides an overview for the variability that can occur in the inspection process.

Inconsistencies and inaccuracies in inspection results can have many sources. Because visual inspection is a subjective process, inspector characteristics can play a key role.

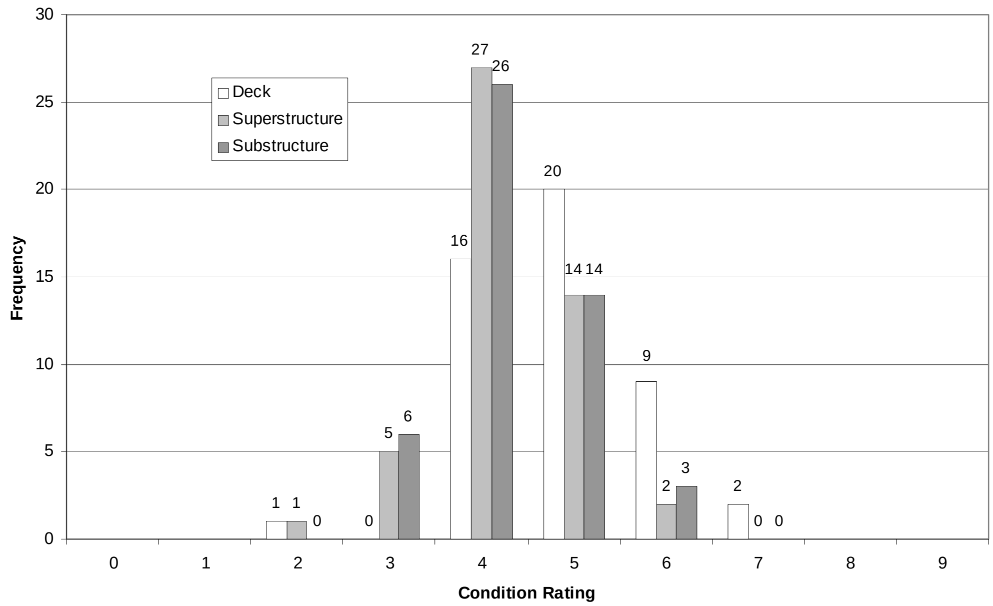

Figure 2-2: Condition rating dispersion for a highway bridge showing NBIS ratings for the deck, superstructure and substructure(Moore 2001).

Variance in inspection results between different inspectors can have several sources, including:

- Inspection training
- Education
- Experience
- Understanding of the inspection requirements and procedures
- Interpretation of the inspection practices when applied in the field
- Attitude and work ethic

Variations can also arise from inadequacies in the procedures and processes developed to implement the inspection program. These may include things like the quality of the inspection manual or inspection instructions, implementation and understanding of inspection program requirements, and available resources. Gaps may exist between inspection practices and the intended correct inspection procedures.

Inconsistencies may arise from inadequate or insufficient training. Inconsistencies may also arise from simple errors, for example, miscoded items or errors in data entry.

The complex nature of bridge inspection is subject to inherent variations resulting from the fact that bridge designs, materials, age and exposure environment (climatic conditions) are highly diversified in the U.S.. As a result, it is not possible to develop an inspection system (requirements, procedures, practices and training) that adequately addresses all possible conditions without ambiguity. Therefore, there is always an element of interpretation in the inspection results that leads to variability that can be minimized but never fully eliminated.

Such inconsistencies in inspection results can have a negative impact on the ability to effectively evaluate the safety of bridges, and to accurately assess bridge repair and maintenance needs. The distribution of State and local funds may be affected by these results, and certain Federal funds are allocated based on sufficiency ratings that depend (in part) on inspection results. The effectiveness of repair and replacement programs can be influenced by the accuracy, consistency and thoroughness of condition ratings. Consequently achieving consistent, reliable and accurate inspection findings is critical to the long-term health of the bridge inventory. Reliability and consistency in load rating procedures are also needed to ensure bridge safety. Quality control (QC) an d Quality assurance (QA) procedures are intended to reduce the inconsistency and minimize the variations in the inspection system and load rating programs. Historically, these procedures have had limited implementation nationally in the U.S., with a few notable exceptions. Given the importance of the quality inspection results to successful bridge management, both in terms of resource allocation and safety, the need to improve the quality level of inspections and broaden the implementation of effective QC/QA procedures has been recognized.

To address the need for improving quality in the bridge inspection process, a scanning tour of selected European countries was conducted in 2007 to develop knowledge about quality processes outside the U.S.(Everett 2008). A 10 member team of was formed including representatives from the FHWA, State and County transportation agencies, and the academic and consulting communities. The scanning team conducted a series of meetings and site visits with government agencies and private sector organizations to investigate methods and procedures utilized in Europe to ensure the quality of bridge inspections. The scanning tour revealed that most nations visited employed a technical decision making process to determine the frequency and scope of inspections bridge inspections. The scope of the inspection procedures observed during the scanning tour was typically more rigorous than is typical in the U.S., analogous to an in-depth inspection in the U.S., but these inspection were generally conducted less frequently than in the U.S.. Innovative methods of ensuring quality were observed, including methods to measure the quality of inspection results and quantitative assessments of inspector quality.

In Finland, for example, a system of quantitative assessment of bridge inspection quality has been developed and implemented as part of the national bridge inspection policy (Dietrich 2005). The quality program has three components: control inspections on a sampling of the bridge inventory to assess the realized inspection quality under field conditions, bridge inspector examinations, and inspection qualification and training. The control inspections are conducted on a sampling of 1-2% of the 3000 bridge inspections conducted annually in Finland. The quality measurement consists of one standard and two control inspections. Following the standard bridge inspection, the agency responsible for conducting the inspection selects two "control" inspectors that perform an independent inspection under the supervision of Federal authorities (FINNRA, Finnish Road Administration). A system of measuring the quality of the inspection is based on the deviation of the standard inspection results from the average of the standard and control inspection results. The results of the control inspections and the original inspection are documented and differenced or inconsistencies identified. After the control inspection, the causes of deviations in inspection results are discussed as a training tool and corrective action to transfer knowledge of the inspection process.

To ensure that inspectors in Finland have the requisite knowledge and training to become certified inspectors, inspectors must attend a qualification program that includes practical training at a bridge sites and inspection examinations. Inspector examinations include both a written component and a performance test that requires inspectors to perform inspections in the field that meet a standard level of quality. In addition, required annual training sessions are organized for certified inspectors. In the training sessions, lectures on inspection procedures, practices and possible problem areas are presented to the inspectors. The inspectors are also required to perform inspections on two common bridges. The results of these inspections are compared with a standard to identify inconsistencies and problem areas. These training sessions serve several purposes, including

- Creating a common understanding of inspection practices
- Calibrating inspection practices by having all inspectors evaluate the same bridges
- Facilitating knowledge transfer
- Providing for peer collaboration
- Obtaining direct feedback to and from inspectors
- Identifying problem areas

The results of quality evaluations are linked to corrective actions and control by using the inspector quality measurements obtained through testing in the evaluation process for contracts for bridge inspection. Additionally, the system has a quality control requirement for agencies conducting inspections that requires reporting of deviations that occur and corrective actions to address the deviations.

The scanning tour also found the utilization of ISO 9001 Standards as a means of specifying quality requirement for contractors conducting inspections. The standards provide overall concepts and procedural requirements for effective quality programs. Additional quality practices that were found included that the host nation's typically had several well-defined scopes for their inspections. While detailed evaluations may be conducted only at long intervals, up to nine years, less comprehensive inspections were typically conducted in the interim to assess major faults or accidental damage. The competency of the inspection crew was considered as part the decision making process in determining the frequency and scope of inspections. The implication of this finding is that improved quality could be obtained from inspectors that met more rigorous or higher level qualification standards.

3: Program Elements

3.1. Quality Control

The definition of the Quality Control, as provided in CFR part 650, is “Procedures that are intended to maintain the quality of bridge inspection and load rating at or above a specified level.” Activities that are part of a QC program may include programmatic functions, such as organized maintenance of records and/or files, and review functions, such as review of inspection results and findings. Review elements of a QC program typically occur at specified sampling intervals, frequently 100% for inspection reports, or, for example, once a month for a field review, or on 10% of bridges, etc., while programmatic elements are systematic and maintained on an on-going basis. Therefore, and bridge inspection and load rating quality control program typically consists of review functions, intended to ensure the quality level of specific inspection activities, and procedural functions intended to ensure that the overall program meets NBIS requirements and maintains quality through meeting those requirements systematically. Specific items that could be considered as QC program elements include such items as:

- Systematic documentation of inspector qualifications
- Documented organization of bridge inspection program
- Required training and retraining programs for inspectors

- Maintenance of a high quality bridge inspection manual
- Maintenance of comprehensive bridge files in accordance with the AASHTO Bridge Evaluation Manual and State requirements

The requirements and procedures for programmatic elements of quality control typically originate from the central administrative offices. The activities themselves are QC processes that may be verified in a QC review within a work group, and/or verified during QA reviews. For example, documenting adequate inspector qualifications is a QC process that can be verified during a QC or QA review.

There are many activities or functions that could fit generally within the description of being a quality program element. Most of these are systematic and are fully described elsewhere, such as in the AASHTO Bridge Evaluation Manual(AASHTO 2008). Several of these programmatic elements are described herein due to their close alignment with ensuring quality within the inspection program, or their relevance to inspection practice particularly. These include documentation of inspector qualifications, peer rotation for quality control, bridge file maintenance and QC roles and responsibilities.

There are several different procedures for measuring the quality level within a work group through review activities. These review activities can be generally described within three procedures for implementing QC. This includes QC Office Review, focused on review of inspection reports to ensure quality, QC field review, which includes traveling to the bridge site to verity data contained in the inspection report, and QC Field Performance Review, which focused on the evaluating the performance of the inspection team during the process of inspection.

3.1.1 Documenting Inspector Qualifications

Inspector qualifications are a key element of ensuring quality control and maintaining compliance with the NBIS. The effective documentation of inspector qualifications, as well as the maintenance of required retraining, varies from State to State (Hearn 2007). Several States utilize some form of a centralized reporting system to maintain a record of individuals that are qualified to perform bridge inspection in the State. Others rely on personnel records to contain adequate data to confirm the qualifications of inspectors. For other bridge owners, inspector qualifications may be documented and maintained as part of the bridge file.

A centralized certification database of inspectors, where each inspector is provided with a certification number that is then entered on the inspection report, is a convenient means of providing documentation that the inspector is qualified. This database may include the experience and training of individual inspector's that meet the requirement of the NBIS and provided data on training / retraining requirements and needs for individual inspectors. A centralized certification process can provide assistance to local agencies that employ consultant inspectors, as the State certification number is one means of efficiently verifying qualifications prior to the inspection process or the award of contracts. A centralized system for certifying inspectors can enhance quality in the program overall by controlling the authority to approve the qualifications of individual inspectors.

A sample form for documenting inspector qualifications for centralized qualification systems in included in appendix B-1. This sample form can be used for individual inspectors to apply to the centralized authority, such as the State Program Manager, to achieve approval of their education and experience as documented on the form. Appendix B-3 is a sample letter for verifying work experience that is utilized to confirm experience documented in the application.

Some States rely on personnel records or a personnel database having records of training and experience for Team Leaders. Such a process can be supplemented by the use of standardized forms such as the forms shown in appendix B-4. The form can be used to document both the Federally required qualifications for team leaders and program managers and State- specific requirements. Appendix B-4 shows a sample form in which the requirements for training and experience are delineated on the form in accordance with the State and Federal requirements.

Appendix B-6 shows a sample form that allows for entry of training and education data only. Such a form can be maintained in the bridge file or adequately referenced from the bridge file such that inspector qualifications can be established at the time of the inspection and quickly verified in either a QC or QA review.

If a centralized database is used for tracking inspection qualifications, the inspector certification number and signature (or equivalent unique identifier) would normally be included as part of the bridge inspection report. This confirms the participation of qualified personnel in the inspection and allows for subsequent review of the inspector qualifications during QC or QA reviews. If personnel records are relied on for establishing inspector qualifications, the inspection report should include the name and signature (or equivalent unique identifier) of the team leader. In this case, confirmation of the qualifications of the inspector should be documented sufficiently within the work group or agency to confirm the qualifications of the inspector at the time of inspection. This may require periodic review to ensure training and retraining requirements are maintained.

3.1.2 Performance Testing

Performance testing is a method of verifying that training and qualification requirements for a bridge inspector are successful in achieving the desired results. In a performance test, a bridge inspector is required to perform a bridge inspection on one or more typical highway bridges, within a timeframe that would be typical within the State given the size and complexity of the bridge being inspected. The results of the bridge inspection are then compared with control inspection results. The characteristics of the control inspections would typically be established by the Program Manager or Bridge Engineer to be in compliance with the State's procedures and guidelines for inspection. Control inspection results may be established by an expert team or by past inspection results for the bridge that are current and have undergone QC review to ensure consistency with established procedures. The results of the inspection by the subject inspector are then compared with the control results to measure variation and determine if the inspector has adequate and operational knowledge of the inspection procedures to successfully implement those procedures in the field.

Performance testing can be utilized as a component of the certification of bridge inspection team leaders. Such performance testing establishes that training and experience requirements results in adequate performance of an inspector in the field.

This confirms the effectiveness of training, and can highlight areas of training that may need to be improved to ensure consistent performance of inspectors in the field. The results of performance testing can also assist in identifying individuals for which training and experience requirements have not been successful in reaching a full understanding of the inspection procedures, application of associated guidelines or department policies. Performance testing would typically occur during the initial certification or qualification process. Once certified, performance testing may conducted as a part of normal QC/QA review processes.

For example, a performance test might consist of an inspector being required to complete a number of bridge inspections over a defined time period, say over a two day testing interval. The inspector is required to complete element lists and condition ratings, and complete NBI inventory information and condition ratings with an average accuracy of less than 4 errors per bridge to become certified. The threshold for an error might consist of a misidentification of a CoRe element, a condition rating greater than +/-1 from a control rating, or a serious error in the element condition states that indicate a lack of understanding in how to identify or quantify a condition state. The thresholds and metrics for performance during the performance testing should be clearly documented prior to the testing to ensure that results are consistent, and that the inspector understands performance expectations.

3.1.3 Peer Rotation for Quality Control

The rotation of inspection teams can be used as a tool to enhance the quality of the inspection program. Under this scheme, inspection teams are rotated such that one team does not inspect a bridge on back-to-back inspection cycles. Such an approach has several advantages, including minimal cost, improvement in the safety of bridges, and enhancement in peer to peer information exchange.

Systematic rotation of bridge inspection teams can help ensure that teams are not inspecting the same bridges repeatedly, which can lead to complacency that may reduce the quality of the bridge inspection. Peer rotation can improve the overall safety of the bridge population by reducing the possibility of a deficient team conducts inadequate inspections of the same bridge in consecutive inspection cycles. Peer rotation may be a QC process, if the teams are rotated systematically as part of normal inspection practices and no assessment of variations or inconsistencies between inspections by different teams is made. When applied in this manner, the peer rotation does not provide a means for corrective action that addresses the cause of the inconsistency, it only corrects the inconsistency (assuming the current inspection has yielded the correct result). If the teams report inconsistencies in their inspections compared with the previous inspection, the peer rotation has a QC review element that allows for analysis of the cause of the inconsistency and corrective actions to be taken.

A peer rotation approach can have minimal cost to the owner agency because the same number of bridge inspections will occur as would have occurred if inspection teams were not rotated. If there are multiple inspection teams within the same office, there will be no additional cost for implementing the activity of inspections and reporting. However, this has the disadvantage of limiting information exchange between the geographically separate offices. Geographically relocating inspection teams to perform inspections, for example, moving inspection teams between districts as part of a rotation cycle, can help to improve the consistency of inspection activities by exposing the inspection teams to the results of inspection from other teams operating in different work groups. This can support peer-to-peer exchange and indicate if the inspection teams are performing in a similar manner. This can also assist the owner agency in identifying inspection teams with substandard performance. The cost of such an approach is increased due to the requisite travel for the inspection teams to visit other districts to inspect bridges; the level of cost is dependent on the geographical and organization characteristics of a particular State.

Bridge safety overall can be improved by a peer exchange. If there is a deficiency in the performance of particular team, presumably the impact on bridge safety will be reduced if the deficient team does not inspect the same bridge in back to back cycles. If the performance of teams is at an equal level than different teams will bring a different perspective to the inspection, because of differences in experience and training between teams. This provides an additional level of confidence in the inspection results for the owner agency and improves the quality of the program overall.

A peer rotation scheme is frequently employed when consultant inspection teams are used. Utilizing multiple firms and rotating inspections between the firms provides a level of the quality control for the inspection process. For States with large consultant inspection pools administered from a central office, minimal effort is required to initiate such a QC process. Local owner agencies may not have easy access to a pool of consultant firms, and may need to be encouraged or even required to initiate a peer rotation scheme.

The peer rotation method can be enhanced if analysis of results is included in the QC procedure. This data analysis requires that inconsistencies between different teams' inspection results be documented and analyzed. Inconstancies between teams may stem from deterioration between inspection cycles, or may stem for inconsistent application of the rating guidelines, oversights and omissions, or other factors. Results of different teams' inspections should be analyzed to identify inconsistencies in the application of guidelines, oversight or omissions, or inconsistencies in the process of data collection, that is, notes and photographs documented by the inspection teams. Such analysis can lead to corrective actions to address inconsistencies, such as improved training, identifying teams with deficient performance, or changes to the inspection guidelines to provide for more uniform application. Obviously, there is increased cost associated with consolidating and analyzing the results of peer rotation inspections.

3.1.4 Bridge File Maintenance

The maintenance of the Bridge File is a QC process that is typically verified by the QA process. This function is very important to ensure that the overall quality of the inspection program is maintained and that reporting requirements are achieved. The elements of a bridge file are detailed in the AASHTO MBE and include the following:

- Plans
- Specifications
- Correspondence

- Photographs
- Materials and Tests
- Maintenance and Repair History
- Coating History
- Accident records
- Posting
- Permit Loads
- Flood Data
- Traffic Data
- Inspection History
- Inspection Requirements
- Structure Inventory and Appraisal Sheets
- Inventories and Inspections
- Rating Records

The maintenance of comprehensive bridge files is a QC procedure that helps ensure the quality of the inspection results. Review of the bridge file for adequacy is a QA function typically, though may be a part of an oversight review for QC.

3.1.5 QC roles and responsibilities

Selecting suitable, qualified personnel to conduct a QC review is an important element in effective QC practices. States utilize a variety or personnel for the implementation of QC practices. These include peer team leaders, supervisors within an inspection unit or owner agency, or dedicated personnel identified with QC responsibilities. Individuals with QC responsibilities are referred to herein as a Quality Control Officer (QCO).

Due to the diversified nature of bridge inspection organizations, especially at the local level, State-wide standard procedures for QC may not exist, as the QC role may be delegated to the owner agency. Minimum characteristics of individuals that perform a QC review of inspection reports include:

- Independence from the original inspection or load rating
- Full and operational knowledge of inspection program requirements, procedures and practices

Independence from the original inspection report is important to reducing elements of bias that may exist from an inspector reviewing his/her own report. If the reviewer is not independent from the inspection team, the reviewer may be more reluctant to criticize other team members, create additional workload on the work group, and/or reveal ineffective inspection performance of a colleague. Additionally, if the reviewer is a part of the inspection team conducting the inspection, the transition from in-progress work to completed work can be ambiguous, and reviews may be conducted before it is appropriate. This can undermine the quality of the review.

It is also important that the individual conducting the QC review be qualified such that they have the requisite knowledge and experience to effectively review the results and conclusions of the inspection team. A QCO would ideally be familiar with the bridge inventory under inspection, such that local factors such as environment, special loading conditions, or specific deterioration modes or common construction issues are familiar to the reviewer. Requiring a QCE to be qualified as a Team Leader or Program Manager under the NBIS requirements can provide an accessible framework for specifying QCE qualifications.

Typical methods used for ensuring independence of the QC review include peer review, in which a team leader from a separate team is charged with reviewing the inspection results. This peer may be from a separate team in the same work group, or from a separate work group. The second method is hierarchical, in which the QCE is in a supervisory role over the inspection team conducting the inspection. Under such a model, the supervisory reviewer should be fully qualified as described above, and be knowledgeable of the bridge inventory. A third approach could be to identify a specific individual to perform QCE for several work groups, such as if a QCE consultant was hired to perform QC functions for a specified population of work groups, say for all of the townships in a district, for example.

3.1.6 QC Review Procedures

The process of QC is typically conducted within the work group conducting the inspections, though the definition of a "work group" can vary significantly between different organizational structures utilized by individual States. A typical example would be to have quality control for an inspection program to be delegated to the district in which the inspections are conducted. When consulting firms are employed to conduct inspections, QC functions are frequently delegated to the consultants, with some QC oversight by the owner agency. The purpose of QC is to ensure that the quality of the inspection process is maintained, and as such the focus of QC reviews typically focus on the quality of inspection process, as documented in the inspection report or may be observed through a review of activities. Evaluations of "quality" include evaluation of completeness of data, accuracy of data and data entry, adherence of practices to procedures, guidelines and training, qualifications of personnel, and consistency and accuracy of condition ratings and/or element condition states.

Several review procedures for QC are utilized to ensure the quality of the bridge inspection process. These procedures can be generally described in four models. These include QC Office Review, QC Field Review of inspection data, QC Field Performance review of inspection teams, and the Peer Exchange. The following sections will describe these different review procedures more completely. Typical QC programs would include procedures that were similar to one of more of these models, with the QC office review being the most widely implemented. QC Field Review is also frequently utilized. QC field Performance Reviews and Peer Exchange are frequently components of program that include QC Office Review, QC Field Review, or elements of both.

3.1.7 QC Office Review

A primary focus of QC review is ensuring the accuracy and completeness of the inspection report. This is typically accomplished through an office review of reports and/or a field review of inspection findings. The office review of reports consist of reviewing the inspection report to ensure it is complete and meets the State and FHWA reporting requirements. This review typically includes the following elements:

- Appropriate forms have been used
- Consistency of ratings for NBIS items
- Accuracy of data entry in accordance with
    - FHWA coding guide
    - State specific inspection requirements
        - Bridge management systems (Pontis, etc)
        - State-specific Bridge inspection forms
- Scheduling of inspections for
    - Biennial inspections
    - Fracture critical inspections
    - Special inspection
    - Underwater inspections
- Scour
    - Scour evaluation
    - Plan of Action, if required
- Consistency with previous inspection results
- Completeness of supporting notes and photographs
- Recommended actions, critical findings and flags
    - Adequate supporting photographs, sketches and notes
- Maintenance recommendations consistent with inspection findings
- Clearance and waterway profile updated as necessary
- Inventory items correctly entered

- Verification of inspector qualification

The QC review of the inspection report should review the report for the purposes of ensuring the accuracy of data input for the inventory items required as well as meeting the State inspection reporting requirements.

The accuracy of the NBI ratings are typically evaluated in an office review based on the photographic documentation included in the inspection report, supporting notes and comments, and previous inspection results. Component rating (items 58-62) should be compared with previous inspection results to ensure that the rating provided are consistent with expected deterioration behavior, and that significant changes to the ratings are adequately justified and consistent with supporting notes and photographs. Consistency with State procedures and guidelines should be included as part of this review. For element level inspections, the assigned condition states should be reviewed for consistency with supporting notes and photographs, and agreement with previous inspection finding considering anticipated deterioration. The appropriate selection of CORE elements should also be assessed as possible provided the information available.

A tabulated check-list can be utilized to ensure that QC reviews are completed in a consistent and uniform manner. This check-list should be customized to meet the needs and format of individual States, but could be of the form as shown in Exhibit B1. Such a tabular format can be effective in ensuring that QC reviews are complete and uniform. In the check list, the QCO enters the previous rating for each component (last rating), the rating included in the inspection report being reviewed (new rating), and checks to ensure that adequate sketches, comments and photographs are included in the report. The generic form shown here is intended as a basic model that would be modified according to the data input model for a particular State, including core elements if element-level inspections are being conducted. A sample form for review of element level inspection is illustrated in appendix C-2.

Critical findings, if any, identified in the report should be reviewed to ensure that supporting comments and photographs are included, and the data is properly entered and identified to ensure follow-up on critical findings according to statewide procedures will be accomplished.

Most States require that evidence of inspector qualifications be included as part of the inspection report. This data may be included by an inspector's certification number, employee number, name or other reference that is traceable to a record of the inspector qualifications. The signature of the team leader on the report is normally required. The QC review should ensure that such data is provided in the report.

It should be recognized that such office QC of inspection findings does not provide a full measure of the accuracy of the inspection findings, but is a process for ensuring the quality of the report, i.e. that the report is complete and contains information that is consistent and adequate. However, since no assessment of the actual conditions at the bridge is available during such a review, there is an implicit assumption that all notable deterioration is included in the report. If the inspector fails to document adequately deterioration at the bridge, there my be no way for the reviewer to be aware of the deterioration. As such, the QC Office Review has some limitations in its ability to fully ensure the quality of the inspection results. The office review may be complimented with a field QC review that provides an opportunity to assess the accuracy of the condition ratings, notes and photographic documentation, and verify inventory data included in the report.

3.1.8 QC Field Review

A field review of inspection teams may also be a component of the QC review. A typical field review may consist of two elements. First, the review may include an independent verification of data included in the inspection report. This review consists of evaluating the findings and documentation from the inspection report, and evaluates the quality and consistency of the data produced from the inspection, and as such will evaluate the consistency and accuracy of component rating, adequacy of photographic documentation and notes, recommended maintenance, critical findings, etc. The field review may also include a QC Performance Review of the inspection team. The *performance review* of the inspection team evaluates the process of conducting the inspection. The performance review will typically consist of evaluating items such as proper resources (tools, access equipment, etc.), safety items, thoroughness of the inspection process, etc. These two separate functions may be combined to form a comprehensive QC review of the inspection process and inspection data, or may be conducted individually.

To perform a QC Field Review, the QCE visits a subject bridge with the new inspection report in-hand and review the entries in the inspection report to verify the accuracy of condition ratings and supporting documentation. This field review should be conducted within 1-2 months of the field inspection if practical to ensure conditions have not changed significantly. If done in coincidence with a QC Field Performance review, the visit would occur during a normal inspection.

The field review of inspection data typically includes the following components:

- Independent verification of condition ratings
- Proper identification of CoRe elements
    - Appropriate application of condition states
- Adequacy of photographs, notes and sketches
- Confirm recommended actions, critical findings, and flags
- Confirm load posting (if applicable) and signage
- Confirm physical measurements
    - vertical clearance measurement
    - waterway measurements
    - Roadway width, etc.
- Evaluate maintenance recommendations
- Verification of inventory data

A standard form can be utilized to support the QC field review and document the results of the review. Use of such a form helps ensure that the reviews are conducted in a uniform manner, and that items are not overlooked. Such a form may be very similar to either appendix C-1 or C-4, depending on the type of inspection being conducted. If the field review includes evaluating the performance of the inspection team, the form may be supplemented with data as described below.

3.1.9 QC Field Performance Review

A field review of inspection team performance is a QC activity that can help assure that the process of the bridge inspection is being conducted in a uniform manner, and to verify the field performance of inspection teams. The goal of the performance review is to ensure that the process of inspection is conducted adequately to meet standards and requirement of the NBIS and State requirements. The review may also include safety related items to determine if State safety procedures are being followed in the field. The review may also include determining if the resources available or utilized by the team match requirements and needs.

During a field performance review, the QCO witnesses regular inspections being conducted by teams operating within their jurisdiction. A typical field performance review would typically include the following elements:

- Timeliness
- Thoroughness of inspection
- Safety practices
- Equipment used
- Confirm qualifications of on-site team
- Observe the overall performance of the inspection team

It is important that the field review of the inspection team be conducted in a constructive manner, such that inspection teams do not feel intimidated by the process of observation by the QCO. A positive environment of communication should be maintained with the inspection team being observed, such that the inspection team recognizes the role of QC as improving the overall process, rather than a feeling of being "tested." A positive and constructive environment helps support improved communication that will enhance the quality of the process.

A sample form for a QC Field Review is included in Exhibits B3 and B4. Exhibit B3 shows a sample for for evaluating the performance of an inspection team. Exhibit B4 shows safety items that may be reviewed as part of a field performance review.

3.1.10 Sampling approaches for QC Review

There is a variety of approaches to sampling for quality control. Many States implement first-line elements of quality control for 100% of bridge inspection reports. This QC review consist typically of the QC office review as described above. This may be limited to the quality control checks in edit/update software, but typically involves specifying review of the inspection reports by a supervisor or independent peer team leader to confirm adequacy of the inspection report. This review should include verification that all inventory items are correctly coded, that the report is complete with supporting photographs and notes, and the critical findings are adequately identified and justified with notes and photographs as required, as discussed in section 2.2. Performing QC checks on all inspection reports is good practice for ensuring the quality of data and avoiding coding errors, ensuring completeness of reports and maintaining a high quality level for the inspection reports.

This activity is sometimes delegated to the agency responsible for the inspections, such as a State district, local bridge owner or consultant. In such cases it may be appropriate for a smaller number of inspection reports, say 10% of the inspection reports, to be checked at a higher administrative level to ensure that QC procedures are being effectively implemented to ensure quality.

Field QC reviews typically sample from the overall inspection inventory, for example, 10% of the bridges. The objective of the sampling is to evaluate each inspection team. The field review should include at least one field review for each inspection team submitting reports within the work group, to ensure that deficiencies that may be team-specific are identified and addressed. For inspection teams that are new to the inspection program, it may be appropriate to conduct a field review of the inspection results within the first few months of activity, to confirm the team is operating within the guidelines and procedures required. A secondary consideration for field QC reviews should be sampling a representative group of the bridge population for which the inspection teams are responsible.

Within the sampling for field reviews, including bridges with components with a low rating of 5 or less within the field sample population can assist in ensuring that severely deteriorated components are being adequately assessed. Bridges with components that are rated low can be more difficult to assess consistently given the subjectivity of the rating scale. Requirements for notes, sketches and photographs of deterioration are greater, presenting a more complete opportunity for assessment of the performance of the inspection team. Maintenance recommendations and critical findings are also more likely to be included as part of the inspection results. Additionally, review of bridge with severely deteriorated components can assist in ensuring safety by providing an additional review of bridge condition.

3.1.11 QC Organizational Structures

Quality control is typically implemented within a work group or organizational entity, to ensure the quality of work within that group. Depending on the organizational structure of the DOT, the QC process may be horizontal, in which the QC is the responsibility of a single organizational layer, or hierarchical, in which QC functions are delegated to several organizational levels to provide redundancy to ensure the effectiveness of the QC process.

A horizontal QC structure is characterized by QC activities being conducted within a single work group conducting the inspection, or within single organizational level. For example, if the QC function for bridge inspection is delegated to a local bridge owner (town, county or parish) in a decentralized system. In these cases, QA processes are needed to address consistency between the separate work groups, and ensure that the defined QC practices are effective in maintaining consistency in the inspection process. Such a system may have limited redundancy, and the <u>frequency of QA reviews should consider the limitations that may exist if individual agencies are not effectively implementing QC within their inspection practices.</u>

Another approach for QC structure is to apply a hierarchical model, in which sampling is done for the purposes of QC at a deescalating rate up a chain of command. Such a model

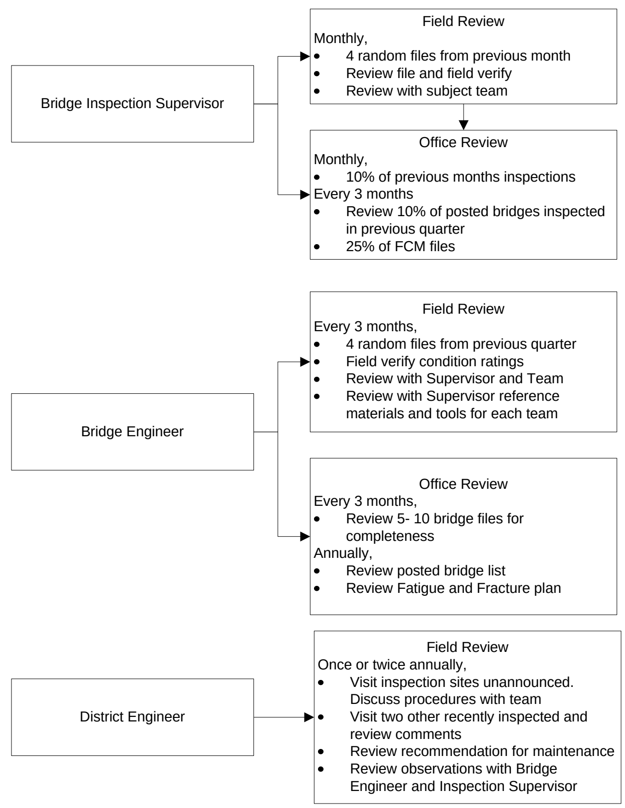

Figure 3-1. Schematic diagram of hierarchical QC structure.

is shown schematically in Figure 1. In this process, there is redundancy built into the QC process through the chain of command, and separate roles and responsibilities are clearly defined at each level. For example, in this structure, the bridge inspection supervisor is charged with performing two QC activities, a QC office review and a field review. The office review is conducted on 10% of the inspection reports generated the previous month. On a quarterly basis, 10% of posted bridges are reviewed to ensure current and accurate load ratings, and 25% of Fracture Critical Members (FCM) files are reviewed to ensure necessary data is present to support upcoming FCM inspections. This QC function is backed-up by a less frequent office review of 5 to 10 randomly selected bridges each quarter, and an annual review of the posted bridge list and fatigue and fracture control plan, conducted by the Bridge Engineer (BE). The BE also conducts a QC field review of four bridges inspected in the previous quarter. Finally, on an annual basis, a district engineer is charged with visiting inspection teams during unannounced site visits to observe inspection teams, and field – verify inspection results for two other bridges. This hierarchical structure provides redundancy in the QC process that confirms the effectiveness of each level of QC.

An important element of the hierarchical model is the review of QC results with inspection teams, supervisors and engineers to ensure that they are aware of any problems or inconsistencies that were determined through the QC review. This ensures that corrective actions can be taken in response to issues identified through the QC process. Without such interactions, mistakes are repeated and quality is not improved.

Such a hierarchical model can be applied to a variety of organizational structures and inspection programs. The fundamental characteristics of the hierarchical model are:

- Independence of reviews between organizational layers
- Reduction of frequency with increasing organizational level
- Documentation of review results and review with subject work group

An example of a hierarchical model for QC for a decentralized system, such as when localities or consultants are required to perform inspections and conduct QC, could include a QC field and/or office review applied at an intermediate organization layer, such as at a district office. In this case, and QC review is applied to an appropriate sampling of inspections prior to submission of the inspection report to the State. This ensures the quality of the data from the inspections is maintained at or above a specified level, and this is discriminated from Quality Assurance (QA) because it affects an identified work group (say, the district or region) and does not evaluate the effectiveness of QC practices across the inspection program. Rather, it is a QC process that maintains the quality of the bridge inspections.

A schematic diagram of this type of approach is shown in Figure 3-2 for use when inspections are conducted by consultants under the direction of a State district. In this scheme, the consultant is responsible for QC of inspection reports and load rating bridges. The consultant QC plan may involve a supervisor reviewing 100% of the inspection reports submitted by each of their teams, and performing a field review of a sampling of the reports. Load ratings are also reviewed, and this may include a review of the underwater inspection reports and scour data. Corrective actions based on inconsistencies or errors in the inspection reports are corrected prior to submission to the responsible State unit, for example, the district. Any significant corrections should be confirmed with the inspection teams conducting the inspections. At the district level, a sampling of the submitted reports are reviewed to ensure consistency within the reports (QC office review), completeness of the bridge file, and check any load rating changes that have been submitted. A QC field review of a sampling of the bridges may be conducted to verify data in the inspection reports. Errors, inconsistencies or missing data is reconciled with the consultant submitting the reports, by returning the report to the consultant for correction or other corrective action as specified in the QC procedure. It is important that the consultant have within their QC plan a process to provide these corrective actions to the inspection teams conducting the inspections, to support continuous improvement in quality in the program. Once corrections are made, the report is finally submitted at the State level for submission to the FHWA. At this level, a data check to confirm accuracy of data input for submission is accurate may be conducted, or an office or field review of selected reports and load ratings may be conducted as the final step in the QC process.

This process is discriminated from QA because the goal of the actions undertaken is to ensure the accuracy and quality of data within specific inspection reports. There review processes are undertaken within specific work groups, the consultant, the District and finally the State.

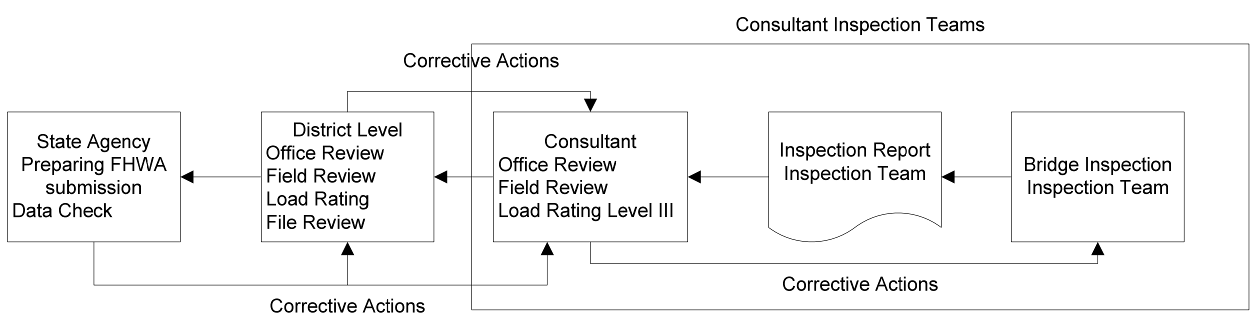

Figure 3-2. Flow chart for QC program involving consultant inspection teams.

3.1.12 Corrective Actions for QC

The results of QC review of inspection reports may determine that errors or omissions have occurred in the inspection process, or that new information has emerged that affects the inspection report. To ensure the validity and integrity of the bridge inspection report, all changes to the inspection report that occur after the original inspection is complete should be documented and the record maintained. All inspection report changes should be made by either the team leader submitting the report, or by the QCO. However, the QCO should not implement significant changes in the report without the knowledge and consent of the team leader. The team leader that conducted the original inspection may have information not available to the QCO (or visa-versa), or may have a legitimate disagreement regarding the change. To address such cases, the QC procedure should include a documented process for implementing changes to the inspection reports based on the QC review, and for resolving differences between the inspection team leader and the QCO.

Specific procedures for controlling changes to the inspection report based on a QC review may vary from State to State based on the process for documenting inspection results and the overall organizational structure. For States utilizing electronic reporting processes, changes to the inspection report may be controlled through software tools that limit changes to an inspection report during the submission and acceptance procedure. For State using a paper reporting process, a procedure for controlling changes to the report can be developed to provide guidance on the process. The example given below illustrates one States approach to controlling changes to the inspection report.

In this example, changes to the inspection report are categorized to provide guidance on when the team leader should be consulted in making a change.

Table 4-1: Example language for controlling changes to inspection reports, New York State.

Administrative changes	If an inspection report must be changed only for administrative reasons (such as a coding error in the control data), draw a single line through the incorrect entry and write the correct on above or below the lined-out entry. If the reason for the change is obvious, no further action is required. Otherwise, provide an explanatory note at the bottom of the page.
Changes in the Field	When a change is required to reflect new information (e.g. discovery of a defect no previously observed), line-out any ratings and/or coments as necessary and add the new ratings and/or comments next to the lined-out items. Provide an initialed and dated explanatory note at the bottom of the page.
Minor Quality Control Changes	When the QCO needs to make a minor change, such as a 9 rating to an 8, or finds a discrepancy between a condition rating and the remarks or photos, (where the correction is obvious), the QCO should line-out the rating, remark or photo description, and write the correction next to the lined-out item. The QCO should date and initial the change.
Significant Quality Control Changes:	When the QCO disagrees with the conclusions of the Team Leader on one or more significant elements of the bridge, the QCO and the team leader need to confer and agree on the change (if any) that needs to be made. If a change is necessary, it can be made by either the TL or the QCO by lining out any ratings, photo description sketch components, remarks, etc. that have to be changed. New ratings, remarks, etc. should be made next to the lined-out items if possible. It may be necessary to supplement the report with additional pages of comments. All changes need to be initialed and dated. Changes made by the QCO should be co-initialed by the Team leader to show concurrence with the changes. In the TL does not agree with the QCO changes, the Regional Structures Engineer should be consulted to resolve the problem.

To ensure continuous improvement through a QC program, it is important that the results of QC reviews be documented, and that the subject teams are notified when errors or omissions occur. There are two components to documenting the QC review: first, documentation should be maintained that required QC reviews have been conducted. Second, results of the review, both positive and negative, should be provided to the inspection teams reviewed such that corrective actions can be taken to avoid errors and/or omissions in the future, and to provide confirmation of procedures and activities when no errors or omissions have occurred.

Documentation that the QC reviews have been conducted may be in the form of a QC log book to track the performance of reviews over time. This log book should contain the name of the QCE conducting the review, the date of the review, and the bridge number. Other data that may be appropriate for the log book includes:

- Date of the original inspection
- Name or certification number of the Inspection team leader
- Results of the review, such as any problems noted during the review
- Information on the corrective actions taken, e.g. Notified team leader by email on 12/10/2008
- Type of review conducted, i.e. QC Report review, QC Field Review, QC performance review

Corrective actions taken as a result of the quality control review might be included in a periodic summary letter provided to the Team leader that identifies specific items from the review (s), discussions with the Team Leader or inspection team, or other written documentation that serves as a basis to ensure that quality improvements will occur as a result of the QC review.

Another method of corrective action is a periodic meeting (monthly, quarterly or bi-annually) within the work group to review the results of the QC review process. Such meetings serve not only to transmit data from the QC review, but also as a means of peer exchange that allows teams to share experiences, indentify deficiency or corrective action needed to improve the quality of the inspections, and allow teams to benefit from the experiences of other teams. These meeting also provide a vehicle for implementing changes or updates, or discussing new directives, requirements or advisories. The collaborative nature of the meetings helps ensure a common understanding of requirements that will improve consistency and helps promote team building.

3.1.13 QC for Load Rating

Organizational structures for load rating vary widely between States. In some States, the responsibility for load rating of bridges lies in the design branch, in some States load rating is done within the centralized maintenance office, while in others the responsibility for load rating may be delegated to the bridge owner or consultant conducting biannual inspections. As a result, QC processes vary widely, and may range from review to ensure a subject bridge is properly posted according to its current load rating, to recalculating the load rating to ensure the quality of the load rating process utilized.

Systematic processes to ensure quality in load rating include clear documentation of the load rating processes being maintained in the bridge file (or available by reference). This documentation should include the following:

- Method of load rating (LRFR, Allowable Stress, Load Factor or Nondestructive Load Testing)
- Indication of the software used for analysis, including revision number
- Supporting calculations
- Data input file
- A clear statement of all assumptions used in calculating the load rating
- Reference to guidelines or specification used in the load rating process
- Documentation of the engineer responsible for the load rating

Maintaining this documentation helps ensure the quality of the load rating process and enables the review and recalculation of the load rating during subsequent QC or QA reviews. The documentation also supports rapid recalculation of the load rating as a result of changes in the conditions at the bridge, such as a vehicular accident that damages the structure or an extreme weather event.

Review processes for load rating QC can be general described as fitting a multi-level model that includes the following:

Level I Review of load posting

Level II Review of Documentation

Level III Recalculation of the load rating

A level I review is conducted to verify that the load rating provided in the bridge file matches the signage in the field. This ensures that any changes to the load rating are accurately reflected in signage at the bridge, and that the inspectors are noting the current load posting on the bridge. This is the most fundamental process for QC of load rating. This review should include an assessment to determine if the load rating is current, or if a new load rating is needed due to changes that may have occurred to the bridge. This should also include verification that the load rating engineer is appropriately qualified.

Level II QC review includes the review of assumptions and documentation of the load rating in the bridge file. This review should confirm that the load rating is up to date with the most recent bridge inspection, and has considered any changes in bridge condition. This includes ensuring that the load rating is updated to reflect maintenance or renovation activities at the bridge, changes in bridge condition revealed through inspections, or unexpected events such as vehicular accidents or extreme weather events. The assumptions utilized in the load rating may be reviewed for consistency with inspection results and available plans for the bridge. The Level II review should confirm that the bridge file includes:

- Method of load rating (LRFR, Allowable Stress, Load Factor or Nondestructive Load Testing)
- Indication of the software used for analysis, including revision number
- Supporting calculations
- Data input file
- A clear statement of all assumptions used in calculating the load rating

- Reference to guidelines or specification used in the load rating process

A level III QC review of load rating includes a recalculation of the load rating by a supervisor or supervising authority. This recalculation can help reduce calculation errors and ensure that assumptions that support the load rating are consistent with the condition of the bridge, as determined though the biannual inspection process. A recalculation of the load rating should be conducted by a supervisor or QCO such that the recalculation is independent of the original load rating. This recalculation may be based on the assumptions used for the original load rating, such that the review confirms the accuracy of the calculations. Alternatively, independent assumptions for the load rating based on the current conditions at the bridge (as documented in the bridge inspection reports) can be developed, and the load rating recalculate based on independently developed assumptions. In such cases, it may be necessary to establish a threshold for determining consistency in the load rating process. A typical measure for consistency is 10% difference in the load rating between the review load rating and the original load rating.

The three levels of QC review for load rating described would typically be cumulative, such that a Level II review would include the components of a Level I review, and a Level III review would include the elements in Levels I and II. When a hierarchical structure is used in the QC process, these reviews may be conducted at different levels of the hierarchy. For example, a Level I review may be conducted at the lowest level in the hierarchy, Level II at the next higher level and finally Level III at the highest level. This may have diminishing frequency at increasing organization levels.

Frequency of QC reviews for load rating vary widely in current practice. Level I and II reviews are typical QC practices that may be a part of the QC review of inspection reports, and as such have a sampling frequency that is the same as that utilized for inspection report review. This sampling frequency may be as high as 100% of inspection reports, or a sampling of the bridges inspected (for example, 5% of the bridge inspections). A level III review is more likely to be conducted on a sampling of bridges that may be random sampling (5% of bridges, for example) or event-based, i.e. conducted in response to changes in the load rating or major renovations at the bridge. The review of the load rating described may be a part of the QC program when applied within the organizational structure or work group, or may be part of QA process when applied across a bridge inventory.

3.2. Quality Assurance Elements

Quality assurance is defined in the NBIS as "The use of sampling or other measures to assure to assure the adequacy of quality control procedures in order to verify or measure the quality level of the entire bridge inspection or load rating program." A key characteristic of quality assurance so defined is that the evaluation of quality is focused on entire bridge inspection or load rating program. In contrast to quality control processes, which are typically executed within a work group or organizational element, the process of QA is intended to ensure that the QC process within the work groups are effective, that these processes are adequate to ensure quality, and that the overall program is effective in maintaining quality equally from each of the work groups within the program. As such, QA is typically conducted from outside the work group, while QC is conducted within the work group itself.

In some cases, QC activities and QA activities may include the same functions, for example, a QC office review may and QA office review may both include a review of ratings, inventory items and contents of the bridge file, but with different end goals. The QC review ensures that procedures are adequate to maintain quality within the work group, and to correct deficiencies in specific inspection report. The QA review ensures that these QC efforts are equally effective across different work groups, resulting in overall quality in the bridge inspection program. As a result, it can be difficult and confusing sometimes to determine if a particular function or activity in QC or QA. Generally, the objective of QA activities are not correct deficiencies within a specific inspection report or load rating, but rather to monitor and adjust as necessary the activity or program to ensure overall quality levels are maintained at the desired level.

It is important that a QA program have documented procedures and practices to ensure that QA is conducted in a uniform manner.   This includes delineating the frequency of reviews, the procedures to be conducted as part of a QA review, methods of assessing quality, reporting requirements, procedures for implementing corrective actions. It is important that the QA program be fair and objective, such that all units evaluated undergo the same level of review. In conducting these reviews, it is equally important to establish procedures and practices that are constructive and have the overall goal of improving the inspection program. It is important that the subject of the QA review understand the process and appreciate the goals of the QA review, such that the process is perceived as a constructive and collaborative effort to improve the quality of bridge inspections. If the perception of the QA program is that the goal is to reprimand or punish inspectors, the program will be viewed in a negative way that could be detrimental to the overall goals of the program. If the QA process is viewed as a constructive effort intended to improve the overall program, then it is more likely to be viewed positively by inspectors. A QA process can have many positive benefits for inspection teams, including identifying needs for improved guidelines, identifying where additional resources or training may be required, and supporting the efforts of the inspection teams to ensure effective bridge management. If presented in a constructive manner, the implementation of a QA program can improve the morale of inspection teams and improve the overall quality of the program merely by its existence.

To ensure that the QA program is perceived as a constructive process by inspectors, it is important that the review procedures are well documented and understood by the inspection teams being evaluated. These procedures should be objective and fair, should provide quantitative results to the extent possible, and be administered uniformly and consistently during each review.

3.2.1 Characteristics of QA Reviews

Common characteristics of a QA program for bridge inspection include the following elements:

- Review of Inspection Reports
    - Appropriate forms have been used
    - Accuracy of ratings for NBIS items

    - Accuracy of data entry in accordance with FHWA coding and local requirements (Pontis, State-specific Bridge Management System, etc.)
    - Completeness of supporting notes and photographs
    - Appropriate use of recommended actions, critical findings and flags
        - Follow-up actions on critical findings
    - Documentation of inspector qualifications
    - Maintenance recommendations consistent with inspection findings
    - Communication between inspection and maintenance groups
    - Clearance and waterway profile
    - Current load rating
- Field review of Inspection teams
    - Verification of condition ratings
    - Adequacy and accuracy of photographs, notes and sketches
    - Verification of inventory data
    - Review of the Field performance of the inspection team
        - Timeliness
        - Thoroughness of inspection
        - Safety practices
        - Equipment used
        - Confirm qualifications of on-site team

- Review of Bridge File elements
    - Scour evaluation/plan
    - Load rating
    - Underwater inspections
    - Qualifications of inspection staff
    - Drawings and Plans for the bridge
    - Inspection schedule
        - Underwater inspection schedule
        - Biennual inspections
        - Fracture Critical Members
    - Review of critical findings
        - Reporting of critical finding
        - Schedules for addressing critical findings

3.2.2 Methods of Quality Assurance

The application of QA procedures is widely varied from State to State due in part to the diversified organizational structures of States, and the level of sophistication for these QA practices cover a wide spectrum of possibilities. QA practices of States can be generalized into several models for conducting office and field reviews. These models address the overall requirements for QA review with the goal of validating the effectiveness of the QC procedures.

The models were developed to provide concise summaries of different approaches to conducting QA reviews of a bridge inventory. Specific QA programs may have characteristics of more than one of these models, or more than one model may be applied within a program. The models are provided for guidance on different conceptual structures for a QA practice. Specific overviews of how such models can be implemented are provided.

There are certain characteristics of the models that are common and represent basic functions of the QA process. This includes documentation of the QA process as discussed previously. This documentation describes, among other things, the qualification and characteristics of the review team, the procedure for selected the bridges to be part of the review, a description of the review process, and the documentation that will be generated as part of the review. The review function itself varies in characteristics according to the overall model for QA being implemented. There is a step in the process in which the results of the QA review are compiled and analyzed. Finally, there is a step in the process that provides feedback to the team being reviewed based on the QA review. This feedback identifies team-specific corrective actions that are used to improve the performance of the team or work group being reviewed. Corrective actions at the team level might include identifying additional training or resources required to improve the quality of inspections conducted by a particular team. Finally, the results of the QA review are compiled to determine corrective actions at a program level. Corrective actions at a program level might include changes to inspection guidelines, indentifying additional training needs, or providing different resources to the inspection teams across the State.

This section describes four general models for implementing a QA program. These models are intended to general describe the organizational structure and goals of different approaches to QA currently utilized by State Departments of Transportation. Because the organizational structures of States vary considerably, the described models to not delineated specific positions, roles or procedures for QA, but rather describe an overall approach that can be adopted. Specific procedures can be developed within these conceptual models to meet the individual needs and resources of a State.

The first model described in the independent oversight model (IOM). The fundamental characteristic of this model is that there is an independent re-inspection of a sampling of bridges to identify inconsistencies between the re-inspection and the original inspection. The second model presented in the Control Bridge Model (CBM). This model is characterized by the utilization of a small number of “control bridges” to evaluate inconsistencies in the results of many inspection teams performing inspections on the same bridges. The third model is the Collaborative Peer Review (CPR) model, which generally utilizes a collaborative, team-based approach to reviewing inspection practices and results to develop consistency in the inspection process. Finally, the Field Verification Model (FVM) is described, in which quality is evaluated by comparing a current inspection report with conditions in the field to verify the inspection results and identify inconsistencies. The following section describes the fundamental principles of each of these methods.

3.2.3 Quality Assurance Models

The following quality assurance models were a main focus of this research. They were developed by studying the current state programs which are described in Chapter 5. All of these state programs have qualities that allow them to fit into one of the following models.

3.2.3.1 Independent Oversight Model (IOM)

A commonly used model for QA review is the Independent Oversight Model (IOM), in which a third party is enlisted to re-inspect a number of bridges. Under this model, bridges that have been inspected by the subject work group undergo a complete re-inspection that is independent of the inspection being evaluated. This re-inspection generates a companion inspection result that can be compared to the subject inspection data for analysis of consistency and accuracy.

The re-inspection is typically conducted without knowledge of the subject inspection result to ensure the independence of the review. This reduces potential bias created by knowledge of the current inspection ratings and other data being evaluated by the review team. If the current inspection results are known to the review team, the review team may be reluctant to identify inconsistencies, or otherwise be influenced by the existing inspection results. The re-inspection is typically conducted without the subject inspection team being reviewed present during the re-inspection. This helps to maintain objectivity and ensure that the process is conducted without influence of personality, appearance, and/or personal interactions. The independence and objectivity of the re-inspection is important to ensuring the effectiveness and consistency of the QA process.

Specific methods of applying an IOM model to bridge inspection QA can vary according to the organizational structure of the State and resources available for conducting reviews. Key characteristics of a typical IOM model include:

- An independent re-inspection of bridges by a third party
- Review of bridge file including
    - Validating inspector qualifications
    - Review of load rating
    - Review of the scour action plan
    - Review of underwater inspections
- Report on difference between the re-inspection results and the original inspection results
- Close-out meeting with subject agency to review results and indentify inconsistencies found during the review
- Adjustments as required to policies, procedures and manual (corrective actions)
- Summary reports providing an overview of the QA results.

This model can applied through a variety of means for State and local authorities. A QA consultant may be used to perform the re-inspection; peer teams, supervisors or other qualified personnel can also be used as independent re-inspectors to evaluate the performance of teams in the field. It is advantageous to utilize a limited number of independent reviewers to ensure consistency in the QA review. For example, if a large number of peer teams are used as independent reviewers, the variation in results across the population of review teams may be significant, reducing the ability to evaluate the overall consistency of the inspection results. The review team should also be free of conflicts, such as might be encountered if members of team review their own inspection findings, or finding from their own work group. The qualifications and organization of the review team should be described in the QA procedure, as discussed earlier.

An expert team may be utilized to conduct the review. This expert team is a bridge inspection team that is highly knowledgeable and experienced in the inspection practices and policies of the State. The expert team may include the bridge inspection Program Manager, or individuals selected by the Program Manager. Key members of the expert team should be fully qualified as team leaders and be highly knowledgeable of the correct implementation of the State's guidelines and procedures. Members of the expert team may have special knowledge developed by working closely with inspection program managers and/or working within a centralized unit responsible for defining the guidelines and inspection procedures. The review team may have other members that are not necessarily qualified as Team Leaders, such as an FHWA representative, individuals from the design division, or other members that meet the specific needs of a particular State.

Efforts should be taken to ensure those selected as reviewers are conducting the review at the desired level of quality such that inconsistencies identified are meaningful. In the IOM model, the review team is assumed to provide a control inspection standard.

The original inspection that is being reviewed is compared with this control inspection to determine inconsistencies in the process. Therefore, it is imperative that the re-inspection provides reliable results that are consistent with all aspects of the guidelines and procedures used in the inspection process.

The IOM model is shown schematically in figure 4-3, which shows generally the QA process. In this model, the documentation of the QA program includes a description of the review process, identifies the characteristics of the review team (i.e. QA contractor, expert review team, etc.). There is also documentation or policy on how many bridges are to be selected for evaluation, and what the characteristics of these bridges should be. There is a policy identifying what items are part of the QA review, for example, the elements of the bridge file that will be reviewed, what activities are to be conducted as part of the review, etc.. The inspection process of the subject work group is then evaluated through the independent re-inspection of selected bridges, a process that allows for evaluation of consistency between control inspection and the subject inspection team's finding. This may include condition ratings, inventory items and element level ratings if relevant.

The results of the QA review are typically summarized in a QA report generated and discussed directly with the subject work group at a closeout meeting, which provides an opportunity for corrective actions at the inspection team level. Because the evaluation of QA process is independent and quantified, it is possible to provide quantitative data on the consistency of the inspection process both at a local level and across the entire system. A summary report can be generated including the results of the individual agency reviews, such that programmatic changes can be instituted such as modifications in training, updates to manuals, etc..

Such a model is durable and can be applied to both centralized and decentralized organizations. For example, if localities are responsible for bridge inspections under a decentralized organizational structure, the expert team or QA consultant can be assigned to review a portion of the overall bridge owner population each year. Under a centralized organization, for example with districts reporting inspection results to the DOT, the QA review team may review each district conducting bridge inspections. Care should be taken to ensure that each work group responsible for conducting QC activities be reviewed as part of the QA process, such that the effectiveness of the QC system in achieving the desired level of quality is confirmed.

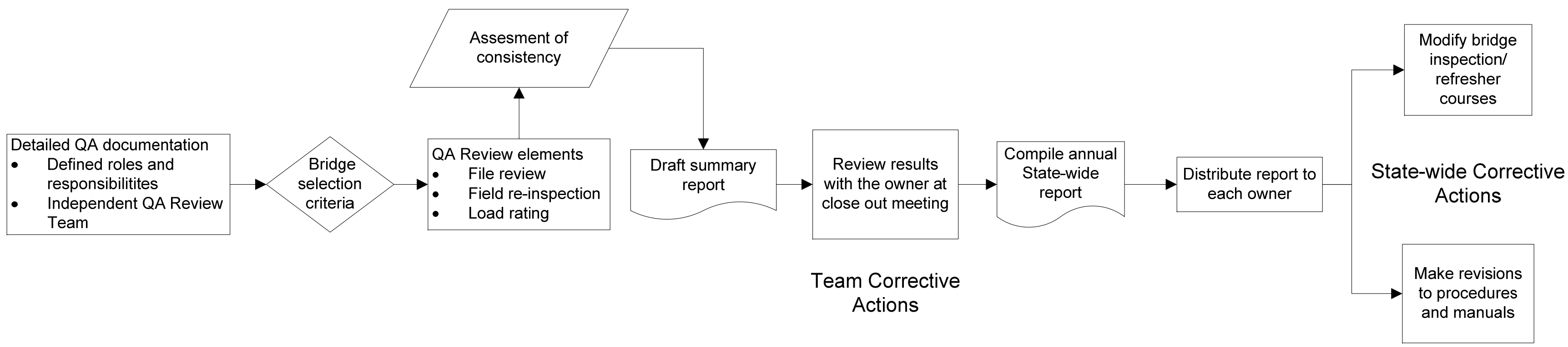

Figure 3-3. Example flow chart for IOM for QA for highway bridge inspections.

3.2.3.2 Control Bridge Model (CBM)

The CBM is characterized by the use of a small number of “control bridges” to evaluate inconsistencies in the inspection process. These “control bridges” are inspected by all of the inspection teams being evaluated as a part of QA review. Each inspection team conducts a routine inspection of the control bridges and generates a suitable and complete bridge inspection report. The results of the inspections from all of the teams are compared with a calibrated or “expert team” inspection of the bridges, to identify inconsistencies or errors between the two inspection results.

The inspection results can then be analyzed for two purposes. First, the results can be used to evaluate the performance of individual teams in conducting inspections at the desired level of quality. This can indicate specific teams that are performing below expectations, and may need additional training or guidance to improve their inspection practices. Second, the results can be analyzed to determine inconsistencies that are programmatic in nature, and signal the need for improving certain characteristics of the inspection program. For example, if the inspection teams use a variety of different CoRe elements to describe the same element, this may indicate that the element descriptions are unclear, not well understood, or too many closely related elements are being used to allow for consistent utilization in the field. If there is a wide distribution of ratings for a particular bridge component, this may indicate that the descriptions associated each numerical rating are inadequate, or that additional training is required to ensure consistent application of the ratings.

Figure 4-4 shows a schematic diagram of the CBM model. To maintain certification as a bridge inspector in the State, semi-annual training session must be attended that include each team inspecting the control bridges and developing an independent inspection report prior to the meeting. The results from all participating teams are assembled prior to the meeting, such that substantive discussions of inconsistencies can be held at the meeting. A benchmark team also inspects the bridge such that individual inspector results can be compared with standard benchmark. The advantage of this method is that it focuses on the individual inspectors, ensuring that the QA process reaches each inspector. Additionally, the assessments are uniform across the population of inspectors participating, such that inconsistencies and frequent errors can be easily identified. This data can then be utilized to support corrective actions, such as changes to the inspection manual or specialized training.

A "control bridge" is simply a highway bridge of typical or common characteristics for the overall bridge inventory in a State. Each inspection team being evaluated observes the same bridges under the same conditions, and as such the bridge acts as an experimental "control." In this manner, the approach to conducting the inspection, tools used, time required, and notes, photos and other supporting information should match across all of the inspector population, if the guidelines and procedures are being applied evenly. The advantage of such an approach is that inconsistencies in the inspection process can be clearly identified. Specific deterioration can be documented, for example, and the results from different inspection teams can be directly compared. This reduces the uncertainty in results compared with the evaluation of teams inspecting different bridges, where a one-to-one comparison between results is not possible. The disadvantage of this approach is that only a small portion of the bridge inventory is evaluated. during the review, such that the review is less broad than if a larger number of bridges are included in the review process.

Another unique feature of the CBM as it has been implemented in Oklahoma is the inclusion of an experimental evaluation of load rating. A questionnaire is distributed to load raters that includes questions regarding procedures and assumptions for load rating based the AASHTO Manual for the Condition Evaluation of Bridges. A load rating for H-20 and HS-20 loading for the test bridge was part of the questionnaire, and subsequently compared with the results from a benchmark team. This allows for the consistency of load rating engineers to be assessed in a uniform manner.

Discussions with personnel associated with the application of the CBM model indicate that this process has had a significant, positive effect on their bridge inspection program overall. The process has led to numerous improvements in inspection manuals and indentified areas where additional resources or training are needed. Additionally, the engagement of bridge inspectors in the process has improved moral and led to an overall enhancement of the bridge inspection program in the State. Cost data for the implementation of such a model was not available.

One disadvantage of the CBM is that it evaluates primarily the bridge inspectors and inspection process, and does not include QA for other aspects of the typical bridge file. A separate activity to conduct office reviews within the work group conducting the inspection may be necessary to measure the effective of the QC procedures within the work groups in terms of maintaining comprehensive bridge files, scheduling of inspections, and other items not addressed through the CBM process.

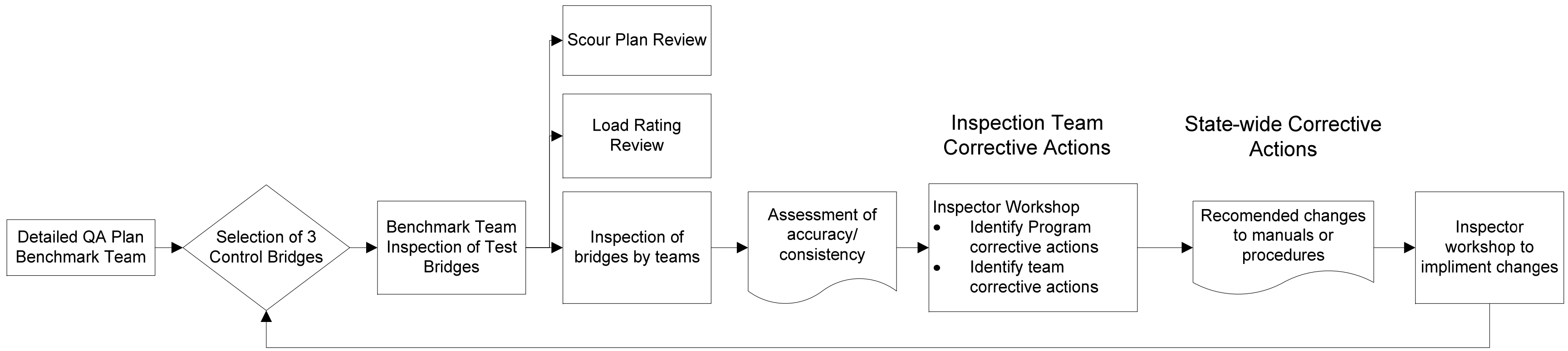

Figure 3-4. Example flow chart for CBM for QA of highway bridge inspections.

3.2.3.3 Collaborative Peer Review Model (CPRM)

The Collaborative Peer Review (CPR) model is characterized by a team-based approach to the review of inspection activities in the field. This process is similar to the IOM in that a re-inspection of bridges within a region or locality's jurisdiction is conducted. The process for CPR is shown schematically in Figure 4-5. In this model, the subject inspection team representative, such as the team leader (or the team), participates in a re-inspection of a sampling of bridges within their jurisdiction. A team of peers are assembled to participate in a team-oriented re-inspection. The peer team would normally be assembled from inspectors from another work group, representatives from the central office, and others that may be appropriate such as the FHWA bridge engineer, design group, or maintenance engineers.

Building from a blank inspection data sheet, the QA team including the subject inspector collaborates to develop appropriate elements and condition states/ratings. Discussion of appropriate ratings and element selection is ongoing during the QA inspection. After the team has developed its report, the original inspection report is reviewed and differences are discussed in detail among the team. A report is generated documenting the results of the review.

The consistency of inspection results are quantified by comparing the results of the collaboratively-developed inspection report with the original inspection results. This provides a means for identifying areas where improvements may be needed for the specific inspection teams, and the summarization of results from multiple reviews can be used to identify programmatic improvements.

The CPR process may include an office review that includes a review of the bridge file, scour action plans, load rating compliance and inspection scheduling. The peer team may also review the resources available to the inspection teams, such as tools, access equipment, etc., confirm the qualifications of inspectors, load rating personnel and underwater inspectors, and normal components of an office review.

The collaborative nature of the inspection provides additional training for inspectors during the inspection and support a positive environment for QA reviews. The ancillary members of the peer group also benefit from improved understanding of the inspection process and challenges face is assessing the condition of the bridge. The inclusion of maintenance engineers or others responsible for the operation and repair of bridges can support improved communication between maintenance and inspection staff and assist in developing a more holistic approach to the inspection and repair of bridges. The inclusion of design staff in the CPR can also support the communication between work groups, and help design engineers to identify design characteristics that may have a negative impact on the durability of a bridge. Additionally, a better understanding of access challenges faced by inspectors can be developed in the design team, which may lead to improve bridge designs for inspectability.

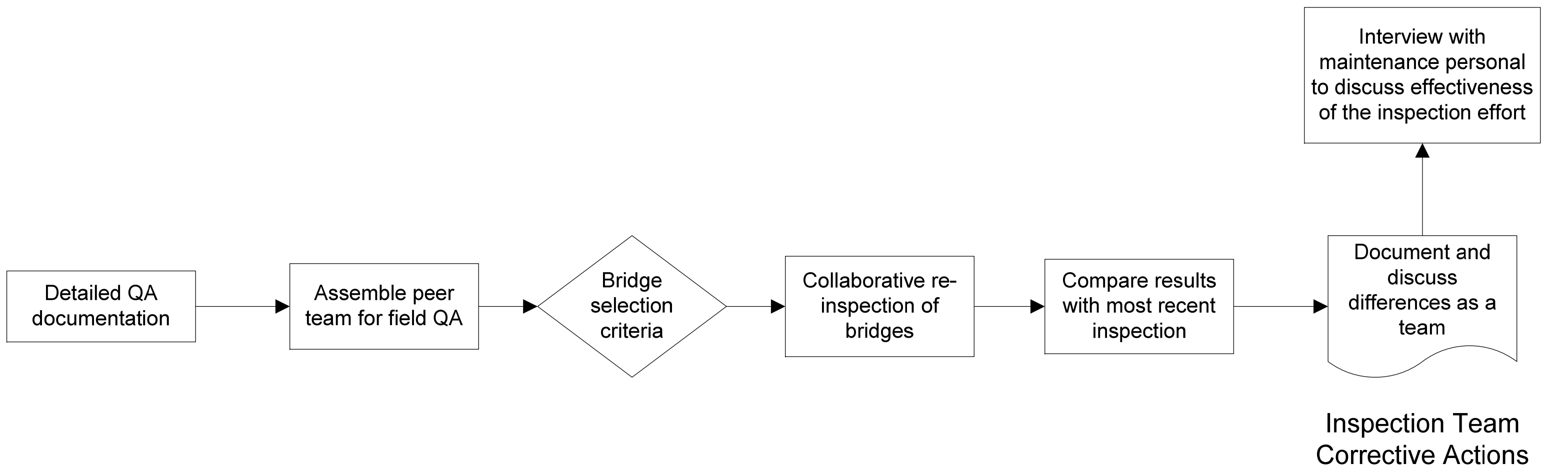

Figure 3-5. Example flow chart for CPR model for QA.

3.2.3.4 Field Verification Model (FVM)

A fourth model used for the QA reviews is a field verification (FVM) of the inspection results. This approach is probably the least formal of the methods for QA. It consists of performing a field review of the bridge inspection results to verify the results, and documents corrections or errors related to the subject team. This review is typically conducted by an individual such as a supervisor or reviewing engineer with responsibility for oversight of one or more inspection teams. The verification inspections are typically conducted with the most recent inspection report in-hand, such that the re-inspection is not necessarily independent or objective. This model is typically employed on a per-team basis, with the emphasis to visit each team over a specified interval. Reporting on the results of such a field review may be through an individual reports to the team and/or annual reports highlighting focus areas for the coming year (Missouri DOT, Wisconsin DOT). Results of such a review can be qualitative in nature, resulting in some limitations in assessing the performance on a system-wide basis. The inclusion of a quantitative approach to document the rate of inconsistencies could be included in such a model, but was not a part of those practices investigated thus far.

3.3. Quality Assurance Conclusions

There are obviously variations on these basic models, with specifics and personnel changing depending on the organizational structure of the individual Department of Transportation. The IOM has several advantages. It is objective, independent, provides a “second look”, can be comprehensive and seems to have fairly broad application in various forms to assess different levels of organizations, with the standard practice including oversight of bridge inspection practices by a higher organizational level. For example, a district being responsible for QA on locally-owned bridges within the district, or for inspections by consultants. Additionally, this basic model may be implemented in an ad-hoc fashion to address specific deficiencies recognized through QC and normal operations, such as a need for evaluation of load rating practices statewide. Disadvantages for the IOM include high cost and very time consuming. The CBM model provides and “apples to apples” comparison, however it focuses on the inspection team is narrow, as well as being costly and time consuming. The CPRM provides training during the test. Kind of continuing education as well as evaluation, however, interpersonal dynamics can come into play making this model subjective. The FVM or field verification model is definitely the lowest cost alternative and requires very few recourses or manpower to implement, however, it is very subjective.

3.4. Role and requirements of ISO 9001

In the past modern quality systems such as the International Standards Organization (ISO) 9000 series have been applied to the manufacturing industry. Similar to quality programs they have been introduced the area of bridge inspection. Generally ISO 9001 has been applied areas such as: definition of product needs, product design, conformance to product design, and product support. When the outcome of a bridge inspection is viewed as a product it is not hard to imagine how ISO could be very beneficial in a bridge inspection quality program.

One tenant of quality programs that appears repeatedly in this report is corrective actions. It does little good to identify problems in quality and inspection programs if measures are not taken to correct these problems once they are found. Corrective actions play a key role in continual improvements, which is one of the fundamental requirements for ISO 9001. Continual improvement implies that a comprehensive quality program will have a goal of improving the quality of the process, not just maintaining quality at a minimum level. In terms of bridge inspection, this suggests that a quality program would enable the continuous improvement of quality, that is, reducing the variability in inspection results as an ongoing process. This is a somewhat more ambitious goal than presently stated in the NBIS, but may be a consideration for developing a forward-looking comprehensive quality program.

The overall requirements of the ISO 9000 process are provided in Appendix A for the purpose of providing general information on quality programs as applied in other industries. There are 11 fundamental requirements for ISO 9001 compliant quality programs that can be generally mapped to QC/QA processes for bridge inspection, several of which have already been mentioned. The essential characteristics of an ISO 9000 compliant quality program include such items as defining a quality system, defining management responsibility, and maintaining a database for all documents. The ISO 9000 requirements also include a process for internal and external audits, and a process for continual improvement as a part of the quality system. Many of these requirements can be mapped to elements of bridge inspection QC/QA, though this process can at times be difficult. However, the requirements indicated in Appendix A provide some context for relating quality programs for highway bridge inspection programs to those utilized in other industries.

4: Program and Program Documentation

4.1. Introduction

As with any program there are certain elements which must be in place in order for the program to be effective. Elements like a program manual which describes the program in detail. Every program should document why, who, what, where, when and how. With this information a person who has no prior knowledge of the program can implement such a program successfully.

4.2. Quality Program Manual

Realizing the QC and QA are two parts of an overall quality program, it may be suitable to develop a unified quality manual that describes the overall system for quality in bridge inspections and load rating. A quality manual documents an organization's quality management system (QMS). Such a manual would typically include:

- Definition of the scope of the QMS.
- Describe how the QMS processes interact.
- Defines roles and responsibilities within the quality program

- Document the quality procedures or refer to them.

Such a manual can provide a convenient means of managing and controlling quality processes by providing a single reference describing the overall program. A quality manual can help indentify gaps in the quality program by providing a centralized overview of the entire program, including both QC functions and QA functions. Such a manual can also help ensure consistency across the program, the key goal of quality documentation.

Regardless of how the documentation of the quality program within a State is realized, there are typical characteristics of the documentation that would normally be included to provide a comprehensive documentation that meets the goal of ensuring consistency in the program. The quality documentation would typically include the following elements: Why, who, what, where, when and how. These elements of QA/QC documentation are described further below. To provide an example of how these elements are implemented in a practical quality document, Appendix F provides an example quality program document from the State of Pennsylvania. Appendix F shows the quality program description from the bridge inspection manual. Notations in the margin have been added to indicate examples of the elements described below.

4.3. Documentation of Why

The goals and objectives of the QC/QA program should be described in quality documents. The role of QA and QC in ensuring bridge safety, reducing variation in bridge inspection results and providing programmatic support should be described such that those charged with implementing the QA/QC procedures can develop a full understanding of the purpose and importance of the program.

4.4. Documentation of Who

A critical element of the quality program is to effectively document the roles and responsibilities of the individual members of the quality process. Documenting the roles and responsibility of the quality team members is critical to ensuring that individuals are aware of their responsibilities and the responsibilities of their colleagues and understand their role within the larger quality program. The functions and activities within the larger quality program should be properly addressed such that the requirements for the role of individuals have legacy when individuals leave the agency or are promoted/transferred.

The documentation should identify who has QCE and QAE responsibilities. This may include describing the qualification or general characteristics necessary to fulfill these roles, such as independence from the inspection process being reviewed, or a general description of knowledge necessary or expected from those filling particular roles. This may include identifying specific positions or individuals within the overall DOT structure. It quality functions are delegated, describe the work groups to whom the responsibility is assigned. The terms QCE and QAE are used here in a general sense to describe the individuals with QC/QA responsibilities, this may be one person in the work group, such as a supervisor or peer team leader. It may be a specific work group, such as a consultant or locality, or several people within an inspection program, such as assigning a QC function to the Assistant District Bridge Engineer in each district.

Define the individuals responsible for conducting QC/QA procedures. This could include the individuals responsible for ensuring that the reviews are conducted, who will actually conduct the reviews, and who will ensure the results of the review are distributed properly and implemented. The qualifications of the individuals responsible for conducting the reviews should be delineated sufficiently to ensure that the desired level of knowledge and experience is achieved. Such documentation should identify specific positions within the organizational structure, rather than simply identifying organizational units. For example, specifying "The Assistant Bridge Engineer shall ….." would be preferable to "The bridge design division shall….," since the latter can be ambiguous and does not suggest the level of qualification of the individual conducting or overseeing the QA procedure. If an outside consultant is utilized to conduct the QC or QA reviews, it may be specified in the documentation.

If QC or QA reviews will be conducted by a team of reviewers, then the characteristics of the team should be described in the documentation. For example, a QA review team may consist of a QA engineer from a central office, a team leader from another district, the team leader being reviewed, and the FHWA Division Bridge Engineer. Documenting the team characteristics in the quality documentation helps ensure the characteristics of the review teams are consistent and maintained between review cycles. This helps support consistency in the program, ensures reviews are conducted in a uniform manner, and that the QA process is fair and objective. This also supports a full understanding of the QA process based on the documentation, such that those that are subject to a review know what to expect, and the process can be reviewed.

The work groups that are the subject of the QC/QA review should also be described. Depending on the organizational structure of the specific State, this may include districts, counties, townships, consultants, etc.. Sufficient description should be provided to fully describe the subject work groups, such that the extent of the quality program can be determined, and those that are subject to reviews can identify their own role in the quality program.

4.5. Documentation of What

Obviously, quality documentation should describe what activities and procedures will be conducted as part of the quality program. This includes describing the types of reviews to be conducted, such as office reviews of inspection reports, and may include documenting systematic elements that are maintained on an on-going basis within the program, such as inspector qualification and documentation procedures. The review functions that are to be executed by the QCE and the QAE should be described. Review functions might include a review of the inspection report, a field review of inspection results, a field performance review, a peer exchange, a combination of methods, or other approaches not mentioned here. Several methodologies for performing reviews for both QC and QA are documented in these guidelines, other procedures may be appropriate for a particular bridge owner or agency.

Effectively documenting what will occur during the quality process will help ensure that the subject of the process will have a full understanding of what will take place. It will also assist those implementing the QA process do so in a uniform and consistent manner. It also provides an overview of the process that can be evaluated and reviewed as part of development and improvements to the program or during a program audit or review.

The documentation should specify how the process results and associated corrective actions will be documented and information distributed through quality reports. Sufficient data should be included to ensure that the results of quality reviews, either QC or QA, will be adequately documented in quality reports and disseminated or transmitted to relevant groups or organizational elements. Again, consistency in the QC/QA process is the end goal, and documenting what reporting is expected and to whom the reported should be disseminated supports that goal. This also ensures that relevant participants in the process are aware any findings and corrective actions that are needed.

4.6. Documentation of How

Quality documents may include specific descriptions of quality procedures to be implemented to achieve the goals of the quality program. These procedures provide specific descriptions of how certain reviews are to be conducted. For example, the quality program may implement an office inspection report review as part of QC. The procedure for how to perform that review should be documented to ensure that the purpose and goals of the review are established, and that the reviews are done in consistent manner. Forms to be completed during the quality process can provide a means of ensuring that procedures are completed in a consistent manner, and items are not overlooked. Detailed forms or procedures may be a part of the quality manual that describes the program overall, or may be referenced from such a manual.

Alternatively, the specific procedures for conducting quality functions may be delegated to the work group conducting the inspection or load rating. For example, QC may be delegated to a local bridge owner or consultant. In such cases, it may be useful to provide some overall goals, minimum characteristics or expectations such that the delegated procedures meet the needs of the quality program in terms of thoroughness, rigor and consistency. This also ensures that those charged with developing the procedures have an understanding of what is expected.

4.7. Documentation of When

The sampling frequency for the quality functions should be documented. Frequency of the quality function may be a measure of time, such as performing a procedure annually, or may be a quantity, such as a 10% of inspection reports, or a combination, 10% of reports annually. However stipulated, the documentation of frequency for the QC functions identified in the quality program help ensure that the functions are performed at the expected rate, that the dimension of the program is described, and the thoroughness of the program can be assessed. If the frequency of quality functions is delegated to the work group conducting the inspection, it should be so stated in the quality documents.

A QA procedure may include specific agendas or time schedules for the conduct of the QA review. This helps develop a full understanding of the process by the work groups being reviewed and helps ensure the reviews are conducted in a uniform manner. This may include a specific schedule for the QA review, for example, a daily schedule that provides and overview of when reviewers will arrive, what activities are anticipated during the review, and follow-up meetings to be held.

4.8. Documentation of Where

The location of the QA reviews may be described in the quality documentation. This might include basic information specific to the State's organizational structure, such as "…the QA team will travel to the District office to conduct a review." This may also include general descriptions such as "at the bridge site," or "at the consultant's office." The "where" may also be implied, such as stipulating "prior to submittal to the State," implies a "where" that is relevant to the submitter.

The elements indicated provide some guidance for what characteristics quality documents might possess. Given the diversified nature of State programs, the quality documents address herein may have many different forms or exist in many different kind of documents, but these basic elements would normally be identified in effective and complete quality documentation.

4.9. Form recommendations

A series of forms have been developed that help ensure that certain vital aspects of a quality programs have not been overlooked. Some of these forms were developed from scratch; others were taken and modified from forms already developed by the states agencies. These forms include many of the items discussed earlier in this report. These forms are located in appendices B-E. Appendix B contains forms pertaining to inspector qualifications. Appendix C contains forms pertaining to QC. Appendix D contains forms pertaining to QA. Appendix E contains a load rating questionnaire.

5: Current State of Practice

5.1. Introduction

Currently there are many different quality programs being utilized by DOTs. Each state has its own program as required by NBIS. Recommendations are made at the federal level as far as what quality program should include, however, these recommendations are not all specific or clear in their meaning. And while some states follow the federal recommendations very closely, others do not. Some programs are very thorough while others are almost inexistent.

Several of the more noteworthy programs are outlined below. They are placed under the QA outline for which they fit best. Although they are not necessarily an exact match, they share common key characteristics.

5.2. IOM States

5.2.1 Connecticut

The Connecticut Department of Transportation's Bridge Safety and Evaluation (BS&E) uses eleven State employee bridge inspection teams, four of them are Consultant Engineer (CE) bridge inspection teams one of which specializes in underwater inspection. The teams inspect, over 5,000 bridges, 1,800 sign supports, 900 mast arm supports, and about 40 high mast illumination towers.

The QC/QA procedure uses CE to perform field review of bridge inspections. Every year, two of the four CE bridge inspection teams switch to perform two field reviews of bridges that are inspected by each of the State and three other CE inspection teams including one of each CE's sub consultant. The CE and State teams may both perform partial field reviews of the underwater CE firm as well. Currently there are a total of 16 field reviews by each of the two Consultants for a total of 32 per year. Since BS&E has increased the number of State inspection teams, these field reviews will also increase accordingly.

The guidelines as written by the state of Connecticut for QA/QC field reviews are as follows:

1. Bridges will be picked randomly, but each State team and CE firm will be represented. Per the Bridge Inspection Manual (BIM), at least two bridges per team/firm will be selected each year
2. No culverts will be selected
3. For major structures, the CE will be given a time frame of a day or two for a specific span(s)
4. Structural inspection of portion of a movable bridge may be included
5. The Consultant will have access to all information on file for the assigned structure with the exception of the original inspection report for which QA is being performed
6. Following the field review, the CE will review the original inspection report and comment on the following:
    - Did the team use the appropriate equipment, etc.?
    - Does the report include all necessary forms, sketches, photos, etc. as required?
    - Does the coding correctly reflect the condition of the bridge?
    - Was the review by the engineer adequate?
    - Was a maintenance memo required/justified?
7. The CE will then summarize their findings by noting any problem areas between their field review and the original inspection report, and recommend steps that should be taken to resolve problem areas

8. The final submittal shall include marked-up inspection report, the above summary, and include the following table below to track items needing follow-up. The is shall be part of the responsibilities and duties of the Supervisor in accordance with BIM (Connecticut DOT 2008)

5.2.2 Massachusetts

In Massachusetts quality control is performed by the District Bridge Inspection Engineer (DBIE) in each district. All of the inspection reports are reviewed for compliance prior to being entered into the bridge inventory. This review ensures that proper forms have been used, that the information has been entered properly, consistency with NBIS ratings on items 58 through 62, adequate documentation and photographs are taken, as well as consistency with previous inspection reports.

The quality assurance program is charged to Bridge Inspection Engineer (BIE). During the quality assurance process personnel qualifications are checked, as well as making sure that inspectors are current in their training. The BIE also ensures that individuals evaluated stay within the required parameters of their position, and double checks that correctional measures have been implemented or that the necessary follow up is being performed.

Field and report evaluations are also performed at this time. This is done by the Area Bridge Inspection Engineer (ABIE). During these reviews forms are completed for the corresponding evaluation. These forms ask questions like "Did the team arrive at bridge in a timely manner?" for the field evaluation form and, "Is the Quality Control Engineer Qualified?" for the report evaluation form. (Massachusetts Highway Department 1998)

5.2.3 Michigan

Most of the bridge inspection program (BIP) functions are delegated to the bridge owner by MDOT. The BIP functions retained by MDOT are primarily limited to responding to the issues raised by local agencies or their consultants through bridge inspection. The Bridge Operations Unit (BOU) performs these state retained functions.

QA is performed by consultants hired by MDOT. They perform these reviews on a rotation however there are so many different bridge owners that QA is only preformed every 8-10 years. The procedures followed by these consultants are shown below as listed by MDOT.

- Notify agency of the upcoming review and arrange date(s).
- Select bridges and review inspection reports. The number of bridges to review was based

  on the agency's total number of NBIS bridges. This criterion was set in the QA consultant contract.
- Perform QA review including:
  - Opening meeting with agency personnel and inspection staff.
  - Office review of bridge files.
  - Field review of selected bridges.
  - Close-out meeting with agency.

5.2.4 New York

The quality program for New York is contained in two documents, Chapter 11 of Bridge Inspection Manual contains the procedures for quality control, and the Structures Division Quality Assurance Procedure contains the Quality Assurance procedures. In New York quality control involves both field reviews and examination of all bridge inspection documentation. All field reports are checked for completeness, accuracy, and conformance to Bridge Inspection Manual. Checking for completeness involves the Quality Control Engineer checking all records to ensure that all the required items are included, as well as ensuring that all the forms are filled out correctly. By using the quality control checklist they have developed, they are able to ensure that nothing is overlooked. Checking for accuracy and conformance is also performed by the Quality Control Engineer. This is done by reviewing all reports to make sure all components were properly documented and rated. All the photos and remarks are reviewed to ensure consistency. The job of ensuring that the required level of inspection intensity was performed is left to the Quality Control Engineer.

The quality assurance program was created by the Structures division. In the Structures division they have followed these procedures for years. Quality assurance is performed in several manners under this program. First is the initial data submission review. During this review clerical or administrative items are checked. Basically it is an office review for consistency and completeness of the report. Next there is a technical review. This review covers all of the inspection data and has up to three components. First there is a folder review. This review checks all inspection documents, plans and photos. The second component is a scan review. In this review a sample of inspection reports are scanned for errors or omissions. Only critical parts of the report are reviewed. This review is used to select reports or a more rigorous review. This review is the third component and is called the select review. During this review the report is reviewed in a similar manor to the scan review but in greater depth. After the initial data submission review is completed a QA submission review checklist is completed. This review provides a final look at the inspection documents. This gives the reviewing engineer an opportunity to flag any mistakes or inconsistencies that have been missed (New York DOT 1999).

5.2.5 Pennsylvania

The Pennsylvania model is characterized by widespread, systematic and independent re-inspection of a large number of bridges. The population of bridges that are re-inspected include 30 bridges in each of 11 Districts and 15 bridges for the Pennsylvania Turnpike, for a total of 345 bridges per year. The quality assurance review of these bridges is comprehensive, and includes the following primary items:

- Office File Review: Review of bridge file content
- Field Inspection: Independent, complete NBIS re-inspection of bridges, including independent condition/appraisal ratings
- Load Rating analysis and Posting Recommendations: A load rating analysis is performed on the subject bridges and compare with existing load ratings in the bridge inspection file to identify inconsistencies, posting needs or difference, etc.
- Preparation of Summary Reports

- Field View and Close-out meeting
- Cycle Summary Report

The procedure also specifies specific limits for the expected consistency between the QA review inspection and the existing bridge inspection records. The original inspection item ratings are considered out-of-tolerance if they vary more than +/-1 from the ratings compile by the QA team. Capacity ratings are considered out-of-tolerance if they differ more than 15%, and for posted bridges the tolerance limit is 2 tons.

The quality assurance system is applied using a consulting firm to re-inspect the bridge selected. There are two separate reports generated as a result of the QA review. A draft summary report is prepared for each district summarizing the results of the QA review. The results of the QA review are discussed at a close-out meeting between the QA consultant, the subject District engineer and inspection staff, local bridge owners and their inspection consultants. A field review of several of the bridges is conducted with members of the Bridge Quality Assurance Division prior to the close-out meeting to review the findings of the QA review. Following the close-out meeting, the summary report is finalized and submitted to the BQAD for review, and finally distributed back to the districts.

In addition, cycle summary reports are prepared after the QA process has been completed for all of the Districts and Turnpike Authority bridges. A separate report is prepared for Districts, local bridge owners and the Turnpike Authority. The cycle summary report includes an overview of State-wide and individual District’s results for the QA cycle, documenting out-of-tolerance items including condition and appraisal items, scour rating, load ratings and omissions in maintenance needs.

Corrective actions include revisions to Procedures and Manuals, and changes to bridge inspection training. In this QA process, the focus is on a population of selected bridges as determined by a process described in the policy documents. The bridges are generally selected to representative of the District's local bridge inventory, and have had recent bridge inspections completed (6 to 9 months). The estimated cost of the QA program of bridge re-inspection is $1 million / year.

5.2.6 Washington

In Washington State cities inspect their own bridges. These agencies must meet NBIS requirements then submit the data to WSDOT. It is the job of the inspection organization (WSDOT level) to maintain and inventory of bridges, which contains information such as bridge type, dimensions, clearance, and condition. Generally inspection frequency is every 2 years, but ultimately it is at the discretion of the head of the bridge inspection organization.

Quality assurance happens in the form of Quality Assurance Inspection reviews. Every year a random group of bridges are field reviewed. In this field review inconsistencies are addressed, and conformance to NBIS is checked. These reviews also review the latest inspection report and inventory information. The bridge inspector at the regional level completes and office review. Discrepancies are discussed with the bridge inspection team leader. Underwater inspections are also reviewed. These inspections are contracted out to consulting (Washington State DOT 2002).

5.3. CBM States

5.3.1 Oklahoma

The Oklahoma model takes an entirely different approach, which is related to the control inspection concept utilized in Finland(Karper 2008). In this model, rather than having a selection of bridges chosen for re-inspection, a small number of "control bridges" are selected for inspection by all of the bridge inspectors being evaluated. In odd-number years, and each participating bridge inspection team is required to inspect those specific bridges prior to a bridge inspector's workshop. The bridges are inspected by a benchmark team from the Central Office to establish target values (control values) for component ratings and element descriptions and ratings. The data that the teams submit is evaluated for consistency and the results are presented to the participating inspectors at a workshop. During the workshop, small break-out groups of inspectors are utilized to develop recommendations on elements or areas that are found to be inconsistent. These recommendations are then presented to the entire workshop at the end of the day. ODOT management and the FHWA then try to implement the recommendations.

During even-numbered years, the annual inspector's workshop is utilized to review the implementation of recommendations from the previous year's QA review process. The workshop format allows for interchange between inspectors regarding the appropriateness and effectiveness of the recommended changes. If the inspection teams agree to these changes, then the changes are implemented for the next cycle of inspections.

As part of the Test Bridge concept implementation, a scoring scheme has been devised to evaluate the consistencies between inspector's ratings and the ratings of the Benchmark team. The scheme is applied to Pontis data collected, and is intended to provide a means of evaluating the assignment of condition states. Because of the nature of the element-level inspection data, it is more complex to effectively evaluate the consistency of results. The scoring scheme compares the benchmark team rating with inspection results, and weights the assignment of quantities in various condition states and the number of possible states to determine one single score for the evaluation.

For component level inspection, the process of evaluating the consistency of results is less complex because portions of the component cannot be assigned to different states. The typical estimate of condition ratings of +/- 1 is generally applied to evaluate the consistency of ratings. One advantage of the Test Bridge Model is that quantifiable results are produced that can be easily compared for assessment and to identify particular shortcomings or inconsistencies on a uniform basis for all inspectors. Other models are implemented on a variety of bridges such that such 1 to 1 comparisons are more difficult. An example of data from Oklahoma is shown in Figure 1 which shows the results for the Item 58, bridge deck. The distribution of rating extends over 5 ratings for this component. The rating from the benchmark team is shown in red in this case. As can be seen from the figure, the inspectors generally rated this component higher than the benchmark team on average. A quality score is also assigned to these ratings based the average consistency with the benchmark team. For the data shown in the figure, the average inspector score was 65.

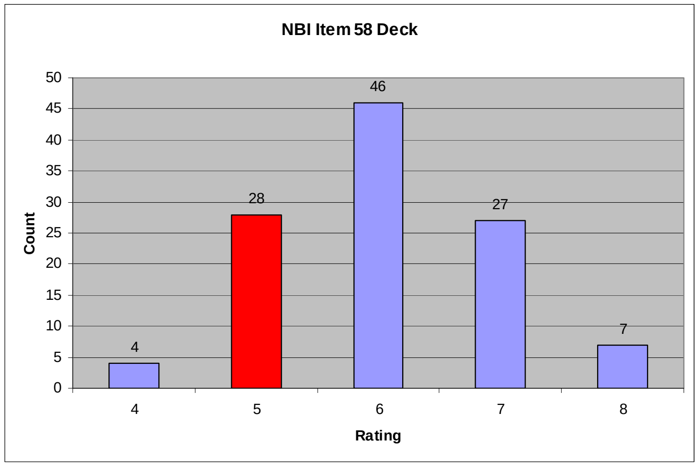

Figure 5-1. Deck component rating distribution for a control bridge in Oklahoma.

Load ratings are also part of the QA process. Load rating calculations are done for the subject bridges are completed prior to the annual meeting by engineers responsible for load rating of on-system and off-system bridges. These load rating are evaluated for consistency and compared with the benchmark team ratings. A written questionnaire has also been utilized to determine the source of inconsistencies stemming from basic knowledge of appropriate load rating practices and procedures. This written questionnaire is submitted prior to the annual meeting such that sources of inconsistency or error can be discussed at the annual meeting. This questionnaire consists of two sections. The first includes general questions as appropriate material properties, LFR rating equations, impact factors, etc. from the Manual for the Condition Evaluation of Bridges. The second section of the questionnaire includes specific questions regarding the subject test bridges, including, for example, what is the appropriate compressive strength to be used for the bridge deck. Bridge plans are provided to support this portion of the questionnaire, and it is expected that the engineer will use the bridge plans provided and the Manual for the Condition Evaluation of the Bridges to answer these questions.

There is a master list of bridge inspectors maintained that documents qualifications of inspectors, and ensures that the inspectors have been participating as required in the annual quality assurance reviews and the associated training (annual bridge inspectors meeting). Corrective actions include adjustments to the bridge inspection manual, local coding descriptions (for Pontis) and focused retraining implemented through the annual meetings.

5.4. CPRM States

5.4.1 Oregon

In Oregon QA is performed in several manors. Part of this review is performed in the field. For STIP projects a QA review team reviews structures in the worst condition in each region and then develops a rehabilitation or replacement plan for every structure in question. They review major bridge maintenance projects and also provide a second opinion when it comes to load ratings. By reviewing bridges in the worst condition the QA team is able to discuss on site plans for repair/rehabilitation. The field review is an independent inspection which is then compared with the findings from the original inspection. The differences are then discussed and an interview is held with maintenance personnel to determine effectiveness of inspection effort

The QA review team is made up of inspectors from other regions and newly hired bridge inspection staff, in order to insure consistency. All questions are openly discussed and it is made sure that everyone is in full agreement.

QA review process

There is also a QA office review, which assures that all inspections performed, and that the appropriate level of follow up is performed. Another item the office review covers is the bridge selection procedure. Typically urgent need, load rating restrictions, rehab needed bridges are selected. The sampling size is 5% of regional routine inspections. It also evaluates the selection of QA review team (Oregon DOT).

5.4.2 Wisconsin

Wisconsin has two levels of quality assurance. The level 1 QA review is a comprehensive review performed by the Statewide Program Manager or their delegate. Then the FHWA Structural Systems Engineer must fill out the 8 page Inspection Quality Assurance Program Review Form. This form may be seen in the appendix.

The level 2 QA Review is a less comprehensive, informal written QA evaluation. County program QA reviews are the responsibility of the district program managers. They are responsible for conducting regular QA evaluations of the county structure inspection programs under their jurisdiction. Local program reviews are assigned to the county managers. They are responsible for conducting regular QA evaluations of the municipal and local government structure inspection programs under their jurisdiction (Wisconsin DOT). These reviews are conducted annually.

The schedules for these reviews are as follows:

- QA reviews scheduled
- QA Program Review forms are sent out two weeks before onsite review
- Agencies scheduled for review are required to fill out the form as completely as possible. Participants in an on site review shall include FHWA Structural Systems Engineer, SPM or Delegate, DPM, or County or Local Manager, and the inspection Team Leaders from the inspection agency being reviewed, including consultants. Other appropriate Inspection team members may attend.
- On site review will be conducted at the district/ local inspection agency's office and will include a field visit to selected bridges.

5.5. FVM States

5.5.1 Florida

Florida's program consists of two parts. The first part is the "Quality Assurance Monitoring Plan" where various primary functions or areas to be monitored are listed in a table. A portion of this table can be found below in Figure 5-2. Along with the areas to be monitored, the authority responsible for monitoring, monitoring methods and frequency are listed, as well as how the results are distributed.

Part two of Florida's program is "Quality Assurance Critical Requirements". A portion of this table can be seen in Figure 5-3. In this portion the critical requirements are listed out in a table and then compliance indicators for that requirement are shown. For example one critical requirement is that, "Work covered by bridge work orders properly completed and documented." In order for that requirement to be met the following compliance indicators must be met: 90% of all work orders are coded correctly, 90% of all work orders must be completed on time, and 100% of emergency and urgent work orders must be completed on time.

This plan is not sufficient in documenting an entire program. The descriptions for the monitoring activities are not detailed enough. However, this would be beneficial as an outline or a quick look at the program (Florida DOT 2007).

PART I

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
QUALITY ASSURANCE MONITORING PLAN

260-010-03
PERFORMANCE MANAGEMENT
08/99
Page 1 of 10

For MAINTENANCE
Office or Functional Area

DATE: 9/6/07

PRIMARY FUNCTONS (Areas to be Monitored)	AUTHORITY	MONITORING ACTIVITY		RESULTS		NONCOMPLIANCE/ OUTSTANDING AREAS
		METHOD	FREQUENCY	REPORTED	SHARED	FOLLOW-UP
Bridge Maintenance and Repair	850-010-031	Evaluate district processes using data, documents and field review	District Office & one Maintenance unit per district annually	Exit Interview, QAR report to District	Quality Assurance Letter to District Secretary, District Maintenance Engineers Meeting, Annual QA Report	District Response, Follow Up Action
Bridge Inspection	Bridge Inspection & Repair Manual 850-010-035, 850-010-030, and Rule 14-48	Evaluate district processes using data, documents and field review	District Office annually	Exit Interview, QAR report to District	Quality Assurance Letter to District Secretary, District Maintenance Engineers Meeting, Annual QA Report	District Response, Follow Up Action
Maintenance Contracts	375-020-002, 850-000-020, 850-000-025, 850-070-001, and 375-000-005	Evaluate district processes using data, documents and field review	District Office & one Maintenance unit per district annually	Exit Interview, QAR report to District	Quality Assurance Letter to District Secretary, District Maintenance Engineers Meeting, Annual QA Report	District Response, Follow Up Action
Permits	F.S. Chapter 120	Evaluate district processes using data, documents and field review	District Office & one Maintenance unit per district annually	Exit Interview, QAR report to District	Quality Assurance Letter to District Secretary, District Maintenance Engineers Meeting, Annual QA Report	District Response, Follow Up Action
Maintenance Rating Program	850-065-002	Evaluate district processes using data, documents and field review	District Office	Exit Interview, QAR report to District	Quality Assurance Letter to District Secretary, District Maintenance Engineers Meeting, Annual QA Report	District Response, Follow Up Action
Roadway and Roadside Maintenance	850-000-015	Evaluate district processes using data, documents and field review	District Office & one Maintenance Unit per district annually	Exit Interview, QAR report to District	Quality Assurance Letter to District Secretary, District Maintenance Engineers Meeting, Annual QA Report	District Response, Follow Up Action

APPROVED BY: ____________ DATE: 9/6/07 REVISION # ____________
Designated Senior Manager
(See Instructions)

Figure 5-2: Portion of Florida's Quality Assurance Monitoring Plan

PART II. QUALITY ASSURANCE CRITICAL REQUIREMENTS
Complete and submit as an attachment to the Monitoring Plan

FUNCTIONAL AREA: Office of Maintenance

PRIMARY FUNCTION: Bridge Maintenance and Repair
Critical Process: Maintenance and Planning of Bridge Repairs

Critical Requirements	Compliance Indicators
Work Covered by Bridge Work Orders Properly Completed and Documented	90% of all bridge work orders are coded properly 90% of all work orders completed on time 100% of emergency and urgent work orders completed on time
Bridge repairs performed using BRRP or PK funds properly scheduled and reported	100% of bridges on the Bridge Work Plan (Deficient Bridge List) have reasonable cost estimates, and are scheduled for corrective action within 5 years 100% of project scopes for major bridge repair have the proper action type assigned in Pontis 100% of bridge repaired with BRRP or PK funds are recorded in the Financial Management System
Scour Evaluation and Action Plans Properly Documented	100% of scour critical bridges have a plan of action 90% of scour data is correct in Bridge Management Data Base

APPROVED BY: Jeffrey A. Pouliotte — Designated Functional Manager (See Instructions) DATE: 9/7/07

Office of Maintenance

PRIMARY FUNCTION: Bridge Inspection
Critical Process: Bridge Inspection and Load Rating

Critical Requirements	Compliance Indicators
Bridge Inspections Properly Performed and Documented	95% of elements correctly identified 95% of elements have proper condition states
Quality Control Practices	District has a Quality Control Plan which identifies areas to be evaluated, frequency of review, review process, corrective action, personnel responsible, and follow up action to be taken Documented Quality Control reviews performed in accordance with the QC plan
All bridges are load rated and data is correctly entered into the Bridge Management System Database	100% of bridges selected in the sample reviewed are 90% properly performed or load tested. These ratings are documented and correctly entered into the database 100% of bridges have been load rated within 90 days for state owned bridges and 180 days for locally owned bridges of final acceptance by Construction
All delinquent postings/closing deficiencies for both state and local bridges are resolved within 90 days of occurrence	For a period of one year, 100% of all delinquent postings/closing deficiencies for both state and local bridges are posted within 90 days of occurrence (when the District becomes aware) and the resolution is properly documented

APPROVED BY: [signature] — Designated Senior Manager (See Instructions) DATE: 9/6/07

Figure 5-3: Portion of Florida's Quality Assurance Critical Requirements

6: Conclusion

This document has presented an overview and description of various methodologies and procedures for implementing QC/QA for bridge inspection and load ratings. Definitions and quality tenants have been provided to develop a better understanding of the purpose of quality programs, what is meant by “quality” in regards to routine bridge inspections and load ratings, and what characteristics are common in bridge inspection QC/QA programs. The document is intended to provide a resource for bridge owners developing or improving their QC/QA programs. As such, the document provides a series of example methodologies and models that can be practically implemented to maintain and assure a high degree of accuracy in the bridge inspection and load rating practices.

It is envisioned that the information provided will be utilized by bridge owners as a foundation for developing QC and QA programs that meets the needs of their particular programs. These procedures can be utilized to assure the systematic QC and QA procedures are used to maintain a high degree of accuracy and consistency in bridge inspection programs.

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Appendix A: Fundamental requirements for ISO 9001 compliant quality programs.

1. Define Quality System	ISO 9001 requires a documented quality policy for the quality system, including procedures, instructions, rating systems, and performance measures.
2. Define Management Responsibility	Corresponding responsibilities for management and authorities for all personnel must be specified, not just an "agency." Available resources must be defined
3. Contract Review Material and Construction Process Tracing	ISO 9001 requires that construction contracts be reviewed to determine whether the original requirements are adequately defined. ISO 9001 also requires that all materials and processes used be identified and traceable during each inspection implementation.
4. Database for all documents.	The general documentation requirements of ISO 9001 stated: "(Clause 4.2) management must define the documentation including the relevant records needed to establish, implement and maintain the quality management system and to support an effective and efficient operation of the organization's process."
5. Design Control and Peer Review	ISO 9001 requires that procedures to control and verify the design and design changes be established. It also requires peer reviews for specified control procedures.
6. Test Equipment, Inspection Testing Procedures	ISO 9001 requires that equipment used to demonstrate conformance be calibrated and checked before use and rechecked at prescribed intervals. The inspection and testing are performed according to specified procedures. Inspection intervals must be properly defined.
7. Control of Inspection Results	ISO 9001 requires that inspection results must be thoroughly reviewed and causes of nonconforming features be traceable and corrected if feasible.
8. Internal and External Audits of the Quality Control Procedures	ISO 9001 requires that audits be planned and performed. The results of audits are communicated to management, and any deficiencies found are corrected.
9. Training	ISO 9001 requires that training needs be identified and that training be provided for implementation personnel. Records of training are maintained.
10. Analysis of inspection Results	ISO 9001 states that, where appropriate, adequate statistical techniques and tools are identified and used to verify the analysis of inspection results and in auditing procedures.
11. Continual Improvement	In ISO 9000:2000, a built-in mechanism of continual improvement of the quality management system becomes a requirement. Continual improvement is a giant step beyond "maintenance." It covers the entire spectrum of design, performance measure, production (inspection and service) procedures, documentation, analysis, QC/QA programs and resource allocation, etc. Quality improvement produces enhanced product reliability, longer product life, better user satisfaction and even cost reduction.

Appendix B: Sample Qualification Records

QUALIFICATIONS RECORD
Structure Inspection Program
Wisconsin Department of Transportation
DT2001 2003 s.84.17 Wis. Stats.

Applicant Name	Area Code - Telephone Number - Home	
Address	Area Code – Telephone Number - Work	
City	State	ZIP Code
E-Mail Address	Employer	

Refer to the Wisconsin DOT Structure Inspection Manual for required qualifications. Forward two completed copies of this form to the Statewide Structure Inspection Program Manager via the District Program Manager or directly at 4802 Sheboygan Ave., Room 601, PO Box 7916, Madison, WI 53707-7916. One copy will be returned to you with an assigned number if deemed qualified.

PART I - REGISTRATION/TRAINING - Complete All Information

Wisconsin Registered Professional Engineer - Yes Reg. No.: - Emphasis: Structural
NICET Level III or IV - Yes Reg. No.: If Yes, Attach Copy of Certificate
NHI Based 80-Hour Training Course - Yes Date: If Yes, Attach Copy of Certificate

Pertinent Inspection Related Training Courses Completed

Additional Specialized Certifications

APPROVAL: FOR WISDOT PROGRAM MANAGER USE ONLY! DO NOT WRITE BELOW THIS LINE.

☐ Visual Acuity Certificate Attached
☐ NHI Based 80-Hour Training Course Certificate Attached
☐ Experience Reviewed/Verified
☐ Reference Letter Attached

Qualified As ☐ Program Manager
☐ Team Leader

Reviewed By , Program Manager		Date
☐ Central Office	☐ District	☐ County

Assigned Number	Assigned By
Assigned Date	Date Copy Returned to Applicant

PART II - EXPERIENCE - Attach Additional Sheets If Needed

Persons other than a P.E. or NICET Level III/IV are required to complete Part II in its entirety. A minimum of 5 years of responsible bridge inspection experience for Team Leaders and 10 years for Program Managers must be shown. P.E.'s and NICET individuals are also requested to complete Part II for informational purposes only. List all relevant experience.

Bridge Safety Inspection Field Experience

Please state your experience in various types of bridges (i.e., steel girders, concrete girders, trusses, slabs, prestressed girders, culverts, movable bridges, other complex structures, etc.).

Date From	Date To	Describe Bridge Type(s) and Inspection Type(s)	Name & Telephone No. for References	Approx. %*

* **Percent of year devoted to bridge safety inspection field work.**

I, the undersigned, affirm that all statements and data in Parts I and II are true and correct. I understand that any misrepresentation may constitute fraud, and may be punishable to the full extent of the law. Furthermore, I understand that it is my responsibility to stay current on bridge inspection issues, and that I will notify the WisDOT Statewide Program Manager of any name or mailing address changes in writing within 30 days.

____________________ (Applicant Signature) __________ (Date)

Signature of Individual Providing Letter Reference: See attachment A for Format

____________________ (Signature) __________ (Date)

Wisconsin Sample Reference Letter

ATTACHMENT A
SAMPLE REFERENCE LETTER

(Current Date)

Mr. / Ms. ________________
Bridge Inspection Program Manager
(Address)

RE: (Name of Applicant) Qualifications

Dear Bridge Inspection Program Manager:

This letter is submitted as verification of the experience of Mr./Ms. (Name of Applicant) in the field of bridge inspection and allied areas. I have personal knowledge that Mr./Ms. __________ has ____ years of experience in bridge inspection and allied areas as outlined below:

i. (Please describe applicant's experience including percentage of time and the type of structures on which the applicant worked. In addition to bridge inspection field experience, please indicate experience in bridge inspection office experience, bridge design, bridge construction, bridge maintenance/repair, other structure inspection experience, etc. Furthermore, two copies of the applicant's Qualifications Record, Structure Inspection Program form should be attached to this letter with the author of this letter signing the second page.

ii. (Please explain your affiliation to the person and the WisDOT Bridge Inspection Program).

If you have any questions or concerns, please feel free to contact me at (xxx)-xxx-xxxx.

Sincerely,

____
(Signature of Reference Letter Author)

____
(Title and Bridge Inspection Program Affiliation)
(i.e., District Program Manager, County Manager, Consultant, etc.)

cc: (Name of Applicant)
Attachment: Qualifications Record (DT2001) (2 copies)

Page 3 of 3

Sample Record of Qualifications

Desired Minimum Bridge Inspection Experience Level
The predominate amount, or more than fifty percent, should come from NBIS bridge safety inspection experience. Other experience in bridge design, bridge maintenance, or bridge construction may be used to provide the additional required experience.

Evaluation of Experience Criteria:
When the State or Federal Program Manager evaluates an individual's actual experience for compliance with the experience requirements for a Team Leader, the following minimum criteria are to be considered:

1. The relevance of the individual's actual experience, i.e., has the other experience enabled the individual to develop the skills needed to properly lead a bridge safety inspection.
2. Exposure to the problems or deficiencies common in the types of bridges being inspected by the individual.
3. Complexity of the structures being inspected in comparison to the knowledge and skills of the individual gained through their prior experience.
4. The individual's understanding of the specific data collection needs and requirements.
5. Demonstrated ability, through some type of a formal certification program, to lead bridge safety inspections.
6. The level of oversight and supervision of the individual.

<table>
<tr><td colspan="3">Team Leaders Name</td><td colspan="2"></td><td>Date</td><td></td></tr>
<tr><td colspan="2">Agency Name</td><td colspan="5"></td></tr>
<tr><td rowspan="6">Education:</td><td>Institution</td><td></td><td>Years</td><td colspan="3"></td></tr>
<tr><td>Major</td><td></td><td>Degree</td><td colspan="3"></td></tr>
<tr><td colspan="6">Comments:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="6">Professional Registration:</td><td>State</td><td></td><td>Registration #</td><td colspan="3"></td></tr>
<tr><td>Branch/Agency</td><td colspan="5"></td></tr>
<tr><td colspan="6">Comments:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="5">Bridge Inspection Training:</td><td>Course</td><td></td><td>Sponsor</td><td colspan="3"></td></tr>
<tr><td>Hours</td><td></td><td>Dates</td><td colspan="3"></td></tr>
<tr><td colspan="6">Comments:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
</table>

<table>
<tr><td rowspan="5">Special Technical Course:</td><td>Course</td><td></td><td>Sponsor</td><td></td></tr>
<tr><td>Hours</td><td></td><td>Dates</td><td></td></tr>
<tr><td colspan="4">Comments:</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="6">Bridge Inspection Experience</td><td>Agency/Firm</td><td></td><td>Years</td><td></td></tr>
<tr><td>Bridge Duties</td><td></td><td>% NBIS bridge safety inspection experience</td><td></td></tr>
<tr><td colspan="4">Comments:</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
</table>

Other/Comments:____

____

____

To the best of my knowledge the above information is true and accurate.

Team Leader's Signature:_______________________________ **Date:**_________________

Washington State Bridge Inspector Expierence and Training Record

Washington State Department of Transportation

Bridge Inspector Experience and Training Record

Team Leader Name	Date

Agency Name

Education

Institution	Major	Years	Degree

Professional Registration

State	Branch/Agency	Registration Number

Bridge Inspection Training

Course	Hours	Sponsor	Dates

Special Technical Course

Course	Hours	Sponsor	Dates

Bridge Inspection Experience

Agency/Firm	Bridge Duties	Years

To the best of my knowledge, the above information is true and accurate.

Team Leader's Signature ______________________ Date __________

Having reviewed the above information, I conclude that this individual meets the minimum qualifications for a bridge inspection team leader as specified in the current National Bridge Inspection Standards.

Team Leader's Supervisor's Signature ______________________ Date __________

Supervisor's Name (Print) Title

DOT Form 234-100 EF
8/98

Appendix C: Sample QC Review Forms

Reviewer			
Team Leader			
Team Members			
Bridge Number		**Inspection Date**	

The QC office review is designed to ensure the appropriate forms have been used, consistency of ratings, accuracy of data, consistency between reports, and completeness.

	Yes	No
Have the appropriate forms been used?		
Is the data accurate according to FHWA coding Guide and State requirements?		
Was the clearance and waterway profile updated as necessary?		
Are all inventory items correctly entered?		
Are channel profiles taken near substructures if visual inspection is not possible?		
Is the extent of scour documented by sketches?		
Are under water sketches done if necessary?		
If there are stream channel alignment problems are there stream alignment sketches?		
Is the water depth measured and documented to determine if diving is required?		
Is the load rating current?		
Is the bridge scour critical?		
Is there a scour plan of actions?		

Is Condition Adequately Documented by:			Sketches		Photos		Explanation	
Item 58. Deck	Previous	Current	Yes	No	Yes	No	Yes	No
Wearing Surface								
Deck Condition								
Stay In Place Forms								
Curbs								
Median								
Side Walks								
Parapets								
Railing								
Drainage System								
Lighting Standards								
Utilities								
Deck Joints								
Overall Condition								

Is Condition Adequately Documented by:			Sketches		Photos		Explanation	
Item 59. Superstructure	**Previous**	**Current**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Stringers								
Floorbeams								
Floor System Bracing								
Girders or Beams								
Trusses								
Pin and Hangers								
Conn Plt's Gussets and Angles								
Cover Plates								
Bearing Devices								
Diaphrams/Cross Frames								
Rivets and Bolts								
Welds								
Member Alignment								
Paint/Coating								
Overall Condition								

Is Condition Adequately Documented by:			Sketches		Photos		Explanation	
Item 60. Substructure	Previous	Current	Yes	No	Yes	No	Yes	No
Abutments								
a. Pedestals								
b. Bridge Seats								
c. Backwalls								
d. Breastwalls								
e. Wingwalls								
f. Slope Paving/Rip-Rap								
g. Pointing								
h. Footing								
i. Piles								
j. Scour								
k. Settlement								
Piers or Bents								
a. Pedestals								
b. Caps								
c. Columns								
d. Stems/Webs/Pierwalls								
e. Pointing								
f. Footing								
g. Piles								
h. Scour								
i. Settlement								
j.								
k.								
Pile Bents								
a. Pile Caps								
b. Piles								
c. Diagonal Bracing								
d. Horizontal Bracing								
e. Fasteners								
Overall Condition								

Sample QC review form for element level inspections.

ODOT Bridge Inspection QA Review

Bridge Name ______________ **Br. No.** ________ **Hwy No.** ________ **MP** ___ ___ **Date** ________

Agency / Consulant **Insp Area** **Bridge Owner** **Reviewers**

	Reviewers	Inspector		Reviewers	Inspector
AC Depth			**Deck Condition (58)**		
Wearing Surface Type (108)			**Superstructure Condition (59)**		
Sturcture Status (41)			**Substructure Condition (60)**		
Bridge Posting (70)			**Channel & Channel Condition (61)**		
Safety Features (36)			**Culvert Condition (62)**		
Main Span Type (43)			**Load Rating Needing Review?**		
Appr Span Type (44)			**Bridge Restrictions Appropriate?**		
Scour Code (113)			**Bridge Roadway Width (51):**		
Lanes On/Under (28)			**Appr Roadway Width (32):**		
Waterway Adequacy (71)			**Appr Roadway Alignment (72):**		
Suggested Level Of Acess:			**Vertical Clear over Deck (53):**		
Suggested Inspection Frequency:			**Detour Length (19):**		

Element	Q'ty	1	2	3	4	5		1	2	3	4	5	Element	Q'ty	1	2	3	4	5		1	2	3	4	5

Remarks	Maintenance Recommendations	JSA
Compared to ____________ Inspection.		

Sample Field Performance Review

Inspection start time:____________

Inspection completed time:____________

Performance Question	Yes	No
Are inspections completed in a thorough manner?		
Is the proper equipment utilized when needed?		
Is there and adequate number of inspectors present?		
Was proper determination and use of direction of orientation used?		
Was a field check of previous postings done?		
Was the previous inspection report used during inspection?		
Was 100% hands on inspection of non-redundant members performed?		
Were rating scales used properly?		
Was information input properly into report forms?		
Were appropriate sketches and tables used when preparing documentation?		
Were plans verified or updated?		
Does the team have the proper qualifications?		

Equipment Checklist

The following items were readily available to the bridge inspection team								
	Yes	No		Yes	No		Yes	No
Measuring Tape			Chipping Hammer			Chest Waders or Hip Boots		
100 ft. Measuring Tape			Shovel Spade			Ladder		
Calipers			Scrapper			Sounding Equipment		
Carpenters Level			Wire Brush			Timber Increment Borer		
Plumb Bob			Camera			Underclearence Rod		
Flashlight			Probing Rod			Inspection Mirror		
Binoculars			Boat/Canoe			Brush Hook/Machete		
Life Jackets			Magnifying Glass			Screwdriver		
First Aid Kit			Wrenches/Pliers			Thermometer		

Sample Personal Safety Evaluation Form

Bridge Access and Fall Protection

Safety Question	Yes	No
If bucket truck or aerial lift device is used have the operators been trained in its operation?		
Is the bridge being rigged? And if so…		
Is the team trained to perform this rigging and knowledgeable in all applicable OSHA regulations?		
Are proper safety procedures being followed?		
Does the team feel that additional safety equipment is needed?		
Does the team feel that additional training is needed?		
Does the reviewer feel that additional equipment/training is needed?		
Are the inspection crew members trained in fall protection?		

General Comments:____
____
____
____

Personal Protective Equipment Checklist

	Yes	No		Yes	No
Hard Hat			Harness		
Boots			Gloves		
Respirator			Ear protection		
Lanyard			Confined space air monitor		
High visibility apparel			First aid kit		
Protective eyewear			Dust mask		

Equipment

Safety Question	Yes	No
Is the appropriate personal protective equipment (PPE) being used?		
Is the required PPE available in the vehicle?		
Does the team have a list of emergency phone numbers?		

Sample Work Zone Protection Form

Safety Question	Yes	No
Are cones and signs being utilized on approaches?		
Is maintenance and protection of traffic being used?		
Is the set up in conformance with MUTCD?		

GeneralComments:____

____

____

____

Appendix D: Sample QA Review Forms

LEVEL 1 – REVIEW RECORD

Structure Inspection Quality Assurance Program
Review Performed by FHWA/WisDOT Central Office
Wisconsin Department of Transportation
DT2002 2003 s.84.17 Wis. Stats.

Date	Agency Under Review

QUALIFICATIONS
The AASHTO *Manual for Condition Evaluation of Bridges* states "Qualified personnel should be used in conducting bridge inspections". This section is to determine if personnel meet federal and state qualification requirements. Please refer to Section 2.3 of the Wisconsin DOT Structure Inspection Manual for the required qualifications in Wisconsin. If a consultant is hired to manage the program and/or inspect bridges, it is recommended that they are present during the quality assurance review. **IMPORTANT: Attach an updated copy of the originally approved Qualifications Record (DT2001) and current Inspector Visual Acuity Record (DT2005) for each individual listed below.**

Inspection Program Manager - Person in charge of inspection program

Name	WisDOT Qualification Approval Date

Registered Professional Engineer
☐ Yes ☐ No

Experience

Training

Time Allocation (%)
Bridge/Culvert Inspection Other Bridge Related Activities Non-Bridge Activities

Date of Last Visual Acuity Screening Form Submittal

Inspection Team Leaders - People that sign the inspection reports

Name	WisDOT Qualification Approval Date

Registered Professional Engineer
☐ Yes ☐ No

Experience

Training

Time Allocation (%)
Bridge/Culvert Inspection Other Bridge Related Activities Non-Bridge Activities

Date of Last Visual Acuity Screening Form Submittal

Inspection Team Leaders - People that sign the inspection reports

Name	WisDOT Qualification Approval Date
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection Other Bridge Related Activites Non-Bridge Activities	
Date of Last Visual Acuity Screening Form Submittal	

Inspection Team Leaders - People that sign the inspection reports

Name	WisDOT Qualification Approval Date
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection Other Bridge Related Activites Non-Bridge Activities	
Date of Last Visual Acuity Screening Form Submittal	

Inspection Team Members - People that assist Team Leaders with inspections. Does not sign inspection reports.

Name	Date of WisDOT Qualification Form Approval
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection Other Bridge Related Activites Non-Bridge Activities	
Date of Last Visual Acuity Screening Form Submittal	

RECORD KEEPING

The AASHTO *Manual for Condition Evaluation of Bridges* states, "Bridge owners should maintain a complete, accurate and current record of each bridge under their jurisdiction. Complete information, in good usable form, is vital to the effective management of bridges. Furthermore, such information provides a record which may be important in legal action."

Bridge File - The bridge file describes all bridges under the jurisdiction of the Program Manager. This file should contain all cumulative information about each individual bridge.

Location of Bridge File			
File Accessible to Users			
Bridges Sorted in the File by			
☐ Bridge Number	☐ Road	☐ Township	☐ Other
Separate Lists of Bridges Requiring the Following Inspection Types			
☐ Fracture Critical	☐ Diving	☐ Other Special Inspections	
Length of Time Information is Kept in the File			

Bridge File Documents

Yes	No	Document
☐	☐	Bridge Plans
☐	☐	Correspondence
☐	☐	Original Structure Survey Report
☐	☐	Original As-Built Plans
☐	☐	Load Rating Analysis Computations
☐	☐	Rehabilitation Plans
☐	☐	Initial / Inventory Update Inspection Reports
☐	☐	Routine Inspection Reports
☐	☐	Inspector Qualification Records
☐	☐	Inspector Visual Acuity Records
☐	☐	Inventory and Appraisal Field Review Report
		Special Inspections
☐	☐	Damage Inspection Reports
☐	☐	In-Depth Inspections Reports
☐	☐	Fracture Critical Reports
☐	☐	Underwater Probing Reports
☐	☐	Underwater Profiles Reports
☐	☐	Underwater Diving Reports
☐	☐	Load Posted Reports
☐	☐	Interim Inspection Reports
☐	☐	Movable Bridge Electrical Inspection Reports
☐	☐	Movable Bridge Engine Generator Inspection Reports
☐	☐	Movable Bridge Hydraulic Inspection Reports
☐	☐	Movable Bridge Mechanical Inspection Reports
☐	☐	Ferry Inspection Reports
☐	☐	Miscellaneous Support System Inspection Reports*
☐	☐	Border Bridge Inspection Reports
☐	☐	Other

* Highway sign bridges, high mast light poles, retaining walls, etc.

LEVEL 2 FILE REVIEW
Discuss Level 2 Reviews since last Level 1 Review.

INSPECTION
The AASHTO Manual for Condition Evaluation of bridges states, “Bridge Inspections are conducted to determine the physical and functional condition of the bridge”. “Successful bridge inspection is dependent on proper planning and techniques, adequate equipment, and the experience and reliability of the personnel performing the inspection”.

Planning and Scheduling

Number of Bridges the Program is Responsible to Inspect

Number of Inspections Performed in the Past Calendar Year

Number of Inspections Performed in a Day

Length of Time for an Average Inspection
Beam/Girder Slab Truss Box Culvert Other

Previous Inspection Reports Available at the Bridge for Review
☐ Yes ☐ No

Bridge Plans Taken to the Bridge for use During Inspection
☐ Yes ☐ No

Bridge Plans Available in Office, if needed
☐ Yes ☐ No

Initial Inspections - New and Rehabilitated Structures

Baseline Assessment Performed and Problems Identified
☐ Yes ☐ No

Inventory and Appraisal Field Review Report Verified
☐ Yes ☐ No

Bridge Inspection Report Form Updated to Reflect Modifications
☐ Yes ☐ No

Comments

Routine Inspections

List Frequency for Routine Inspections

All Inspections Performed in One Year
☐ Yes ☐ No

Inspections Performed Each Year
☐ Yes ☐ No

List Type of Vehicle Used for Bridge Inspection

Dedicated to Inspection Full-time or Part-time

List equipment carried on vehicle for inspection and taken to the site

Y/N/A	Equipment	Y/N/A	Equipment	Y/N/A	Equipment
	Extension Ladder		First Aid Kit		Feeler Gauge
	100-Foot Tape		Steel Wire Brush		Probing Rod
	6-Foot Rule		Brass Wire Brush		Vertical Clearance Rod
	Geologist Hammer		Calipers		Radio / Cell Phone
	Inspection Mirror		Shovel		2-inch Scraper
	Flashlight		Inspection Forms		Optical Crack Gauge
	Thermometer		Extra Paper		Magnifying Glass
	Plumb Bob/Protractor		Screwdriver		Hard Hat
	Camera		Pliers		Safety Shoes
	2-Foot/4-Foot Level		Wrenches		Reflective Vest
	Binoculars		Incremental Borer		Dust Mask
	Brush Hook		Sounding Chains		Respirator
	Laptop Computer		Hip Boots / Waders		Flashing Light
	Boat		Paint Stick / Marker		Harness/Lanyard
	Life Jackets		Scraper		Safety Glasses

Y/N/A - Yes, No, Available

INSPECTION - continued

SPECIAL INSPECTIONS

Damage Inspections

☐ Bridge load posted | ☐ Bridge closed

Load Posted / Closed Bridges

Number of Bridges

Describe How Load Posting and/or Closure was Determined

Computations for a Load Analysis is on File for All Bridge Load Posted and Closed
☐ Yes ☐ No

Comments

List Frequency of Inspection for Signs on Load Posted and Closed Bridges

In-Depth Inspections

Number of Redundant Bridges with Unique Features that May Require an In-Depth Inspection

______ Pin & Hanger
______ Pin Thru Web
______ 3 Girder Trap Box
______ Truss & Girder Bridges with Floor Beams & Stringers
______ Fatigue Prone Details – Category D, E, E'
______ ADT ∞ 50k
______ Other Details

Fracture Critical Inspections

Number of Fracture Critical Bridges the Program is Responsible to Inspect

List Inspection Frequency

List Procedures and Criteria Used for a Fracture Critical Inspection

Underwater Inspections

List Number of Bridges that are over Water

List Number of Bridges that have Been Screened for Scour Susceptibility

List Number of Bridges that are Scour Critical

List Number of Bridges Requiring

______ Visual/Probe Inspection ______ Frequency
______ Diving Inspection ______ Frequency
______ Underwater Profile Survey ______ Frequency

Scour Critical Bridges

Number of Bridges

Describe how Scour Critical Nature was Determined

Written Monitoring Action Plan for Each Bridge is Developed and on File
☐ Yes ☐ No

Monitoring System Installed on Scour Critical Bridges
☐ Yes ☐ No

INSPECTION - continued

SPECIAL INSPECTIONS

Interim Inspections

Who Determines What Bridges Require an Interim Inspection?

List Criteria Used

List of Bridges that Currently Require Interim Inspections

Number for Structural Condition

Number for Hydraulic Condition/Scour Critical

Other

Movable Structure Inspections

Number of Movable Bridges the Program is Responsible for Inspecting

List Inspection Frequency

Testing Equipment

List nondestructive testing equipment that may be used for special inspections and who determines the test requirements.

Type of NDT	Test Performed Y/N	Equipment Used	Bridge Component Tested	Who Determines Test Requirement
Audible				
Infrared Thermography				
Ground Penetrating Radar				
Acoustic Emission				
R-Meter				
Schmidt Hammer				
Impact Echo				
Windsor Probe				
Half-Cell				
Chloride Ion				
Material Sampling				
Ultrasonic				
Liquid Penetrant				
Magnetic Particle				
Monitoring Systems				
Unknown Foundation Investigation				

Access Equipment

List the Type of Access Equipment Available for Inspection

- ☐ Underbridge Access Unit
- ☐ Aerial Lift
- ☐ Ladder
- ☐ Scaffolding
- ☐ Boat
- ☐ Other

SAFETY

The AASHTO Manual for Condition Evaluation of bridges states, "Safety of both inspection members and the public is paramount." Inspection should always be performed as a team of two or more persons, never alone.

Personal Safety

Inspections Regularly Performed by a Team of Two or more Inspectors

☐ Yes ☐ No

Indicate Safety Equipment Available To You For Inspection.

☐ Hard Hat	☐ Ear Protection
☐ Safety Vests	☐ Confined Space Air Monitor
☐ Safety Glasses	☐ First Aid Kit
☐ Safety Shoes	☐ Dusk Mask
☐ Safety Harness	☐ Respirator

Public Safety

Work zone protection should be in accordance with "Manual of Uniform Traffic Control Devices." Describe how traffic control is set up for bridge inspection.

FOLLOW-UP ACTIONS

Each inspection report shall be reviewed by the maintaining authority for completeness and recommendations. The inspector's recommendations should be considered for implementation within the limits established for public safety, cost effectiveness, and fiscal restraints.

Inspectors Recommend Maintenance Actions on Inspection Form ☐ Yes ☐ No	Recommendations are Categorized or Prioritized ☐ Yes ☐ No
Special Maintenance Form Used ☐ Yes ☐ No	Recommendations Made by Inspector are Reviewed by Maintaining Authority ☐ Yes ☐ No
Inspectors Inform Maintenance Personnel About Routine Maintenance Needs ☐ Yes ☐ No	Repair Costs and Quantity Estimates are Made ☐ Yes ☐ No

Completed Repairs are Entered on a Paper or Electronic File

☐ Yes ☐ No

List Inspector's Contacts for Emergency Closures or Repairs

List Who has Authority to Close a Bridge Under an Emergency

List Who has Authority to Open a Bridge

Describe how Damage Repairs are Documented

List Who is Responsible to Develop Repair Plans and What Equipment is Available for Repairs and/or Maintenance

Describe how Bridge Repairs and/or Maintenance are Accomplished

Describe how Maintaining Authority is Informed when Maintenance Repairs are Completed

Bridge Replacement/Rehabilitation/Preservation

Taking Advantage of all Funds Available ☐ Yes ☐ No	Costs Entered onto the Bridge File ☐ Yes ☐ No

Describe Who You Contact for Bridge Projects

Describe How Bridge Projects are Prioritized

Describe Problems Encountered in Attempting to Program a Bridge

INSPECTED AGENCY COMMENTS

We have asked a detailed list of questions. Please take this opportunity to ask questions or make comments about the inspection program.

GENERAL

Does bridge inspection team feel it has enough time / equipment / training / experience to do their job properly?

FIELD REVIEW

The field review is intended to look at a minimum of three bridges (typically with problems); bridges that are in the replacement program; bridges with special features; bridges of local interest or questions; and load posted bridges.

List bridges along with reasons for selection.

SUMMARY OF LEVEL 1 REVIEW COMMENTS

Reviewer's Comments

Reviewer's Confidence Level	**Good**				**Poor**
	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

________________________________ __________
(Reviewed Agency's Program Manager Signature) (Date)

________________________________ __________
(Statewide Program Manager or Delegate) (Date)

Wisconsin Level 2 Review Record

LEVEL 2 - REVIEW RECORD

Structure Inspection Quality Assurance Program

Review Performed by Region/County for Locals

Wisconsin Department of Transportation

DT2003 1/2007 s.84.17 Wis. Stats.

Date	Agency Under Review
Regional Program Reviewer or County Manager Reviewer	

QUALIFICATIONS

Please refer to Section 2.3 of the Wisconsin DOT Structure Inspection Manual for personnel qualification requirements.

Inspection Program Manager - Person in charge of inspection program

Name	WisDOT Inspector Certification Number
Registered Professional Engineer ☐ Yes ☐ No	Program Manager ☐ Yes ☐ No

Time Allocation (%)

Bridge/Culvert Inspection | Other Bridge Related Activities | Non-Bridge Activities

Inspection Team Leader(s) - People who conduct inspections and sign inspection reports

Name	WisDOT Inspector(s) Certification Number

Registered Professional Engineer

☐ Yes ☐ No

Time Allocation (%)

Bridge/Culvert Inspection | Other Bridge Related Activities | Non-Bridge Activities

RECORD KEEPING

Bridge File

Location of Bridge File

File Accessible to Users

☐ Yes ☐ No – Comments:

Bridges Sorted in the File by

☐ Bridge Number ☐ Road ☐ Township ☐ Other:

Separate Lists of Bridges Requiring the Following Inspection Types

☐ Fracture Critical ☐ Diving ☐ Other Special Inspections:

Length of Time Information is Kept in the File

Bridge Inspection Reports

Bridge Inspection Reports Are Reviewed for Accuracy and Completeness

☐ Yes ☐ No – Reviewer:

INSPECTION

Planning and Scheduling

Number of Bridges the Program is Responsible to Inspect	Number of Inspections Performed in Past Calendar Year

Bridge Plans Available in Office If Needed

☐ Yes ☐ No – Comments:

INSPECTION - continued

Initial Inspections – New Structures

Baseline Assessment Performed and Problems Identified ☐ Yes ☐ No - Comments:	Load Rating Performed and Calculations on File ☐ Yes ☐ No

Inventory Update Inspections - Rehabilitated Structure

Bridge Inspection Report Form Updated to Reflect Modifications to Structure ☐ Yes ☐ No - Comments:	New Load Rating Performed ☐ Yes ☐ No
SI&A Information Updated ☐ Yes ☐ No - Comments:	Fracture Critical Members Located and Recorded ☐ Yes ☐ No

Routine Inspections

List Frequency for Routine Inspections

All Inspections Performed in One Year or Split Between Years
☐ Yes ☐ No - Comments:

Damage Inspections

Damage Inspections Performed
☐ Yes ☐ No - Comments:

Load Posted / Closed Bridges

Number of Load Posted Bridges	Number of Closed Bridges

Comments

In-Depth Inspections

Number of Redundant Bridges with Unique Features that May Require an In-Depth Inspection
_____ Pin & Hanger _____ Pin Through Web _____ Truss & Girder Bridges with Floor Beams & Stringers
_____ Moveable _____ Other: _____

Comments

Fracture Critical Inspections

Number of Fracture Critical Bridges the Program is Responsible to Inspect

List Inspection Frequency

Underwater Inspections

Number of Bridges that are over Water	Number of Bridges that are Scour Critical	Action Plans Implemented ☐ Yes ☐ No
Number of Bridges that Require Underwater Inspection by Visual/ Probe - Frequency:	Number of Bridges that Require Underwater Inspection by Diving - Frequency:	

Interim Inspections

Who Determines what Bridges Require an Interim Inspection?
- Comments:

Number of Bridges that Currently Require Interim Inspections	Number of Load Posted
Number of Scour Critical	Other

Moveable Structure Inspections

Number of Movable Bridges the Program is Responsible for Inspecting
- Frequency:

Who conducts Structural, Mechanical, Electrical and Hydraulic Inspection?

SAFETY

Personal Safety

Inspections Regularly Performed by a Team of Two or More Inspectors
☐ Yes ☐ No - Comments:

Is Adequate Safety Equipment Available to you for use in Inspection Work?
☐ Yes ☐ No - Comments:

Public Safety

Work zone protection should be in accordance with the "Manual of Uniform Traffic Control Devices." Describe how traffic control is set up for bridge inspection.

FOLLOW-UP ACTIONS

Inspectors Recommend Maintenance Actions on Inspection Form
☐ Yes ☐ No

Recommendations Made by Inspector are Reviewed by Maintaining Authority
☐ Yes ☐ No - Reviewer:

What procedure is used to follow-up and track maintenance actions?

Are completed repairs noted in bridge file?
☐ Yes ☐ No

FIELD REVIEW

The field review is intended to look at a minimum of two bridges (typically bridges with problems); bridges that are in the replacement program; bridges with special features; bridges of local interest or questions; or load posted bridges.

List bridges along with reasons for selection

BRIDGE REPLACEMENT

Taking Advantage of all Bridge Replacement Funds Available
☐ Yes ☐ No

Describe how bridge replacements are prioritized.

SUMMARY OF LEVEL 2 REVIEW COMMENTS

Reviewer's Comments

Reviewer's Confidence Level **Good** ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1 **Poor**

______________________________ ____________
(Regional Program Reviewer or County Manager Reviewer Signature) (Date)

______________________________ ____________
(Reviewed Agency's Inspection Program Manager Signature) (Date)

MINNESOTA DEPARTMENT OF TRANSPORTATION - BRIDGE OFFICE
National Bridge Inspection Standards (NBIS)
Quality Assurance Review of Bridge Owners

This questionnaire should be completed by the Agency's Inspection Program Administrator, and must be returned to the Mn/DOT Bridge Inspection Unit.

AGENCY	
ADDRESS	

1. Bridge Inspection Program Administrator

Each agency must designate an individual to oversee the inspection, inventory, and load capacity ratings of their bridges. This individual must be registered in Minnesota as a Professional Engineer and successfully complete the 2-week bridge inspection class.-To maintain certification, attendance is required at a minimum of two one-day refresher seminars every four years. ***Verify*** *the name and contact information for the Inspection Program Administrator below.*

ADMINISTRATOR'S NAME			
PHONE #		**EMAIL**	
PE REGISTRATION #		**MOST RECENT INSPECTION SEMINAR (YEAR)**	

2. Bridge Inspection Team Leader(s)

A bridge inspection team leader must be present during each bridge inspection. *Certification requires successful completion the 2-week bridge inspection class, 5 years of inspection experience (or engineering registration), and passing a field proficiency test. To maintain certification, attendance is required at a minimum of two one-day refresher seminars every four years.* ***Verify*** *the name and information for each Bridge Inspection Team Leader below. Note: Program Administrators who perform inspections must also be certified as Inspection Team Leaders.*

TEAM LEADER'S NAME:	1-WEEK CLASS (YEAR)	2-WEEK CLASS (YEAR)	LAST INSPECTION SEMINAR (YEAR):

3. Assistant Bridge Inspector(s)

An assistant bridge inspector cannot perform inspections unless accompanied by a certified Bridge Inspection Team Leader. *Anyone who successfully completes the 1-week bridge inspection course is listed as an Assistant Bridge Inspector.* ***Verify*** *the name and information for each Assistant Bridge Inspector below.*

ASSISTANT INSPECTOR'S NAME:	1-WEEK CLASS (YEAR)	2-WEEK CLASS (YEAR)	LAST INSPECTION SEMINAR (YEAR):

4. Frequency of Bridge Inspections

All bridges located on (or crossing over) public roads are required to be inspected and included on the Mn/DOT Bridge inventory. Bridges are generally inspected on a 2-year (24-month) cycle - bridges in poor condition (NBI ratings of "4" or less) must be inspected on a 1-year (12-month) cycle. Note: fracture critical bridges that carry vehicular or railroad traffic must be inspected on a 1-year (12-month) cycle. ***Review the attached Inspection Frequency Report. To request changes to inspection frequencies, submit the report (with any corrections) and the 2-Year Bridge Inspection Interval Request Form (available on the Bridge Office Website) to the Mn/DOT Bridge Office.***

TOTAL NUMBER OF BRIDGES	
BRIDGES CURRENTLY ON 12 MONTH INSPECTION CYCLE	
BRIDGES CURRENTLY ON 24 MONTH INSPECTION CYCLE	
BRIDGES ELIGIBLE TO MOVE TO 24 MONTH INSPECTION CYCLE	

Interim bridge inspections (at intervals less than 12 months) should be scheduled if the Inspection Program Administrator has reason to suspect that condition of a critical element may deteriorate substantially before the next regularly scheduled inspection. ***Verify the number of bridges with interim inspections below.***

NUMBER OF BRIDGES INSPECTED ON A LESS THAN 12 MONTH SCHEDULE	

5. Scheduling of Bridge Inspections

An annual bridge inspection involves, at a minimum, visual examination of all the structural elements of the bridge to determine if there has been any change from the previous inspection. If an excessive number of bridges are inspected in one day, this may indicate that inadequate time was allocated for a thorough inspection.

MAXIMUM NUMBER OF STRUCTURES INSPECTED IN ONE DAY	
HOW MANY OF THESE ARE USUALLY CULVERTS?	
COMMENTS:	

If bridge inspections are conducted in the winter, the inspector should return during more favorable weather conditions to complete the inspection. Follow-up inspections should be noted in the comments section of the inspection report

BRIDGES INSPECTED DURING DECEMBER, JANUARY, OR FEBRUARY	
FOLLOW-UP INSPECTIONS OR NOTES TO VERIFY COMPLETE INSPECTION?	
COMMENTS:	

While bridge inspections may be performed by one person, it is recommended that bridge inspections be performed by a team of two (or more). ***For each inspector, place an "X" in appropriate box (place an "X" in both boxes if inspections are sometimes performed alone).***

INSPECTOR'S NAME:	INSPECTS ALONE?	INSPECTS AS A TEAM?

6. Bridge Inspection Equipment

Indicate whether or not the following inspection is readily available to the bridge inspection team (Y/N)

MEASURING TAPE		CHIPPING HAMMER		PROBING ROD	
100 FT MEASURING TAPE		SHOVEL/SPADE		BOAT/CANOE	
CALIPERS		SCRAPER		CHEST WADERS (OR HIP BOOTS)	
CARPENTER'S LEVEL		WIRE BRUSH		LADDER	
PLUMB BOB		BINOCULARS		SOUNDING EQUIPMENT	
FLASHLIGHT		CAMERA (FILM)		TIMBER INCREMENT BORER	
BINOCULARS		CAMERA (DIGITAL)		UNDERCLEARANCE ROD	

7. Reviewing of Bridge Inspection Reports

Each agency is required to keep signed copies of bridge inspection reports - each report should be signed by the Inspection Team Leader (who was present for the inspection) and the reviewer (typically the Bridge Inspection Program Administrator). ***Enter the name(s) of who signs inspection reports, who reviews inspection reports.***

WHO SIGNS INSPECTION REPORTS AS THE REVIEWER?	

8. Reviewing of Structure Inventory Reports

It is important that information on the Structure Inventory Report be periodically reviewed for accuracy (preferably during each inspection). Items such as wearing course depth or required bridge signage often change over time. ***Inventory updates may be mailed in (or called in) the Mn/DOT Bridge Management Engineer.***

ARE STRUCTURE INVENTORY REPORTS BROUGHT ALONG DURING BRIDGE INSPECTIONS (Y/N)?	
WHO REVIEWS STRUCTURE INVENTORY REPORTS FOR ACCURACY?	

9. Critical Findings

A "Critical Deficiency" is a condition observed during a bridge inspection that, if not promptly corrected, could result in collapse or partial collapse of the bridge. This includes structural conditions or scour conditions that are found to be critical ***during the inspection*** *or that are* ***likely to become critical before the next scheduled inspection.*** *Technical Memorandum No. 05-02-B-02 (July 2005) outlines the policy for responding and reporting critical findings.*

The attached Critical Bridge Report lists all bridges with a rating of Condition "2" for the Critical Finding Smart Flag (PONTIS element #964) - this rating indicates that a critical finding is present. ***Review the attached Critical Bridge Report for accuracy…***

IF ANY BRIDGES ARE LISTED AS HAVING "CRITICAL FINDINGS", HAVE THESE FINDINGS BEEN REPORTED TO THE BRIDGE OFFICE AND HAVE ACTIONS BEEN TAKEN TO RESOLVE THESE FINDINGS?		
ARE ANY BRIDGES INCORRECTLY LISTED AS HAVING "CRITICAL FINDINGS"?		
COMMENTS:		

The attached Critical Bridge Report lists also lists bridges with an NBI condition rating of "2" or less for Items #58 (Deck), #59 (Superstructure), #60 (Substructure), #61 (Channel), # 62 (Culvert), or #113 (Scour) - these ratings may indicate a that a critical finding is present, or may be the result of improper coding.. ***Review the attached Critical Bridge Report for accuracy…***

IF ANY BRIDGES ARE LISTED AS HAVING AN NBI CONDITION RATING OF 2 OR LESS, WOULD ANY OF THESE CONSTITUTE A CRITICAL FINDING?		
ARE ANY BRIDGES WITH AN NBI CONDITION RATING OF 2 OR LESS STILL OPEN TO TRAFFIC?		
ARE ANY BRIDGES INCORRECTLY CODED AS HAVING AN NBI CONDITION RATING OF 2 OR LESS?		
COMMENTS:		

10. In-Depth Inspections

Review the attached lists of bridges in your county requiring "in depth" inspections - this includes Fracture Critical bridges, bridges with pinned assemblies, and bridges requiring underwater inspections. Indicate if any bridges should be added or deleted from these lists.

A copy of the "in-depth" inspection report (fracture critical, pinned assembly, or underwater) should be retained in the bridge file. It is the responsibility of the county to review the inspection report, and to respond appropriately to any "Critical Findings" or other high priority maintenance recommendations.

10.1. Fracture Critical Bridges

Fracture Critical bridges have at least one tension member whose failure would be expected to result in collapse of the bridge (trusses, two-girder structures, and welded steel pier caps are examples of Fracture Critical bridges). Note: only non-redundant bridges carrying vehicular traffic are considered to be Fracture Critical (railroad and pedestrian bridges are excluded). ***While "In-depth" inspections are usually performed by the Mn/DOT Bridge Office, the Program Administrator and bridge inspectors should be aware of which bridge members are Fracture Critical, and ensure that they are examined during each annual inspection - this should be noted under the Fracture Critical Smart Flag (Element #964)***

RE ANY BRIDGES INCORRECTLY LISTED AS BEING FRACTURE CRITICAL?		
RE ANY FRACTURE CRITICAL BRIDGES OMITTED FROM THE LIST?		
OMMENTS:		

10.2. Bridges with Pin & Hanger (or Single Pin) Hinge Assemblies

Bridges with pin & hanger (or single pin) hinge assemblies require ultrasonic inspection on a 5-year cycle (in addition to routine bridge inspections). The Mn/DOT Bridge Office Inspection Unit is available to conduct these inspections (traffic control is the responsibility of the county). ***Review the attached list of bridges with pinned assemblies requiring special ultrasonic inspection.***

RE ANY BRIDGES INCORRECTLY LISTED AS HAVING PINNED ASSEMBLIES?		
RE ANY BRIDGES WITH PINNED ASSEMBLIES OMITTED FROM THE LIST?		
OMMENTS:		

10.3. Bridges Requiring Underwater Inspections

If the underwater elements of a bridge cannot be routinely inspected by wading and probing, a special underwater inspection is required on a five-year cycle. These inspections are performed by divers under a statewide consultant contract. ***The underwater inspection contract for County/Local bridges is administered by the Mn/DOT State aid Office - they should be contacted if any bridges need to be added or deleted from this list.*** *Note: the inspection notes should indicate if the underwater elements of the bridge can be adequately inspected (by wading and probing) during a routine inspection - an interim inspection during low water (or summer months) may be required.*

RE ANY BRIDGES INCORRECTLY LISTED AS REQUIRING UNDERWATER NSPECTION (BY DIVERS)?		
HOULD ANY BRIDGES BE ADDED TO THE UNDERWATER INSPECTION ONTRACT?		
AVE THE RECOMMENDATIONS NOTED IN THE UNDERWATER REPORTS BEEN CKNOWLEDGED AND RESOLVED?		
OMMENTS:		

11. Bridge Load Capacity Ratings

Example bridge rating calculations are explained in the AASHTO Manual for Condition Evaluation of Bridges (available at www.aashto.org). If you have questions about bridge load ratings, please contact the Mn/DOT Bridge Load Ratings Engineer. ***The attached Load Posting and Rating Report lists all bridge within your jurisdiction that have load postings, speed restrictions, or are closed to traffic, review the report for accuracy.***

ARE ANY BRIDGES INCORRECTLY LISTED OR OMITTED FROM THE LOAD POSTING REPORT (Y/N)?		
COMMENTS:		
WHO PERFORMS BRIDGE LOAD RATINGS?		
WHO REVIEWS BRIDGE LOAD RATINGS?		

12. New Load Capacity Ratings

The date of the last load rating is displayed on the bridge's Structure Inventory Report. A new load rating is required when the dead load on the structure is increased (such as when a new deck wearing surface is installed). A new load rating may also be required if a bridge has been damaged or has deteriorated significantly since the last load rating. It may be appropriate to use engineering judgment to supplement calculations when assessing the load capacity of damaged or deteriorated bridge members. If a new load rating is performed, a copy must be submitted to the Mn/DOT Bridge Management Unit (load rating forms are posted on the Mn/DOT Bridge Office web site) - load rating calculations and documentation should be retained by the bridge owner. ***The Load Posting and Rating Report lists any bridge with a structural evaluation of "3" or less (serious condition) - if these bridges are not currently load posted or closed, a new load rating analysis may be warranted.***

ARE YOU AWARE OF ANY BRIDGES THAT REQUIRE NEW LOAD RATINGS (Y/N)? (LIST THE BRIDGES BELOW)	

13. Load Posting Signage

Bridges that cannot support legal loads must be posted with a weight restriction (the recent Timber Hauler's Bill has increased the number of bridges that must be posted). Load posting signs should be placed at each end of the bridge (advance warning signs are also recommended). Missing (or severely damaged) signs should be replaced promptly ***Review the Load Posting and Rating Report and verify that the actual bridge posting signs are correct.***

ARE ALL THE BRIDGES LISTED AS REQUIRING A LOAD POSTING PROPERLY SIGNED (Y/N)?	
COMMENTS:	

14. Bridge Scour Evaluation and Coding

Scour is historically the most common cause of bridge failure. As of a result of a scour evaluation, a bridge may determined to be at low risk for scour failure, limited risk for scour failure, or scour critical. The Mn/DOT Bridge Scour code is displayed on the Bridge Inspection Report (as well as on the Structure Inventory Report). If the Mn/DOT scour code is listed as D, R or U - the bridge has been determined to be "scour critical". However, the inspector should be aware that scour problems can develop even on bridges listed as "low risk".

The scour evaluation manual can be downloaded from the Mn/DOT web site (it is listed under "Documents, Downloads, Forms, and Links") - this manual also outlines scour action plans and scour monitoring. For new bridges, scour screening and evaluation tasks are typically done be the bridge designer. Contact the Mn/DOT Bridge Hydraulics Engineer if you have any questions regarding bridge scour analysis or scour coding.

14.1. Bridge Scour Screening

The FHWA requires that all bridges over water with a length of 20 feet or greater be evaluated for scour. Minnesota counties were required to assess all bridges for potential collapse due to scour by 1993. This process consisted of an initial scour screening, and if necessary, a more thorough scour analysis Contact the Mn/DOT Bridge Hydraulics Engineer for questions regarding scour evaluation or coding. ***The attached Scour Report lists all bridges within your jurisdiction with a scour code of F, G, or J. The scour screening & analysis process must be completed for these bridges - the scour code should be changed to H, I, L, M, N, O, P, R, or U, and the results should be reported to the Mn/DOT Bridge Management Unit.***

F - NO EVALUATION – FOUNDATION KNOWN *Bridge Structure. Scour calculation, evaluation, and/or screening have not been made (all substructure foundations are known). Note: most bridges rated "F" are typically new.*	
G - NO EVALUATION – FOUNDATION UNKNOWN *Scour calculation, evaluation and/or screening have not been made (substructure foundations are unknown). Note: Bridges with unknown foundations may require further evaluation, which may involve foundation investigations or be subjective based on engineering judgment, derived from observations of stream flow or performance during past high water events.*	
J - SCREENED – SCOUR SUSCEPTIBLE *Bridge has been screened and has been determined to be scour susceptible. Note: Bridges that have been screened as scour susceptible require further evaluation to develop a scour protection plan, or to plan for monitoring the bridge during a specified flood depth, or stage.*	

14.2. Channel Cross-Sections

The AASHTO Manual for Condition Evaluation of Bridges states that an assessment of scour vulnerability of substructures should be included in the bridge file. In addition, channel profiles and cross- sections from current and past inspections should be plotted to observe scour or stream instability. Refer to Section 2.4 of the manual and to Mn/DOT Scour Screening Guidelines for more information. ***Enter scour categories for which bridges are cross-sectioned, or "none".***

FOR WHICH SCOUR CATEGORIES ARE CHANNELS CROSS-SECTIONED?	
IF SO, AT WHAT FREQUENCY?	

14.3. Bridges Requiring Scour Action Plans

If the Mn/DOT scour code is listed as G, K, O, P, R, or U, the bridge must have a Scour Action Plan on file to outline procedures for monitoring or closure during high water events. **Review the attached Scour Action Plan Worksheet - verify that all bridges listed have a Scour Action Plan. If the worksheet lists "No" (under the action plan filed column), a copy of the Scour Action Plan must be submitted to the Mn/DOT Bridge Management Unit. Note: the bridge owner should file Scour Action Plans in a readily accessible location.**

G - NO EVALUATION – FOUNDATION UNKNOWN *Scour calculation, evaluation and/or screening have not been made (substructure foundations are unknown). Note: Bridges with unknown foundations may require further evaluation, which may involve foundation investigations or be subjective based on engineering judgment, derived from observations of stream flow or performance during past high water events.*	
K- SCREENED, LIMITED RISK *Bridge screened, determined to be of limited risk to public, monitor in lieu of evaluation and close if necessary.*	
O - STABLE – ACTION REQUIRED *Bridges that have been screened as stable, but field review indicates that action is required. It is required that a Scour Action Plan be developed and filed in the bridge file.*	
P - STABLE DUE TO PROTECTION *Bridges that have been identified as Stable due to protection require no further action. Annual or underwater inspections should note the condition of scour protection systems.*	
R - CRITICAL – LOCAL MONITOR *Bridges that have been determined to be Scour Critical need to be monitored during certain flood events or before reopening the bridge after a flood event. A Scour Action Plan must be developed for each bridge rated R to define at what flood stage to begin monitoring the bridge and the action required when a critical scour elevation occurs. A copy of the action plan is required to be placed in the bridge file.*	
U - CRITICAL – PROTECTION REQUIRED *Bridges that are rated Critical Protection Required have been determined that such frequent monitoring is required or may be too risky, and that installation of a protection system is a priority repair to this bridge. Until protection is installed, the bridge must be monitored during certain flood events or before reopening the bridge after a flood event. A Scour Action Plan must be developed and for each bridge rated U to define at what flood stage to begin monitoring the bridge and the action required when a critical scour elevation occurs. A copy of the action plan is required to be placed in the bridge file.*	

Enter the number of bridges with monitoring plans on file, protection systems inplace, and those requiring immediate action.

NUMBER OF BRIDGES RATED "R" THAT HAVE MONITORING PLANS IN BRIDGE FILES	
NUMBER OF BRIDGES RATED "U" THAT NEED SCOUR PROTECTION INSTALLED	

FOR BRIDGES THAT REQUIRE MONITORING, HOW DO YOU TYPICALLY DETERMINE IF SCOUR IS BEGINNING TO THREATEN YOUR BRIDGE, OR WHEN IT IS SAFE TO REOPEN?

15. Bridge Files

The AASHTO Manual for Condition Evaluation of Bridges states in chapter 2 that "Bridge Owners should maintain a complete accurate and current record of each bridge under their jurisdiction". Complete information in good usable form is vital to the effective management of bridges. It should provide a full history of the structure including damage and all strengthening and repairs to the bridge. The bridge record should provide data on the capacity of the structure, including computations substantiating reduced load limits if applicable."

As a minimum each bridge file should include a chronological record of Inventory and Appraisal sheets and inspections performed on the bridge, including special underwater and fracture critical inspection reports, bridge load rating and posting records, photographs, and relevant correspondence. Other suggested items for the file are listed in Section 2.2 of the AASHTO Manual for Condition Evaluation of Bridges.

Do you have a copy of the "AASHTO Manual for Condition Evaluation of Bridges"?	
Do you have a signed inspection on file for each bridge?	
Are Inspection Reports from past years filed?	
Are Structure Inventory Reports filed?	
Is bridge-related correspondence filed?	
Are bridge maintenance and repair records filed?	
Are recent photographs (roadway and elevation views) available for each bridge?	
How is bridge repair work prioritized and scheduled?	

Appendix E: Load Rating Questionare

Enclosure (2)

QC/QA Bridge Rating

The following questions apply to load rating engineers who currently load rate on-system bridges for ODOT or load rate off-system bridges for the counties. The questions can be answered using the following resources:

Manual for Condition Evaluation of Bridges, 1994 Edition
Manual for Condition Evaluation of Bridges, 2003 Edition

In addition to these resources, feel free to use any additional resources/software that you deem necessary to answer the questions. For the second set of questions relating to a specific bridge, use the bridge plans provided and the above resources. Assume a construction date of 1962 and 1959 design specifications. Select the answer that best fits your solution.

If software is available, please load rate the bridge and report the H-20 and HS-20 LFR ratings in tons in the spaces provided. If no software is available, please indicate this by entering N/A in the spaces provided.

Once the questions and load ratings have been completed, send a hard copy of your results to the following address:

Oklahoma Department of Transportation
Attn. Tony Sutton, Room 2B5
200 NE 21st Street
Oklahoma City, OK 73105

The solutions will be discussed at the May 2007 QC/QA meeting.

QC/QA Bridge Rating Questions - General

Name______________________

Organization______________________

Use the Manual for Condition Evaluation of Bridges (1994 or 2003) to answer the following questions. Choose the answer that best fits your solution.

1. What is the general expression for the LFR rating equation?

   A) $RF = (C – A_1D)/A_2(1+I)L$
   B) $RF = (C – D)/(1+I)L$
   C) $RF = (C – 1.3D)/1.3(1+I)L$
   D) $RF = (C – 1.3D)/2.17(1+I)L$

2. What is the steel yield stress (Fy) assumed to be for a bridge that is built in 1927?

   A) 18 KSI
   B) 36 KSI
   C) 30 KSI
   D) 33 KSI

3. What is the compressive strength of concrete (fc') assumed to be for a bridge built in 1962 if the strength of the concrete is unknown?

   A) 1.0 KSI
   B) 0.8 KSI
   C) 3.0 KSI
   D) 2.5 KSI

3. What is the yield stress (Fy) assumed to be for steel rebar in a bridge built in 1950?

   A) 60 KSI
   B) 40 KSI
   C) 36 KSI
   D) 33 KSI

5. What is the maximum amount of steel that can be assumed for a simply supported, reinforced concrete slab span bridge with no plans to be used to calculate ultimate moment capacity?

   A) 100% of ρ_{bal}
   B) 75% of ρ_{bal}
   C) 50% of ρ_{bal}
   D) 25% of ρ_{bal}

6. What are the appropriate values for A_1 and A_2 found in the LFR operating rating equation?

A) 1.0 and 1.0
B) 1.3 and 2.17
C) 1.0 and 2.17
D) 1.3 and 1.3

7. For a 3 X 12 timber plank deck with 3 X 12 runners, what is the effective plank width?

A) 11.50"
B) 12.00"
C) 16.75"
D) 18.00"

8. Using standard AASHTO provisions, what is the moment distribution factor for an interior steel beam if the center to center beam spacing is 7' 6"?

A) 1.25
B) 0.94
C) 1.36
D) 1.00

9. What are the appropriate values for A_1 and A_2 found in the LFR inventory rating equation?

A) 1.0 and 1.0
B) 1.3 and 2.17
C) 1.0 and 2.17
D) 1.3 and 1.3

10. Deflection caused by vehicular loading is most likely to affect which members most on a truss bridge?

A) $U_1 U_2$
B) $L_1 U_1$
C) $L_2 L_3$
D) $L_1 L_2$

Name_______________________
Organization_______________________

11. What is the standard AASHTO impact loading factor for a 53' beam?

A) 1.60
B) 1.45
C) 1.31
D) 1.28

Use the Manual for Condition Evaluation of Bridges (1994 or 2003) and the provided bridge plans to answer the following questions. Choose the answer that best fits your solution.

1. What is the yield (Fy) strength that would be appropriate for the structural steel in this bridge?

A) 26 KSI
B) 30 KSI
C) 33 KSI
D) 36 KSI

2. What is the compressive strength (fc') for the deck that would be most appropriate?

A) 1.0 KSI
B) 2.5 KSI
C) 3.0 KSI
D) 4.0 KSI

3. What is the web stiffener spacing near support 1?

A) 5.0'
B) 5.5'
C) 6.0'
D) N/A

4. What is the web stiffener spacing near support 2?

A) 5.0'
B) 5.5'
C) 6.0'
D) N/A

5. What are the dimensions of the web stiffeners?

A) 4" x 1/2"
B) 5" x 3/8"
C) 6" x 1/2"

D) 7” x 3/8”

6. What are the dimensions of the bearing stiffeners at support 1?

A) 4” x 1/2”
B) 5” x 3/8”
C) 6” x 1/2”
D) 7” x 3/8”

7. What is the dead load due to one curb (K/FT)?

A) .18
B) .25
C) .36
D) .50

8. What is the moment distribution factor for the interior girder?

A) 1.048
B) 1.182
C) 1.333
D) 1.409

10. What are the dimensions of the bearing stiffeners at support 2?

A) 5” x 3/8”
B) 6” x 1/2”
C) 7” x 3/8”
D) 8” x 1 1/2”

Using available software, list the H-20 and HS-20 ratings (in tons) below for the bridge shown in the plans. If there is no software is available, disregard this exercise.

	H-20	HS-20
Inventory	_______	________
Operating	_______	________

Appendix F. Pennsylvania's Quality Program

Publication 238, Part IP, Chapter 6 - Quality Measures for Safety Inspection

Why

6.1 QUALITY MEASURES

The bridge inspection process is the foundation of the entire bridge management operation and the bridge management system. Information obtained during the inspection will be used for determining needed maintenance and repairs, for prioritizing rehabilitations and replacements, for allocating resources, and for evaluating and improving design for new bridges. The accuracy and consistency of the inspection and documentation is vital because not only does it impact programming and funding appropriations but also it affects public safety. Therefore, the Department addresses this need with extensive formalized quality control and quality assurance procedures.

6.2 QUALITY CONTROL

What

Quality Control (QC) is the enforcement, by a supervisor, of procedures that are intended to maintain the quality of a product or service at or above a specified level. Quality Control of the inspection of highway bridges is a daily operational function performed in each organization performing the safety inspections, including consultants, owners, and District Bridge Units. A set of effective QC procedures will provide for uniformity of inspection and recording methods and will ensure quality reports. To ensure statewide uniformity and consistency the Department shall provide basic inspection training and mandatory biannual refresher courses (See IP 07, Training and Certification Program).

Each bridge safety inspection organization (e.g. Department District Bridge Units, engineering consultant firms, or bridge owner's staff) is to have internal quality control procedures in place to assure that the public safety is maintained on the bridge and that the inspections are performed in accordance with NBIS and Department standards. An effective quality control program for safety inspection should address the following areas:

- Organization and Staffing.
- Review ofField Inspections.
- Office File Review.
- Bridge Maintenance/Rehabilitation/Replacement Needs.
  Annual Meeting with Bridge Inspection Staff.

A record ofQC efforts (e.g. a QC Logbook) should be maintained by the inspection organization.

6.2.1 Inspection Organization and Staffing

What

An effective QC program begins with assuring that an adequate, qualified and properly equipped staff is in place to address the primary functions of a bridge inspection program:

- Engineer-in Charge
- Field Inspections and Final Report
- Bridge Analysis, Rating and Posting Evaluations
  Maintenance and Improvement Needs
- Internal Review Engineer

The Engineer-in-Charge is to maintain a roster and organization chart of the staff addressing these primary functions. The Engineer-in-Charge is to ensure that the staff meets NBIS and Department requirements for certification, training, and experience. The staffing complement must be sufficient and properly equipped to ensure that inspections are performed in a timely manner and in compliance with NBIS and Department requirements.

The District Bridge Engineer is to ensure that engineering consultants, bridge owners and Districts have the proper staff for the bridges assigned to them, see IP 2.1.

6.2.2 QC Review of Field Inspections

Review of the field inspections by the Engineer-In Charge and Review Engineer can be a most effective quality control measure. It can build a strong communication link between the inspectors and the reviewers. A sample plan for the Districts is suggested below. This can be modified for other organizations:

Who
When
Where
How

Bridge Inspection Supervisor

- Once a month (select different inspection team each month) do follow-up review as follows:
  - Pull four files at random from the previous month's inspections. Review files for the purpose of QC.
  - Visit bridge sites and cross check most recent comments in the inspection reports, and other items as warranted.
  - Upon return, enter sites visited in a QC logbook - with appropriate comments.
  - Review comments with respective teams within 2 weeks.

Who
When
Where
How

Bridge Engineer

- Once every three months, select four bridges that were inspected during the previous quarter, and visit sites.
  - Using BMS Coding Manual, rate the bridge for condition and appraisal ratings. Review field observations with the Bridge Inspection Supervisor and Team Leaders. Enter comments and site locations in a QC log book.
  - Review with the Bridge Inspection Supervisor reference materials and inspection tools with each team for adequacy.

Who
When
Where
How

District Engineer and/or ADE Design

- Once or twice (preferred) per year request current inspection sites for that week.
  - Visit inspection sites unannounced and observe inspection team. Discuss inspection procedures with team and question team on condition of bridges.
  - Visit two other recently inspected bridges and visually compare condition with inspector's comments in inspection report.
  - Review recommendations for maintenance and improvements.
  - Enter bridge sites visited and any observations/comments in a QC log book.
  - Review observations/comments with the District's Bridge Engineer and Bridge Inspection Supervisor.

6.2.3 QC Review of Office File

The bridge files in the office should be reviewed to ensure that the information needed for bridge inspection is readily available. All documentation of inventory and inspection information should be kept in an orderly and retrievable manner. A sample plan for the Districts is suggested below. This can be modified for other organizations:

Who
What
How

Bridge Inspection Supervisor

- Review the files for approximately 10% of the bridges inspected the previous month for completeness and accuracy.
- Every three months, review posted bridge lists and review the files or 10% of these bridges, which were inspected within the previous three-month quarter to see that the file documentation is sufficient and agrees with the posting, and the rating is current with latest inspection findings.
- Review 25% of FCM bridge files to ensure information needed for a fatigue and fracture inspection is available one month before the upcoming inspection.

Bridge Engineer

- Review five to ten bridge files for completeness at random, once every three months.
- Annually review the list of posted bridges to determine repair or replacement options for bridges on list
- Annually review Fatigue and Fracture Inspection Plan for District's FCM Bridges to develop rehabilitation/replacement strategies.

6.2.4 QC of Bridge Maintenance/Rehabilitation/Replacement Needs

The determination of bridge needs (maintenance, *rehabilitation,* and *replacement)* by the inspection organization should be reviewed annually. A sample plan for the Districts is suggested below. This can be modified for other organizations:

<u>Assistant District Engineer-Design:</u>

- Review with the District Bridge Engineer the procedures to be used in the event of a bridge emergency for reporting and coordinating repairs.
- Review with the District Bridge Engineer the procedures for selection of candidates for bridge maintenance program and rehabilitation/replacement programs. Review accomplishments and identify concerns.
- Review how large differences in bridge inspection condition/appraisal ratings or posting recommendations from the previous inspection are handled by the bridge inspection supervisor.
- Document and follow-up problems identified.

6.2.5 Annual Meeting With Bridge Inspection Staff

An annual meeting of field inspection staff with the Engineer-in-Charge, review engineer, and ratings engineer is recommended to ensure that the entire team is aware of the latest developments in safety inspection. Additional meetings should be considered if significant issues or concerns arise. The following suggestion is made for the Districts and may be modified by other organizations.

<u>Bridge Engineer</u>

- Once a year review all Q/C comments and observations with entire Bridge Inspection staff including local inspection coordinator.
  This review may be scheduled following a session of the Refresher Course for Bridge Safety Inspectors that one or more of the inspectors have attended to apprise remaining staff of the latest developments and the Department's current emphasis.
  This review should be separate from the Statewide QA program's District Close-out meeting.

6.2.6 Samples of Good Inspection Practices

Inspection teams take copies inspection files to the field and inspect each bridge. Team completes all condition and appraisal ratings, and reviews other items for correctness if directed by the supervisor on Forms D450 and D491 or BMS printout.

Bridge inspection teams should be rotated so that a team does not inspect the same bridge on consecutive routine bridge inspections. Consecutive inspections by the same team could lead to complacency because of too much familiarity with the structure.

The Bridge Inspector's Supervisor reviews each report for completeness and uniformity. He computes load ratings for any bridge which has changed due to section loss or recent repair, etc. or whose ratings were never computed.

What

6.3 PENNSYLVANIA STATEWIDE BRIDGE INSPECTION QUALITY ASSURANCE PROGRAM

Quality assurance (QA) is the verification or measurement of the level of quality of a sample product or service. The Statewide Bridge Safety Inspection QA Program is performed by the Bridge Quality Assurance Division (BQAD) in conjunction with its Bridge Safety Inspection QA Consultant.

Why

The purpose of Statewide Bridge Safety Inspection QA Program is to measure the accuracy and consistency of Pennsylvania's bridge safety inspections. The findings from this program are used to enhance or emphasize training needs in the state's bridge inspection training courses and to address any statewide bridge inspection anomalies.

Pennsylvania was the first state to implement such a program.

The Department's Statewide Bridge Safety Inspection Quality Assurance Program consists of independently re-inspecting 30 NBIS bridges in each of 11 Districts and 15 bridges for Pennsylvania Turnpike each year. The 30 District bridges include 15 Department-owned and 15 locally owned structures. The bridges are selected by random using a representative statistical distribution of each District's bridge types. Typically, bridges selected do not require special equipment to inspect, have reasonable ADT's and are of a reasonable size to minimize the cost of reinspect ion and the overall cost of the Statewide Bridge Safety Inspection QA Program.

What

On each bridge, the ratings of 15 inspection items from the QA blind inspection are compared to the ratings from the original inspection. The original inspection item ratings are considered to be out-of-tolerance if they vary more than 1± from the ratings compiled by the QA team. Bridge capacity ratings are redone for all bridges having sufficient documentation to do so. Bridge capacity ratings are considered to be out-of-tolerance if they vary by more than 15% from the capacity ratings done by the QA team. For posted bridges, the bridge is considered to be out-oftolerance ifthe posting evaluation varies by more than 2 tons from the QA team's posting evaluation.

Results of the QA inspections in the form of a draft District Summary Report are reviewed with the inspectors in each District during the District Close-Out Meeting. The Close-Out Meeting is an important part of the QA process because it encourages communication between the QA reviewers and the individual inspectors. Findings from the QA inspections, rating analyses and posting evaluations, and other bridge inspection related issues are discussed. The results of these meetings are used to emphasize training requirements, improve inspection techniques, and initiate needed changes to inspection and coding manuals and Department rating programs.

The results of the QA Close-Out Meeting are incorporated into the report and the Final Report is distributed to the District. The final results of the QA review contained in the District Summary Report are a collaboration of the inspectors, consultants, BQAD and the QA consultant.

When all District Summary Reports are finalized and distributed to the respective Districts, the annual Statewide Cycle Summary Report is compiled and a copy is distributed to each District.

The Statewide Cycle Summary Report is a compilation of all the Districts' QA results. This compilation gives an indication of statewide trends in bridge inspection. Any consistent problems are identified and corrected through the following means:

- Revisions to Procedures and Manuals
- Bridge Inspection Basic and Refresher Training Courses
  Other Bridge Inspection Related Courses

6.3.1 Procedures for the Statewide Bridge Inspection QA Program

The procedures for the quality assurance review on an annual basis for each of the Districts' and the Turnpike's bridges consists of six tasks for the QA consultant as outlined below:

How

- Task I - Office File Review - The office evaluation shall include the following:
  - General Bridge File Content - complete a bridge file checklist for each bridge that indicates critical contents of bridge inspection records, including but not limited to rating computations, posting evaluation and documentation, drawings, inspection reports, etc. (See chapter IP 8 for Bridge Inspection File contents).
  - Inventory and Inspection documentation (D450 Forms) comparison with the data in the BMS. Load rating analysis comparison with data entered in the BMS.
  - Compliance with posting policy (agreement with the Inventory and Operating Ratings in the BMS).
  - Verify that Form D450M of the Inspection Forms has been completed, especially with regard to critical deficient, narrative comments, and identification of maintenance needs. (Item H08).
  - Verify and highlight, as part of the QA effort, that a need for bridge cleaning as directed by IE 3.8.1.2 is being identified when necessary and note if cleaning has been performed.
  - Contact BQAD to obtain copies of shop Drawings referenced but not available at the District Office.
  - Determine if field measurements are needed to complete the load rating analysis.

- **Task II - Field Inspection** - Field inspection shall include a complete NBIS inspection of all selected bridges.

How

Verify and identify the structure.
Provide maintenance and protection of traffic.
Photograph the structure, preferably using a High Resolution Digital Camera.
Verify BMS inventory data.
Verify safety features and po stings signs.
Perform independent condition/appraisal ratings.
List and prioritize maintenance/repair needs. Conduct Maintenance needs assessment.
Take needed field measurements for bridge load rating analysis.
Prepare or amend field sketches for scour conditions.
Video tape the structure inspected, including; display sheet listing QA cycle, District, and BMS I.D, approach roadways, bridge elevation, channel upstream and downstream, and especially the items out oftolerance for viewing at the close-out meeting.

- **Task III - Load Rating Analysis and Posting Recommendations.**

How

Load rating analyses will be performed for those bridges with sufficient information to do so in the bridge inspection file. Typically, a load rating analyses is done for two-thirds of the bridges inspected. Some field measurements may be needed during Task II to supplement the office file data.
The load rating analysis shall be done using the Load Factor Method of analysis.
The QA load rating analysis shall be performed independently of the current load rating analysis in the bridge inspection file. The QA office file review and field inspection teams must have obtained sufficient data to perform the load rating analysis.
The analysis shall include Inventory and Operating Ratings for H20, HS20, ML80, and TK527 vehicles.
All calculations, both longhand and by computer, and any sketches are to be documented neatly and included in the QA load rating analysis.
Any computer input files and supporting calculations are to be included in the QA load rating analysis.
Compare these load rating analyses with those in the bridge inspection file and highlight any out-oftolerance differences. List any inaccuracies, omissions or errors.
Comment on existing or required load posting.
Be prepared to discuss differences in results or methods at the close-out meeting with each District, and Turnpike.

- **Task IV - Preparation and submission of District and Turnpike's Draft Summary Reports.**

This task includes a draft of the Summary Report, the individual bridge inspection reports, and the bridge load rating analyses for each District and the Turnpike.
The Summary Report contains a discussion about the bridge inspection, the load rating analysis, and the maintenance needs assessment for each of the bridges reviewed. Recommendations and conclusions regarding the District's effort are also included in this Report.
To prepare for Task V, one draft copy of the Summary Report and a set of the bridge load rating analyses are sent to the District for their review.

- **Task V - Field View and Close-Out Meeting for Each District and the Turnpike.**

A Close-Out Meeting is scheduled with each District to discuss the findings of the QA review. A field view of several of the bridges selected for the review is performed by the QA consultant and the BQAD personnel prior to the scheduled meeting.
Recommended attendees of the Close Out Meetings include: ADE-Design, District Bridge Engineer, District Inspection Staff including local bridge inspection coordinator, local bridge owners and their inspection consultants.
Using results from the field view and the Close-Out Meeting discussion, the Summary Report, bridge inspection reports and bridge load rating analyses are finalized and submitted to the BQAD for review. The reports and ratings are finally distributed to the District.

Task VI - Cycle Summary Report

After Tasks I through V have been completed for all the Districts and the Turnpike, 3 Cycle Summary Reports, (one statewide report for Department bridges, one statewide report for Local bridges, and one for the Turnpike bridges) are prepared and submitted to the BQAD for review and distribution to the Districts.

6.3.2 Selection of Bridges for Statewide Bridge Safety Inspection Quality Assurance Review

What

The Department shall perform an annual Bridge Safety Inspection Quality Assurance review statewide to assure the quality of Pennsylvania's Bridge Safety Inspection Program by independently re-inspecting 30 NBIS bridges in each of I I Districts, and 15 bridges for Pennsylvania Turnpike each year. (The 30 District bridges will include 15 state-owned and 15 locally owned structures.) Each District will be required to submit the fifteen locally owned bridges to be reviewed. BQAD will select the fifteen state-owned bridges for each District and the fifteen Turnpike bridges.

The bridges selected shall be chosen by a random selection process using a representative statistical distribution of each District's bridge types.

6.3.2.1 LOCALLY -OWNED BRIDGE SELECTION GUIDELINES

How

The locally owned bridge selection guidelines are as follows:

- Bridges selected should be from normal NBIS inspections that were performed preferably within the 6 months prior to the submittal date established by the Department. If necessary, this 6-month period may be extended to 9 months in order to obtain a sampling of a District's local bridge inventory in accordance with items 2 through 8 listed below.
- Bridges selected should be generally representative of a District's local bridge inventory.
  No more than 5 selections for each consultant, unless that consultant is performing inspections in more than one county.
- Consultants not previously included in the QA process are preferred.
- A void selecting bridges over railroads where there could be possible problems with access or obtaining permission.
- If needed, selections can be made to place emphasis on a specific bridge type, inspection team, or geographic area.
- Bridges must have final inspection reports that have been received and accepted by the District.
- Reasonable effort shall be made to avoid selecting structures that were reviewed in previous QA cycles. Please contact BQAD to obtain a list of previously inspected bridges in your District.

After determining what local bridges that are to be reviewed for the current cycle, complete and submit a copy of the *Bridge Safety Inspection QA Program, Selection of Local Bridges Form* (See Appendix IP 06-A). Location maps, preferably Type 10 County Maps with the selected bridge marked, are to be provided for each bridge site.

A request for reduction in the number of local bridges to be reviewed must be justified. Possible justifications may include: a small pool of inspections that have recently been performed, a large number of the same types of bridges being inspected, the same consultant having performed all inspections or the past performance of the consultant. If a submission of fewer than the required 15 bridges is selected, a letter of justification must be sent to BQAD two weeks prior to the District's submittal date.

The due dates for the Districts to submit their fifteen locally owned bridges to BQAD will be distributed by a Strike-Off-Letter from BQAD well in advance of the deadline for submission.

6.3.2.2 STATE-OWNED BRIDGE SELECTION GUIDELINES

The state-owned bridge selection guidelines follow the same guidelines used for selecting locally owned bridges.

6.3.2.3 PENNSYL VANIA TURNPIKE COMMISSION BRIDGE SELECTIONS

Fifteen Pennsylvania Turnpike Commission (PTC) bridges will be selected by BQAD from the Western, Central, Eastern, or Northeastern portions of the state.

The Statewide Cycle Summary Report includes:

- A compilation of both Statewide results and individual Districts' results for the past QA Cycle Out-of
  - Tolerances for Condition and Appraisal Items
  - Out-of Tolerances for Observed Scour Ratings
  - Out-of Tolerances for Bridge Capacity Ratings
  - Omissions of Maintenance Needs recordation
- Findings
  - Condition and Appraisal Items that are consistently out-of tolerance are noted and discussed
  - Discrepancies between the D-450's and the BMS D-491 Screens are noted
  - Out-of Tolerances for Observed Scour Ratings are discussed; especially noted, are the sub-items that makeup this Item that are consistently coded incorrectly.
- Conclusion and Recommendations

A similar Cycle Summary Report is separately prepared for and distributed to the PTC.