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# 1.3 TYPES OF BRIDGE INSPECTIONS AND ASSESSMENTS

## 1.3.1 Introduction

There are numerous types of bridge inspections. Each inspection type has been designed to obtain specific information from a structure. For instance, when a structure is built, an Initial Inspection is done to document the as-built condition of the structure and its structural elements. This is the baseline inspection, and all future inspection findings are compared to this information. Routine Inspections are performed at regular intervals to monitor the working condition of structure elements. This is the most common type of inspection. The results from a Routine Inspection are used to assess structure safety and structure maintenance needs. Interim Inspections are used to monitor known defects in a structure.

All of the inspection types that are used by the Wisconsin Department of Transportation (WisDOT) help to create a complete picture of a structure's condition and are described in detail in this chapter.

## 1.3.2 Initial Inspection

### 1.3.2.1 Purpose

CFR 650.305 states: *Initial Inspection. The first inspection of a new, replaced, or rehabilitated bridge. This inspection serves to record required bridge inventory data, establish baseline conditions, and establish the intervals for other inspection types.*

An Initial Inspection is the baseline inspection that shall be completed on every new , replaced, or rehabilitated structure preferably before but no later than 3 months after the structure is open to traffic. An Initial Inspection is a fully documented inspection, using the structure plans, to determine basic data about the structure for entry into the Highway Structures Information System (HSIS) file. In addition, special inspections such as Nonredundant Steel Tension Member (NSTM) or Underwater Dive inspections that are needed must be performed as soon as practicable, but within 12 months of the bridge being open to traffic.

Data gathered for Initial Inspections should include the following:

1. An existing set of plans, as-builts, shop drawings, design computations, and hydraulic computations for the bridge (if applicable).

2. An analytical determination of load capacity (performed by a qualified Wisconsin professional engineer).

3. All Structure Inventory and Appraisal (SI&A) data required by federal and state regulations.

4. Other relevant information required by the department to maintain an accurate bridge file.

5. Baseline structural conditions and element quantities.

6. Any existing problems or locations in the structure that may have potential problems.

7. Location and condition of any NSTM members or details.

8. Underwater channel profiles at the upstream and downstream fascia (for structures over water).

9. Using the profile information, assessment of the need for future underwater dive inspections.

When an initial inspection is conducted, a Structure Inventory and Appraisal Field Review must be completed and entered into the Highway Structures Information (HSI) System. This form can be generated by the HSI software for each bridge in the state and must be verified for accuracy at least once every 48 months.

As part of the Initial Inspection, inspectors need to review the appropriate inspection types required on the structure and verify that the HSIS system has those inspection types flagged.

For instance, imagine a bridge with a two-girder superstructure system spanning a waterway. The bridge has a supporting pier in the middle of the channel. First, a two-girder superstructure system does not provide redundant load paths. Should one girder fail, the entire bridge will collapse, and therefore is a NSTM structure. Next, the pier in the channel has affected the normal flow pattern of the water. As a result, the stream channel and the pier foundation may be subject to scour action. Finally, the depth of the stream or the turbidity of the water may obscure the visibility of the pier foundation. It is foreseeable, then, that this bridge will require a NSTM inspection, and possibly an underwater inspection. Once the inspector has decided what inspection types the structure will require, he/she should complete the appropriate boxes for the associated inspection frequencies in HSIS and notify the Inspection Program Manager.

**Figure 1.3.2.1-1:** Inspector Performing an Initial Inspection.

### 1.3.2.2 Precision

The Initial Inspection is required to document "as-built" **conditions**, not whether the structure was constructed per Plans and Specifications. Since this is a baseline inspection, all deficiencies, cracks, construction errors, alignment problems, etc. should be quantified and documented. The compiled documentation will be used during future inspections to determine if defects discover in the future existed when the structure was constructed or if they have materialized from the loading applied to the structure.

### 1.3.2.3 Inventory Update/Rating of Repairs

Since both the National Bridge Inventory (NBI) and Element Level rating scales are based upon existing structural conditions, repairs may improve the condition ratings assigned to a structure. When work is completed on an existing structure, an Interim inspection shall be entered into the HSIS that takes into account the new structural condition.

### 1.3.2.4 Inspection Frequency

Each newly constructed or rehabilitated structure shall receive an Initial Inspection or Interim Inspection within 30 days of opening the structure to traffic. WisDOT prefers that an Initial Inspection be completed before the structure is open to traffic. An initial inspection should preferably be completed before a construction contract can be finalized.

Below is a list of required bridge inspections conducted after the initial inspection.

| Inspection or Activity Frequencies | | |
|---|---|---|
| **Type** | **Maximum Inspection Interval (Months)** | |
| | **Low Risk** | **High Risk** |
| **Routine** | **24** | **12** (2) |
| | **48** (1) | |
| **In-Depth** | **Varies (48 to 72)** (3) | |
| **NSTM** | **24** | **12** |
| **UW-Dive** | **60** | **24** |
| | **72** (4) | |
| **UW-Profile** | **None** | **Varies (24 to 60)** (5) |
| **SI&A Review** | **48** | |
| **Scour POA** | **48** | |

1. **Structure must qualify per section 1.3.3.3**
2. **Includes bridges that are closed; see section 1.3.12 for more information**
3. **Frequency is dependent on structural detail per section 1.3.4.3**
4. **Structure must qualify per section 1.3.7.3**

**5. Dive inspected bridges are on a 60-month cycle per section 1.3.6.1**

## 1.3.3 Routine Inspection

### 1.3.3.1 Purpose

CFR 650.305 states: *Routine Inspection. Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements.*

### 1.3.3.2 Precision

Routine inspections are generally conducted from the deck, ground, or water level or from permanent work platforms and walkways. If any element of the bridge appears to be distressed, the inspector should take a closer look at that element. Critical load-carrying members (*e.g.,* steel and concrete girders, decks, slabs, concrete box girders, piers and bents, bearings, abutments) should be closely monitored. Failure prone details or elements should receive a detailed, close-up (arm's length) inspection. See Section 3.6, NSTM Inspection and Part 2 Appendix D, Fatigue Prone Details for typical critical details. Inspection of underwater portions of the substructure is limited to observations during low-flow periods, probing for signs of undermining, and streambed profile measurements where applicable. This is further discussed in Section 3.9 All inspection results should be fully documented on the report form stored in HSIS.

Any changed or deteriorated structural conditions that might affect previously recorded bridge load ratings should be noted on the inspection form. If the inspector determines that a new load rating is warranted, the "load rating" box should be marked with a "Y". The owner is responsible for rating the structure. That owner is also responsible for getting the updated structure data into the appropriate structure file(s) located in the HSI. The HSI electronic file is the Official Bridge File in accordance with Metric 15 of the *NBIS Metrics for the Overview of the National Bridge Inspection Program.*

Public safety is the primary concern of the structure inspector. Therefore, the inspector should make sure Wisconsin's structures are physically safe as well as structurally stable. Special attention should be paid to the condition of parapets, railings, pedestrian fencing, guardrail, sidewalks, spalling concrete surfaces, and other safety related members. The following are examples of conditions that may warrant documentation and notification of the Local, County or Region Manager:

1. trip hazards, severe approach settlement, or large spalls on sidewalks;
2. rebar protruding from decks, walks, or parapets;
3. loose, missing, or damaged railings or parapets;
4. missing or damaged guardrail;
5. loose concrete that could fall onto a traveled way (road, walk, bike path, waterway, or rail line); and

6. any other condition that the inspector perceives as a threat to public safety.

The inspector may have several documents available to assist him in organizing and performing the inspection. These documents include: as-built plans, original shop drawings, as-built repair plans and shop drawings, and previous inspection reports.

### 1.3.3.3 Routine Inspection Frequency

The NBIS metrics separate bridges into two categories based on routine inspections: lower risk and higher risk bridges.

Metric #6: Inspection Frequency – Routine – Lower risk bridges states:

> Routine inspections are performed at regular intervals not to exceed (NTE) 24 months, or NTE 48 months when adhering to FHWA approved criteria.

Steel twin-tub girder bridges that were analyzed and found to be no longer NSTM but system redundant member (SRM) bridges shall have a maximum required inspection frequency of 48 months for the interior of the tub girders. The rest of the bridge is to follow the eligible routine inspection frequency.

The interior tub inspection frequency shall be the lesser of 24 months or the eligible routine frequency when any of the following occurs on the interior of the tub girder:

- Steel cracking or distortion defect exists in CS2, 3, and 4.

- Corrosion or Connection defects exist in CS3 over 5% of total Steel Closed Web/Box Girder element length in any one span. *For example, a 150' twin girder span could have a maximum of 5% x 300' =15 LF total combined CS3 corrosion or connection in that span before being subject to the more frequent interior inspection.*

For a bridge to be eligible for 48-month routine inspections, there are 15 specific criteria that must be met. In general, these criteria relate to condition, age, risk, and complexity to determine eligibility.

The criteria a structure must meet to be considered for the 48-month Routine inspection frequency are as follows:

1. The NBI Condition Ratings for Deck (58), Superstructure (59), Substructure (60), Culvert (62), or Channel (61) must be greater than 6 or N.
2. The bridge cannot have an unknown foundation. The NBI Scour Critical Bridge code (113) shall be coded as 9, 8, 7, 5, or N.
3. The bridge cannot have NSTM's. Item 92A will be used to identify these bridges.
4. The bridge cannot have a steel defect of 1010 (Cracking) in CS2, CS3, or CS4.
5. The Inventory load rating must be greater than or equal to RF1.0 (LRFR) or HS20 (LFR). Item 66 will be used to determine this.
6. The structure cannot be load posted; Item 70 shall equal 5.
7. The structure must be less than 50 years old to have an extended inspection frequency. Item 27.
8. The ADT on the structure must be less than 50,000. Item 29.

9. The primary superstructure or substructure material cannot be Timber. Item 43A will be used to determine this.
10. Bridges with vertical clearance on or under (Item 53 and 54) must be greater than 14.0'.
11. Structures with Pin & Hanger assemblies or Pin thru Web assemblies do not qualify. Element 161.
12. Structures with Primary Gusset Plates do not qualify. Element 162.
13. Structure must have at least two (2) routine inspections on file approximately 24 months apart to be eligible.
14. Border bridges with adjoining states are not eligible, unless the adjoining state has criteria in place that matches or exceeds the WisDOT criteria and both States have a signed agreement to inspect the bridge at the extended interval. NBI Item 98
15. No complex bridges, as defined by WisDOT (movable, suspension, or cable-stayed), are eligible. NBI Item 43B <> 13, 14, 15, 16, 17

The 48-month extended frequencies is optional and is up to the structures owner to utilize. Local agencies are required to be assessed at a level of Compliance or Substantial Compliance for each of the FHWA 23 metrics to be eligible to utilize the extended frequency provisions. The link to the Metric document is below.

https://wisconsindot.gov/dtsdManuals/strct/inspection/nbip-metric-manual.pdf

Failure to assess at these levels for any of the 23 metrics will require the local agency to write a Plan of Corrective Action (PCA) to correct the deficiencies. The plan must be approved by the Statewide Inspection Program Manager and Regional Program Manager and the deficiencies must be corrected within the timeline agreed to in the PCA to maintain eligibility.

The structures owner interested in participating in the 48-month extended frequencies needs to have the County PM or Commissioner fill out the DT2002 Structure Inspection Quality Control Form and follow the instructions enclosed.

Metric #7: Inspection frequency – Routine – Higher risk bridges states:

> Routine inspections are performed at regular intervals not to exceed (NTE) 24 months.

WisDOT requires a routine inspection at a maximum frequency of 12 months for structures that meet the following High-Risk criteria:

- Are load posted at less than 40 tons (excluding emergency vehicles), or
- Have a NBI file value for Superstructure (Item 59), Substructure (Item 60), or Culvert (Item 62) of 4 or less

For structures that have rigorous routine inspection procedures and requirements, the owner may request that only a partial inspection be completed on the element(s) contributing to the NBI poor condition rating of 4 or less. Approval from the Statewide Inspection Program Manager must be granted 2 months or more in advance of the inspection including the reason for exemption and inspection procedure for the partial inspection. Inspections meeting this criterion must be entered in the Highway Structures Information system as a Routine inspection with only the inspected elements checked and inspection procedures for the partial inspection including BOS approval date. A full Routine inspection for each element must occur in a 24-month timeframe.

### 1.3.4 In-Depth Inspection

#### 1.3.4.1 Purpose

An In-Depth Inspection is a visual, hands-on inspection of one or more structure elements above or below water level that may be supplemented by non-destructive evaluation. This higher-level inspection can be performed on any structure type, though it is commonly performed on steel superstructure bridges with problematic details that need close up evaluation (as discussed below).

The exception to this is NSTM bridges, which have a federally mandated "In-Depth" inspection of all primary tension members. This specific type of In-Depth is called a NSTM inspection and is entered into the Highway Structures Information (HSI) System as a NSTM Inspection only. More information on this inspection type can be found in section 1.1.2 of this manual.

An In-Depth Inspection can be scheduled independently of a Routine Inspection, though generally at a longer interval, or it may be a follow-up for a Damage Inspection. Generally, specialized equipment is required to obtain the necessary hands-on, arm's length access to the element (snooper trucks, scissor lifts, ladders, etc.).

On small bridges, it may be practical to include all elements of the structure during the inspection. In this case, both the Routine and In-Depth boxes shall be checked in the Highway Structures Information (HSI) System when entering the inspection. If NDE is used during this inspection, or any other inspection type, the activity type for Non-Destructive Evaluation should also be checked.

For large and complex structures, In-Depth Inspections may be scheduled separately for defined segments of the bridge or for designated groups of elements, connections, or details that can be efficiently addressed by the same or similar inspection techniques. If the latter option is chosen, each defined bridge segment and/or each designated group of elements, connections, or details should be clearly identified in the inspection procedures and inspection specific notes as a matter of record.

The activities, procedures, and findings of In-Depth Inspections should be thoroughly documented with appropriate photographs, test results, measurements, and a written report in the HSI system. In addition, access methods must be clearly documented so that future scheduling needs can be determined.

WisDOT requires an In-Depth inspection at a defined interval for the structures mentioned in section 1.3.5.3. However, there are other conditions and/or structural details that may prompt an unscheduled In-Depth Inspection.

Several common conditions or structural details that could prompt an In-Depth Inspection (and possibly NDE) include:

- Apparent cracks in steel members

- Apparent cracks, de-bonding or loss of tendon section in a Prestressed or post-tensioned member
- Heavily corroded or failed hold down devices.
- Severe section loss in a steel member or primary gusset plate
- Buckled or bent steel girders or beams.
- Welded cover plate end terminations
- Live load bearing anchor pins, and link-bars
- Field welds on tension members
- Intersecting welds, or category D, E, or E’ details
- Unique or Problematic Details

The decision to conduct an unscheduled, In-Depth Inspection, with or without the use of NDE, is the responsibility of the Regional Program Manager. Items to consider when making this decision include (but are not limited to) ADT, Condition, Age and Location.

### 1.3.4.2 Precision

As indicated previously, an In-Depth Inspection is a visual, hands-on inspection of one or more structural elements. Each element under investigation should be within arm’s length of the inspector. The inspection may include a recommendation for a load rating to assess the residual capacity of damaged or deteriorated members, depending on the extent of the damage or deterioration. Nondestructive load tests may be conducted to assist in determining a safe bridge load-carrying capacity. The inspector should exercise sound judgment in recommending when a load capacity analysis is warranted.

### 1.3.4.3 In-Depth Inspection Frequency

In-Depth Inspections are **required** for the following:

- Bridges with pin thru web or pin & hanger assemblies (excluding NSTM Structures)
- Steel Bridges with floor systems (excluding NSTM Structures)
- 3 or 4 Chord Deck Trusses

**Maximum Required In-Depth Inspection Interval:**

| Bridge Type (non-FC Bridges) | Requirement | Maximum Frequency |
|---|---|---|
| Pin & Hanger Assemblies | Visual, Hands-on | 72 Months |
| Steel Floor Systems (Floorbeam/Stringer) | Visual, Hands-on | 96 Months |
| 3 or 4 Chord Deck Trusses | Visual, Hands-on | 48 Months |

Other In-Depth inspections can be scheduled to supplement routine inspections, or as a follow-up to an interim, initial, or damage inspections. But these will generally not have a recurrence interval.

For In-Depth inspections on structures with pins, a minimum of 20% of the pins shall be evaluated with NDE methods, including all components that have indications of cracking, distress, fretting rust, or seizing. The locations that have been evaluated shall be thoroughly documented, and efforts shall be made in subsequent in-depth inspections to vary the components being tested.

### 1.3.5 Nonredundant Steel Tension Member (Fracture Critical) Inspection

#### 1.3.5.1 Purpose

CFR 650.305 defines a Nonredundant Steel Tension Member (NSTM) inspection as: *A hands-on inspection of a nonredundant steel tension member.* An NSTM inspection is a specific type of In-Depth inspection. However, since it is specifically called out in the Code of Federal Regulations, NSTM Inspections must be coded separately from In-Depth inspections on the National Bridge Inventory submittal and in HSI.

CFR 650.305 defines a nonredundant steel tension member (NSTM) as "**a primary steel *member fully or partially in tension, and without load path redundancy, system redundancy or internal redundancy, whose failure may cause a portion of or the entire bridge to collapse.*** "

Common NSTM's include (but not limited to):

- Tie girders on tied arch bridges
- Tension chords or tension diagonals on trusses
- Tension flanges on non-redundant girders
- Tension flanges on non-redundant steel pier cap beams
- Pins on non-redundant girder/truss bridges
- Primary gusset plates connecting NSTM's
- Connecting points of NSTM's chords/diagonals

Primary gusset plates, regardless of connecting NSTM or compression elements, with continuing deterioration (active corrosion, distortion) are risk factors. The locations of these elements, as well as the amount of deterioration shall be measured and documented in the bridge inspection report. The frequency and methods of measurement shall be recorded in the inspection procedures.

NSTM Inspections are regularly scheduled inspections. NSTMs require more thorough and detailed inspections than the members of non-NSTM bridges. In recognition of this, Federal Regulation 23 CFR 650.313(g) requires inspection procedures to be developed and documented for each NSTM bridge.

**Figure 1.3.5.1-1:** Inspectors Performing a NSTM Inspection

Bridges with NSTMs have written bridge specific inspection procedures and NSTM diagrams which clearly identify the location of all NSTMs, specify the frequency of inspection, describe specific risk factors unique to the bridge, and clearly detail inspection methods and equipment to be employed. Guidance for the specific inspection procedures is provided under Section 1.3.5.4.

An NSTM Inspection can be scheduled independently of a Routine Inspection, though it is common to schedule both during the same inspection. Generally, specialized equipment is required to obtain the necessary hands-on, arm's length access to the element (under bridge inspection vehicle, scissor lifts, ladders, etc.). The first NSTM inspection for a bridge or for a bridge with rehabilitated NSTMs must be completed as soon as possible but within 12 months of the bridge opening to traffic per CFR 650.313(f)(3).

On some bridges, it may be practical to include all elements of the structure during the inspection. In this case, both the Routine and NSTM (Fracture Critical (Arm's length)) boxes shall be checked in the Highway Structures Information (HSI) System when entering the inspection.

For some bridges, the NSTM Inspection may be scheduled and completed separately from the Routine Inspection. If this option is chosen, each defined NSTM shall be clearly identified in the inspection procedures and inspection specific notes as a matter of record.

The activities, procedures, and findings of NSTM Inspections must be thoroughly documented with appropriate photographs, test results, measurements, and a written report in the HSI system. In addition, access methods must be clearly documented so that future scheduling needs can be determined.

Floor beams spaced greater than 14 feet apart shall have a hands-on inspection for the entire tension portion of the floor beam. A hands-on inspection also applies to connections located in tension zones, such as the floor beam connection(s) to the primary load carrying member and connections to secondary members such as stringer to floor beam. These floor beams will be inspected using the same techniques as NSTM. This shall be noted in the inspection procedures. The floor beams shall be inspected at the NSTM inspection frequency for the bridge in question and be conducted by a certified NSTM inspector.

In rare cases where arms-length access cannot be safely accomplished by traditional methods (reach-all, ladder, etc.), alternative means of inspection are necessary. These methods require detailed inspection procedures that must be approved by BOS prior to use. Please coordinate with BOS Structures Maintenance prior to developing these procedures.

In addition, if the owner agency has demonstrated that floor beam members spaced greater than 14 feet apart have system or internal redundancy based on an FHWA approved methodology per CFR 650.313(f)(1)(i), then NSTM procedures are not required for those members.

1.3.5.2 Precision

An NSTM Inspection is a hands-on inspection. CFR 650.305 defines a hands-on inspection as: *Inspection within arm's length of the member. Inspection uses visual techniques that may be supplemented by nondestructive evaluation techniques.* Every square foot of the member/member component is examined. The observations and/or measurements are used to determine the structural capacity of the member/member component, to identify any changes from previous NSTM Inspections, and to ensure that the structure continues to satisfy present safety and service requirements.

Under-bridge access equipment is typically required to move the inspector within arm's length of the members. There may be permanent work platforms and walkways available on some larger structures to aid in inspection work. The access methods used during the inspection must be documented in the inspection procedures.

1.3.5.3 Nonredundent Steel Tension Member Inspection Frequency

Nonredundant steel tension members are inspected at regular intervals not to exceed 24-months except as required based on NSTM condition and inspection findings. When an element identified as a NSTM has any portion in condition state 4 or the NSTM Condition State is 4 or less, then the NSTM inspection interval shall not exceed 12 months for the member(s) with the low condition rating(s). If a steel cracking defect

(1010) is found to be in Condition State 3, the NSTM inspection interval shall not exceed 12 months for the member with the defect. The inspection frequency must be identified in the written inspection procedures.

**Maximum Required Inspection Interval:**

Hands-on/visual ........................................................................................24 months

Hands-on/visual when any portion of NSTM is in CS4..................................12 months

Hands-on/visual when NSTM Condition Item is coded 4 or less ...................12 months

Hands-on/visual for element when steel cracking identified in CS3 ..............12 months

Nondestructive Evaluation (NDE)..................................................................72 months

Details to consider for NDE of NSTM Components include:

- Pin and hanger assemblies
- Live load bearing anchor pins and link bars
- Pin thru web assemblies
- Welded cover plate end terminations on NSTM’s
- Field welds on NSTM’s
- Intersecting welds, or category E, or E’ details on NSTM’s
- Unique or Problematic Details on NSTM’s

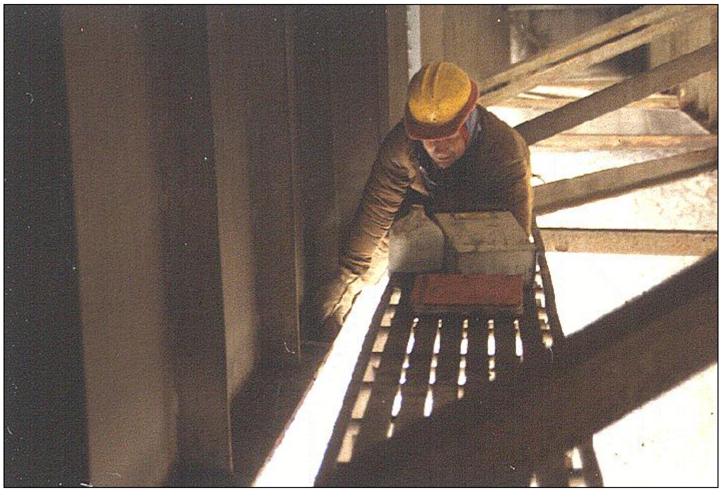

**Figure 1.3.5.3-1:** Inspector Performing Ultrasonic Testing for Crack Detection.

### 1.3.5.4 Specific Inspection Procedures

A bridge identified with a nonredundant steel tension member (NSTM) must have a detailed written inspection procedure specific to that bridge. These inspection procedures are to be kept in the bridge file, reviewed, and updated for **each** NSTM inspection.

The inspection procedures must address any of the following areas that are relevant to the specific NSTM bridge.

- General Information –
    - Provide a general statement indicating the scope of the inspection
        - Include hands-on visual assessment of identified NSTMs
        - Identify problematic details.
    - Identify the method(s) to be used to complete the inspection.
    - Identify any other inspection types or activities that will be performed at the same time, for example, routine or NDT.
- Clearly specify the frequency of the NSTM hands-on visual inspection.
- NSTM Diagram which identifies the location of the nonredundant steel tension members, including any floor beams needing hands-on inspection. The team lead or inspection program manager should verify the diagram is up to date. Form DT2011 may also be used to document the NSTM diagram.
- Workforce/Staffing
    - Staffing level – number of inspectors, team members
    - Staff qualifications needed
    - Define the duties to be performed by each team member or team of inspectors.
- Inspection Tools
    - Special tools not common to a routine inspection
    - Special lighting needs – if needed
    - Nondestructive testing (i.e. magnetic particle, a dye penetrant kit or ultrasonic testing device).
    - Method of access and equipment needed for hands-on inspection of each nonredundant steel tension member. The minimum size and location on the bridge the equipment will be needed.
        - Rope/rigging
        - Ladders
        - Scaffolding
        - Aerial work platforms
        - Under-bridge inspection truck
- Traffic control needs – on and under including any permits required.
        - Roadway
        - Pedestrian
        - Navigation
        - Railroad
- Scheduling – include any conflicts. Some common conflicts to address are as follows:

- Daytime inspection times
- Traffic congestion times
- Known conflicts under the bridge
- Railroad or navigation traffic
- Availability of inspection staff

- Site conditions that impact the inspection
  - NSTM condition
  - Clean surface areas (as necessary) to allow for thorough visual inspection
  - Lighting required to improve visibility
  - Utility attachments
  - Environmental concerns
  - Railroads
  - Safety Concerns
    - Confined spaces
    - Traffic (on and under)
    - Homeless people
    - Night work
- Describe the inspection sequence to inspect the NSTM's.
  - Planned sequence and historic sequence.
- Contacts and/or situational awareness communication
  - State and local agencies (DNR, county hwy dept, local municipality)
  - Federal agencies (Coast Guard, FHWA, Army Corp, etc.)
  - Law enforcement
  - Emergency response
  - Adjacent property owners
  - Utility company
  - Media
  - WisDOT Region Communications Manager (WisDOT bridges)
- **Identify specific risk factors** and problematic details/locations affecting the NSTM. Some possible specific risk factors and problematic details are listed below:
  - Cover plates
  - Discontinuities resulting in stress risers
  - Bolted/riveted connections present
  - Fatigue and fracture prone details (category E and E' details)
  - Problematic materials
  - Poor welding techniques
  - Intersecting welds
  - Tack/field/intermittent welds
  - Back-up bars
  - Out-of-plane distortion
  - Retrofits/repairs
  - Existing steel cracking
  - Steel section loss
  - Load posting
  - NSTM Condition item of 4 or less

- Subject to oversized or overweight loads
- Historic impact damage
- Service life (>30 yrs)
- High ADTT (>5,000)
- NDT (MT, UT, PT, etc.) is required because of existing defect
- Historically significant structure issue.
- Pin/hanger or pin through web connections
- Mechanical fasteners (bolts and rivets)
- Other

NSTM Diagram included with the inspection report and procedures must clearly identify the location of all nonredundant steel tension members.

**1.3.5.5 NSTM Supplemental Inspection Form**

The nonredundant steel tension member (NSTM) inspection report must include a detailed supplemental inspection form which identifies and documents the condition of each NSTM and AASHTO fatigue detail. The inspection report must provide qualitative and quantitative information concerning the NSTM and fatigue detail. This information is important for several reasons: it can offer insight about the condition of the NSTM, it can provide a history of the bridge, and it can be used to substantiate the thoroughness of the inspection effort. The supplement inspection form will be included with form DT2007 for the NSTM Inspection Report. Links to the supplemental inspection forms are below.

Links to supplemental NSTM inspection forms:

DT2010 (Word Document) & DT2011 (Word Document)

Supplemental NSTM Inspection Form A (Excel Spreadsheet)

Supplemental NSTM Inspection Form B (Excel Spreadsheet)

Supplemental Steel Girder-NSTM Inspection Form (Excel Spreadsheet)

**1.3.5.6 Highway Structures Inventory System (HSIS)**

The specific inspection procedure and the supplemental inspection form must be uploaded into HSIS on the *Documents/Images* tab. The procedures will be loaded under the *Category* of Inspection Procedures and the supplemental inspection form will be loaded under the *Category* of NSTM.

### 1.3.6 Underwater Profile

#### 1.3.6.1 Purpose

Scour is the leading cause of bridge failures. Federal Highway Administration (FHWA) regulations have been expanded to require bottom profiling and maintenance of channel records. The FHWA regulations reference the 2008 American Association of State Transportation and Highway Officials (AASHTO) The Manual for Bridge Evaluation, 1st Edition, which provides more specific information. Accordingly, the Department shall maintain such records on applicable bridges and ensure that local units of government do likewise.

Since this work is essentially a surveying task, the individuals taking the profiles need not be certified bridge inspectors. However, the profiles must be reviewed and compared to known substructure elevations and past profiles by the Inspection Team Leader (ITL) or Program Manager.

**All structures over water except four-sided structures (i.e. box culverts and round/elliptical pipes) shall have an initial underwater profile activity taken during the initial inspection.** The results shall be entered into HSI with documentation that show or explain the profile.

The HSI system will allow the uploading of numerous file formats including Excel spreadsheets. At the inspector's discretion, a spreadsheet may be created for a structure and uploaded to the HSI system for future reference and modification, if necessary. Example template spreadsheets can be utilized on our website under Inspection Sketches and Templates.

At a minimum, profiles shall be taken at the upstream and downstream fascia. It is not required to profile around substructure units (as these are covered by probing and/or Underwater Dive Inspections), but this may be done during the profile activity as directed by the inspection team leader or the inspection program manager.

**Follow-up Underwater Profile Activities**

**Higher Risk Bridges –** Structures in this category Include:

- Bridges that are scour critical, having a code of 3 or less, or U for NBI Item 113 or
- Bridges that have NBI Channel (Item 61) coded at 5 or below or
- Bridges that have a scour defect (6000) in Condition State 3 or 4.

**Bridges meeting these criteria shall have profiles taken every 24 months on both the upstream and downstream fascia.**

The inspector and PM shall review the historic profile measurements to ascertain potential movement of the channel and risk of substructure undermining and if such risk exists, notify the Statewide Program Manager.

**Structures involved in a significant flooding event –** Structures over water that experience a significant flooding event shall have a post flood profile evaluation to ensure the channel hasn't significantly shifted to affect the structural integrity of the bridge. A significant flood event is defined as one that causes the stream to flow beyond its banks.

Subsequent profile measurements for structures over water that do not meet the above criteria are not required but should be scheduled by the PM if conditions in the field warrant follow-up actions.

**In Conjunction with Underwater Dive Inspection**

Structures that also require Underwater Dive inspections shall have extensive profiles taken at the Dive inspection interval, and may forgo the 24-month requirements previously mentioned; water depth measurements during an underwater inspection should also include the following "global area" locations:

1. Maximum water depth measurements at each substructure unit in the water.

2. Bottom elevations at sufficient intermediate points between substructure units at the upstream fascia, downstream fascia, 100 feet upstream, 200 feet upstream, 100 feet downstream, and 200 feet downstream to adequately determine the thalweg of the waterway. Where the structure length is less than 100 feet, the upstream and downstream profiles should be taken at locations equal to the structure length and twice the structure length.

3. Termini of upstream and downstream profiles shall be referenced or monumented to ensure that subsequent profiles are taken at the same locations. GPS coordinates are acceptable.

Scour is the movement of channel bed material by the action of the moving water. This movement may result in degradation, or erosion, of material as well as aggradation, or accumulation of material. Degradation of the channel bed may lead to structure instability, posing an often-unseen threat to safety.

There are three forms of scour that can affect the safety of bridges and waterfront structures.

1. General scour is the general degradation or loss of the bed material along a considerable length of a waterway. It can be the result of natural erosion, mining activities, construction, or other events.

2. Contraction scour involves the removal of material from the bed and banks across all or the majority of the width of a channel. Contraction scour is caused by a reduction in the upstream channel cross-section, which results in increased flow velocities, increased bed shear stresses, and subsequent loss of material.

3. Local scour is the removal of material from a smaller area and is restricted to a minor portion of the width of the channel. The main mechanism of local scour is the formation of vortices at the base of piers, piles or other substructure elements as a result of currents, propeller wash, discharge/intake pipes, or other factors.

As discussed in Section 1.3.8, divers should note any signs of scour during underwater inspections. An important assessment during any inspection is how much of the substructure foundation is exposed when compared to design plans.

The inspector should check for scour at every structure over a waterway. The inspector should be aware that scour is generally most severe during periods of high flow[1] and when flows recede to normal levels; the presence of scour is often covered up with silt or timber debris, making detection difficult. Comparison of previous profiles is typically needed to detect and assess general and contraction scour.

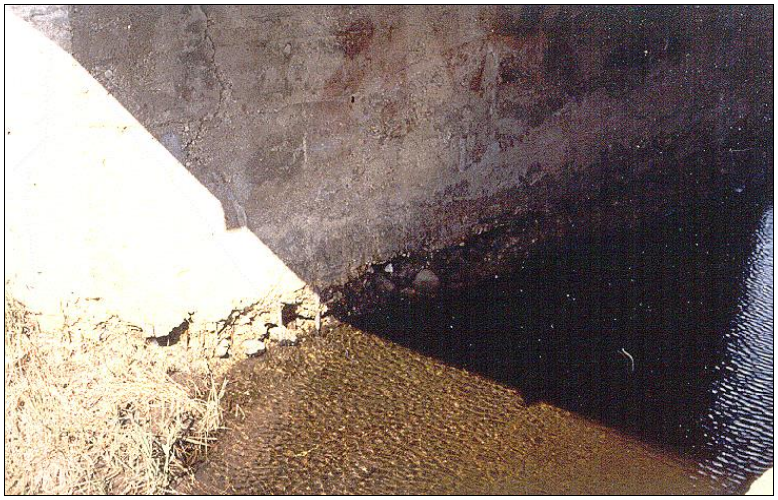

**Figure 1.3.7.1-1:** Local Scour at the Base of an Abutment.

## 1.3.6.2 Precision

Hydrographic survey data is used to evaluate trends in channel bottom movement and to compare channel bottom elevations to footing elevations. Water depth measurements should typically be recorded to the nearest tenth of a foot. However, scour evaluations are typically based on changes in elevations greater than 0.5 foot since most channel bottoms are irregular surfaces with random cobbles, debris, and sand ripples.

It is generally an acceptable practice for scour inspectors to measure the water depth relative to the water surface, in waterways without steep profiles or obvious hydraulic drops, assuming the waterline elevation in most waterways is constant over the surveyed area adjacent to the bridge. In actuality, since water always flows toward a lower topographic elevation, it is common for there to be at least 0.1 foot decrease in water surface elevation over a length of 500 feet in most waterways in Wisconsin. For waterways with steep profiles or obvious hydraulic changes in the water surface elevation, all water surface elevations must be recorded if direct water depth measurements are taken. Rather than documenting several water surface

[1] High flows following a major rainfall event can generally be expected to occur about 12 hours after precipitation ceases as a rough rule of thumb; however, every waterway is different, based on a variety of factors.

elevations, the inspector may choose to record the channel bottom elevation to a constant elevation using a surveyor's level or total station equipment.

**During all underwater surveys, the water surface elevation shall always be referenced to a known elevation on or near the bridge.**

In most instances, a bridge profile is located on a tangent or vertical curve. In order to expedite the streambed profile, the Wisconsin DOT recommends determining the elevation of an accessible bridge component. For example, the top of a bridge rail, or edge of deck are common landmarks an inspector can utilize when taking streambed elevations. The purpose of the profile is to observe changes to the streambed from inspection to inspection. So long as every inspector subsequently uses the same landmark and elevation for data recording, an accurate account is developed. Therefore, it is imperative that the inspector clearly identify the elevation of the landmark (these can be derived off existing plans or arbitrarily chosen) and the location the measurements are taken from (e.g. North Abutment - Upstream Fascia at Centerline of Bearing). When using an arbitrary elevation, the inspector may assume a constant elevation along the length of the structure, even if located on a vertical profile. Again, this is acceptable because the profile is a comparative tool. So long as the subsequent inspections replicated this arbitrary elevation and the locations at which measurements are taken, the data shall indicate whether there have been any changes to channel alignment or elevation.

While the true streambed elevation determined may be skewed due to the bridge profile following a tangent or vertical curve, the data will be able to be compared to later inspections.

#### 1.3.6.3 Inspection Frequency

1. All structures over water except 4-sided structures (i.e. box culverts and round/elliptical pipes) are required to have at least one underwater profile on file.

2. Higher Risk Structures, as defined in section 1.3.6.1, shall have profiles every 24 months.

3. Structures that require underwater dive inspections shall have Global area profiles at 60 months and can forgo the 24-month requirement.

#### 1.3.6.4 Equipment

Several water depth measurement methods, with a variety of equipment, can be used during a scour inspection with a hydrographic survey. These water depth measurements, often called soundings, can be obtained by manual means (lead line or sounding pole) or technological equipment (fathometer, sonar, radar, etc.). Refer to Chapter 19 in Part 5 for information on underwater profile equipment.

### 1.3.7 Underwater Inspection

#### 1.3.7.1 Purpose

CFR 650.305 states the following definition for underwater inspection: *Inspection of the underwater portion of a bridge substructure and the surrounding channel, which cannot be* *inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques.*

Furthermore, Metric #17 of the NBIS *Metrics for Overview of the National Bridge Inspection Program* states the following:

> Bridges requiring UW inspections have written inspection procedures which clearly identify the location of all UW elements, specify the frequency of inspection, describe any specific risk factors, and clearly detail inspection methods and equipment to be employed.

Underwater Diving Inspections are a necessary part of an effective structure management program and are mandated by the Federal Highway Administration (FHWA) on routine intervals not to exceed 60 months. Underwater diving inspections should be completed in accordance with OSHA 29 CFR 1910 SUBPARTS T AND Y, and the requirements described in this section. An underwater diving structure inspection is required if water conditions exist at the structure that prohibit access to all portions of an element by visual or tactical means ensuring a level of certainty during Routine Inspections.

These specialized inspections serve an important part in protecting the public, providing reliable service, and reducing maintenance and construction costs. Structural conditions above water that could lead to failure, loss of life or property damage are often observed well in advance by inspectors, maintenance workers, and sometimes even passing motorists. Conversely, significant underwater structural conditions cannot be observed by these individuals until the defect has progressed to the point where distress is evident above water. Unfortunately, structures exhibiting significant underwater defects often collapse before the distress is evident above water.

Although each type of material has predominant mechanisms of deterioration, the environment (moderate temperatures, moisture, oxygen, and chlorides or other chemicals) at the waterline is most conducive to all forms of deterioration. Furthermore, unique mechanisms, such as bacterial corrosion, are also common near the waterline on structures. This deterioration and distress may not be recognizable from above water, nor can the extent and severity be determined in most cases without inspecting the underwater elements.

### 1.3.7.2 Precision

Due to limited underwater visibility, the inherent access restrictions of the underwater environment, and the presence of marine growth, the required underwater diving inspection precision depends on the level of effort. Three underwater diving inspection intensity levels are defined by the FHWA. The expected underwater diving inspection precision is based on the individual coverage percentage of these three levels of effort. A summary is provided in Figure 1.3.8.2-1 with narrative descriptions of each level following the figure.

| Level | Purpose | Typical Detectable Defects/Expected Findings | | | |
|---|---|---|---|---|---|
| | | Steel | Concrete | Timber | Composite |
| I | General visual/tactile inspection to confirm as-built condition and detect severe damage | Extensive corrosion and holes<br><br>Severe structural damage | Major spalling and cracking<br><br>Severe reinforcement corrosion<br><br>Broken piles | Major loss of section<br><br>Broken piles and bracings<br><br>Severe abrasion or marine borer attack | Permanent deformation<br><br>Broken piles<br><br>Major cracking or structural damage |
| II | To detect surface defects normally obscured by marine growth | Moderate structural damage<br><br>Corrosion pitting and loss of section | Surface cracking, spalling, erosion<br><br>Rust staining<br><br>Exposed reinforcing steel and/or prestressing strands | External pile damage due to marine borers<br><br>Splintered piles<br><br>Loss of bolts and fasteners<br><br>Rot or insect infestation | Cracking<br><br>Delamination<br><br>Material degradation |
| III | To detect hidden or interior damage, evaluate loss of cross-sectional area, or evaluate material homogeneity | Remaining thickness of material<br><br>Electrical potentials for cathodic protection<br><br>Change in material properties | Onset of reinforcing steel corrosion<br><br>Internal voids<br><br>Change in material properties | Internal damage due to marine borers (internal voids)<br><br>Decrease in material strength<br><br>Change in material properties | Change in material properties |

**Figure 1.3.8.2-1:** Summary of Intensity Levels.

## Level I Effort

An inspection involving a visual examination or a tactile examination using large sweeping motions of the hands where visibility is limited. Although the Level I effort is often referred to as a “Swim By” inspection, it must be detailed enough to detect obvious major damage or deterioration due to overstress or other severe deterioration. It should confirm the full-length continuity of all members and detect undermining or exposure of normally buried elements. A Level I effort may also include limited probing of the substructure and adjacent channel bottom. Refer to Figure 1.3.8.2-2 for a view of a structure during a Level I effort.

**Figure 1.3.8.2-2:** Inspector Conducting a Level I Inspection Effort.

**Level II Effort**

A Level II effort is a detailed inspection that requires marine growth to be removed from portions of the structure. Cleaning is time-consuming so there is a need to limit the detailed inspection to a representative sampling of components. For piles, a 12-inch high band should be cleaned at designated locations, generally near the waterline, at the mudline, and midway between the waterline and the mudline. On an H-pile, marine growth should be removed from both flanges and the web. On a rectangular pile, the marine growth removal should include at least three sides; on an octagonal pile, at least six sides; on a round pile, at least three-fourths of the perimeter. On large diameter piles, three feet or greater, one-foot squares should be cleaned at four locations approximately equally spaced around the perimeter, at each elevation. On large solid faced elements such as pier shafts, one-foot squares should be cleaned at four random locations, at each elevation. The Level II effort should also focus on typical areas of weakness such as attachment points and welds. The Level II effort is intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling. The thoroughness of cleaning should be governed by what is necessary to discern the condition of the underlying material. Removal of all biofouling staining is generally not required. Refer to Figure 1.3.8.2-3 for a view of a structure during a typical Level II effort.

**Figure 1.3.8.2-3:** Inspector Conducting a Level II Inspection Effort.

**Level III Effort**

A detailed inspection typically involving nondestructive evaluation (NDE) or partially-destructive evaluation (PDE), conducted to detect hidden or interior damage, or to evaluate material homogeneity. Typical inspection and testing techniques include the use of ultrasonic, coring or boring, physical material sampling, and in-situ hardness testing. Level III testing is generally limited to key structural areas, areas which are suspect or areas which may be representative of the underwater structure. Refer to Part 5 of this Manual for additional information on nondestructive and partially destructive evaluation. Also, refer to Figures 1.3.8.2-4 and 1.3.8.2-5 for views of inspectors conducting Level III efforts.

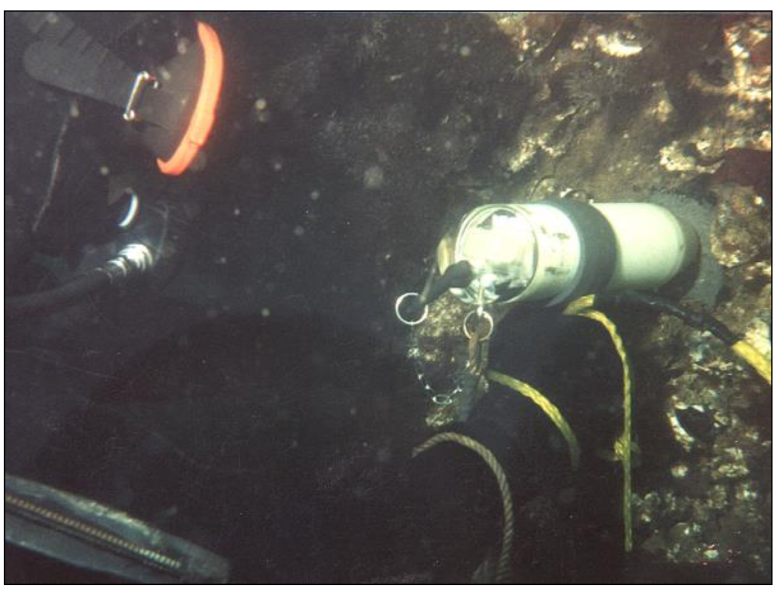

**Figure 1.3.8.2-4:** Inspector Using a D-Meter to Conduct a Level III NDE Inspection Effort.

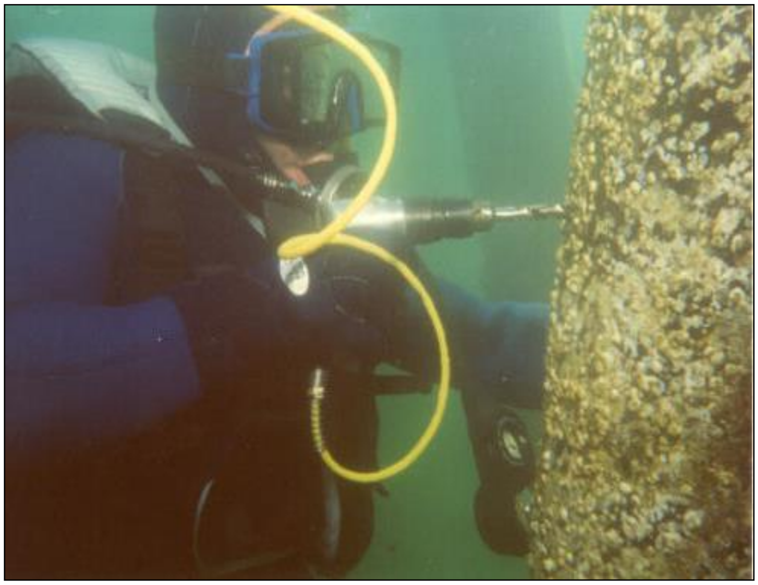

**Figure 1.3.8.2-5:** Inspector Using a Drill to Conduct a Level III PDE Inspection Effort.

### 1.3.7.3 Underwater Diving Inspection Frequency

CFR 650.311(b) establishes the minimum requirements for underwater inspection frequency. These requirements are described and elaborated on in the NBIS *Metrics for Overview of the National Bridge Inspection Program*.

The NBIS metrics separate bridges into two categories based on underwater inspection: lower risk and higher risk bridges.

Metric #8: Inspection Frequency – Underwater –Lower risk bridges states:

UW inspections are performed at regular intervals not to exceed (NTE) 60-months, or NTE 72-months when adhering to FHWA approved UW criteria. The criteria a structure must meet to be considered for the 72-month Routine UW-inspection frequencies are as follows:

1. The NBI Condition Ratings for Substructure (60) or Culvert (62) must be greater than 6 or N (Good Condition).
2. The NBI Scour Critical Bridge code (113) shall be coded as 9, 8, 7, or 5.
3. The structure must be less than 50 years old to have an extended inspection frequency. Item 27.
4. Structure must have at least two (2) Underwater Dive inspections on file to be eligible.
5. Border bridges with adjoining states are not eligible, unless the adjoining state has criteria in place that matches or exceeds the WisDOT criteria and both States have a signed agreement to inspect the bridge at the extended interval. NBI Item 98
6. No complex bridges, as defined by WisDOT and the NBIS, are eligible. NBI Item 43B <> 13, 14, 15, 16, 17.
7. No substructure Elements with the Settlement Defect (4000) in CS2, CS3, or CS4 are eligible.
8. No substructure Elements with the Scour Defect (6000) in CS2, CS3, or CS4 are eligible.

9. No substructure Elements with the Microbial Induced Corrosion Defect (8901).
10. No substructures with timber substructure elements (206, 208, 212, 216, 228, 235, or 242) are eligible.
11. No structures that carry an ADT greater that 50,000 are eligible.

The 72-month extended UW-Inspection frequencies is optional and is up to the structures owner to utilize. The eligibility requirements are the same as previously describe for the 48-month routine inspections. The structures owner interested in participating in the 72-month extended UW-inspection frequencies needs to have the County PM or Commissioner fill out the DT2002 Structure Inspection Quality Control Form and follow the instructions enclosed.

Metric #9: Inspection Frequency – Underwater – Higher risk bridges states:

> UW inspections are performed at regular intervals not to exceed (NTE) 24-months.
>
> Higher risk bridges are defined for this metric as those with a substructure or culvert condition rating of 3 or lower, or evaluated as scour critical.

In addition, Wisconsin requires adherence to the following criteria:

1. An Underwater Profile is required as part of the Initial Inspection

2. An underwater diving bridge inspection should include at least a Level I effort on 100 percent of all underwater elements, a Level II effort on 10 percent of all underwater elements, and a Level III effort as determined by the Team Leader.

### 1.3.7.4 Methods of Underwater Inspection

After identifying that a structure requires an underwater diving inspection, it must be decided which underwater diving inspection method should be used. Underwater diving inspection methods are categorized as “manned” or “unmanned”. The following factors influence the determination of which method of underwater diving inspection is best suited for a structure:

1. Water depth (depth greater than 4.0 feet should be performed by diving)

2. Water visibility

3. Water velocity (if greater than 2 feet per second, should be performed by diving)

4. Streambed conditions (if soft or irregular, should be performed by diving)

5. Presence of debris or other obstructions/obstacles

6. Substructure configuration

The qualified “manned” methods consist of an inspection-diver using commercial Self-Contained Underwater Breathing Apparatus (SCUBA) equipment or surface supplied air (SSA) equipment. For qualified “manned” methods, the Team Leader is required to be a certified diver and be able to perform the underwater inspection.

The “unmanned” methods typically use a real-time submersible videography lens or electronic imaging devices to transmit observation data to a qualified Team Leader. Although electronic imaging devices are not often used in Wisconsin, submersible videography lenses have been used on telescopic poles and in remote operated vehicles (ROVs). When the diver is not a qualified Team Leader and the Team Leader is not a qualified diver, the lenses can be attached to a diver’s helmet. While these “unmanned” methods are acceptable if they are conducted in a way that ensures a sufficient level of certainty, they should be considered only as a secondary alternative if the more preferable qualified “manned” method is not feasible. The Team Leader’s assessment capabilities are adversely affected when unable to perform the actual physical inspection.

Underwater diving inspection in Wisconsin is most frequently conducted by a dive team using SCUBA equipment. This method consists of using a standard exposure suit and a portable air tank. The inspector(s) will make a visual and tactile evaluation of the substructure units by swimming around the individual units. SCUBA equipment allows the inspector greater freedom of movement, the ability to visually inspect the substructure units both above and below the waterline, even in poor water visibility, and to reach all areas even in deep water. Limitations of the SCUBA method are: the duration of the inspection due to a limited air supply (dive should typically be finished prior to a pressure gauge reading of 750 psi); a permissible depth range for safe operation (120 feet); additional tethering in swift currents; and specialized training and equipment for the inspectors. Refer back to Figures 1.3.8.2-2 to 1.3.8.2-5 for views of inspectors using scuba equipment.

Although more common in underwater diving construction, an underwater diving inspection can also be conducted by a dive team using a surface supplied air system. The equipment consists of a standard exposure suit, a full-face mask/helmet, and umbilical cords connecting the diver to the surface. The inspector(s) will make a visual and tactile evaluation of the substructure units by swimming around the individual units. This method of inspection provides many of the same benefits as a SCUBA inspection along with being well-suited for adverse diving conditions, such as swift velocities (typically up to 14 fps), polluted water, and long diving durations. Limitations of the surface supplied air method is that the equipment: limits free movement; a permissible depth range for safe operation (220 feet), and specialized training and equipment for the inspectors. Refer to Figure 1.3.8.4-1 for a view of an inspector using surface-supplied-air equipment.


**Figure 1.3.8.4-1:** Inspector Using Surface-Supplied Air Equipment.

## 1.3.7.5 Inspection Equipment and Tools

The underwater diving inspectors will require a larger than normal amount of equipment to complete the various tasks associated with the structure investigation regardless of the method used. These items are a mix of common tools and specialized equipment that will provide a breathing medium, means of movement, and aid the inspector in collecting data at the structure.

**Personal Equipment**

For an underwater diving inspection, a brief equipment list is as follows:

1. Exposure suit (wet or dry)
2. Dive mask or helmet
3. Breathing apparatus
4. Air supply (portable tank or surface compressor unit)
5. Weight belt
6. Dive fins
7. Buoyancy compensator

8. Depth gauge / pressure gauge (All dives should be terminated at 750 psi.)

9. Wristwatch

10. Light source

***Furthermore, an inspector conducting a diving inspection should carry additional equipment such as a knife and reserve air tank or J-valve on the tank.***

**Access Equipment**

While access is often gained from the shoreline, some structures are best accessed by use of a boat. Typically, an 18-foot or larger vessel can safely carry the equipment and crew. On some occasions, access may be gained from the structure itself.

**Communication Equipment**

While it is not mandatory to be in voice communication during shallow water dive inspections, two-way voice communication greatly aids in the efficiency of the inspection data collection and recording, and it provides an added level of safety. For deep-water inspections, the use of two-way voice or hand-signal communication is recommended. The advantages of direct voice communication are:

1. The diver can communicate directly with the note-taker to describe the location, type, and size of any observed defects.

2. The diver can discuss any observations with surface personnel.

3. When using video equipment, the surface personnel can direct the diver to specific areas that appear suspect or where closer investigation needs to be conducted.

4. The diver can immediately report the extent of any problems.

**Tools**

The inspection team should have access to the appropriate tools and equipment as warranted by the type of inspection being conducted. A number of tools should be available to the inspector and can be categorized as hand-tools or power-tools. Since power-tools are not frequently used, a brief list of typical hand-tools is as follows:

1. Ruler

2. Calipers

3. Probe (ice picks, awls, screwdrivers, etc.)

4. Geologist hammer

5. Scraper

6. Wire brush

7. Pry bar

**Testing Equipment**

Often an inspection requires some level of material testing to ascertain the condition of the substructure unit that may not visually show any significant signs of deterioration. Testing is also the main component of a Level III inspection. Testing may be either nondestructive or partially destructive and is described in detail in Part 5 of this Manual. Nearly all the methods in Part 5, which are applicable for use on substructures, can also be performed underwater.

**Photography & Videography Equipment**

A still or video camera can provide a visual record of defects or deterioration that is observed by the inspector. This information can be reviewed with others to better define and evaluate the significance of the defect.

A still camera can be fitted with a variety of lenses and flash units that are suited for different conditions. In low visibility, the camera will need to be placed close to the object and will require a wide-angle lens. Particles that are suspended in the water, which make it cloudy, reduce ambient light and can reflect light from the flash unit into the lens. When visibility is very low, clear water boxes can be used. A clear water box is constructed of clear plastic and is filled with clean water. By placing the box against the object to be photographed, the box of clean water will displace the murky water allowing for a clear photograph. Refer to Figure 1.3.8.5-1 for a view of a typical clear water box.

**Figure 1.3.8.5-1:** Inspectors Attaching a Clear Water Box to an Underwater Camera.

Video equipment is generally available as self-contained submersible units, or as a submersible camera lens attached to the diver with a cable connection extending to a surface monitor and controls. The latter allows a surface operator to direct the shooting, control the lighting and focusing, and communicate with the diver to obtain the optimum image. A sound track could also be dubbed with the video image by the diver or topside personnel to provide a running commentary pertaining to the observations.

### 1.3.7.6 Underwater Inspection Procedures

A bridge that receives an underwater inspection must have a detailed written inspection procedure specific to that bridge. These inspection procedures are to be kept in the bridge file, reviewed, and updated for **each** underwater inspection.

The inspection procedures must address any of the following areas that are relevant to the specific bridge receiving the underwater inspection.

- Clearly Identify the location of all underwater elements
- Specify the frequency of the underwater inspection
- Describe any specific risk factors
    - The specific risk factors shall be separated into Diver and Structure risk factors.
    - **Diver Risk Factors**
        - For each bridge, include diver risk factors (diver safety) in a separated paragraph under the Inspector Site-Specific Safety Considerations section of the report. Start the paragraph “Diver risk factors:”. If there are no diver risk factors, please note “Diver risk factors: None”.
        - Some diver risk factors could be:
            - Debris accumulation
            - Limited visibility in the water
            - Rapid stream or current
            - Soft or unstable streambed or stream banks for walk in entry
            - Pollutants in water

Note this is not an exhaustive list so others may qualify as diver risk factors.

- 
    - **Structure Risk Factors**
        - Include all structure risk factors (related to scour, environment, or structure) at a bridge in the specific procedures section of the dive inspection report. Provide a separated section of the procedure to address structure risk factors. This section should be started with “Structure risk factors:”. List or describe the structure risk factors. If there are no structure risk factors,

please note “Structure risk factors: None”. Remove any structure risk factors listed elsewhere outside of the UW-Dive specific procedures section or separate documents since they should only be listed in UW-Dive specific procedures section of the report.

- Some structure risk factors could be:
  - Debris accumulation
  - Rapid stream or current
  - Pollutants in water
  - Marine environment
  - Meandering channel
  - Unknown foundation
  - Scour critical bridge
  - Observed scour
  - Environmental conditions (i.e. MIC for steel, timber piling – limnoria) which may accelerate deterioration

Note this is not an exhaustive list so others may qualify as structure risk factors.

- Clearly detail inspection methods
- Equipment and tools to be employed

### 1.3.8 Underwater Probing/Visual (Wading) Activity

These methods of underwater inspection involve either wading or probing with a rod or the feet. Underwater Probing/Visual Inspection is the most basic type of underwater inspection and can often be performed by an inspector wading in the water with no additional training. This type of activity is required for all structures over water that are not dove at regular intervals and should be done in conjunction with the Routine inspection where applicable.

The inspection is conducted by evaluating the substructure units and the waterway by using a probe rod or sounding pole. The inspector wearing waders (or a dry/wet suit) walks around the substructure, probing the units and channel bottom with the rod and with his/her feet, while visually inspecting the areas above and directly below the waterline where visibility permits. Limitations of the wading inspection are deep water, poor water visibility, excessively soft or irregular streambed conditions, and swift currents that make movement difficult or dangerous. Refer to Figure 1.3.9-1 for a view of an inspector conducting a wading inspection.

The results of the probe are entered into the HSI system under the Tab titled Underwater. This tab lists all substructure units on the bridge. If the substructure unit is dry at the time of the probing, the inspector shall note that on the form for the unit in question.

**Figure 1.3.9-1:** Inspector Conducting a Wading Inspection.

### 1.3.8.1 Inspection Equipment and Tools

Personal equipment typically includes hip waders, a hard-hat, reflective vest, and tool belt for an inspector conducting an underwater probing/visual (wading) inspection.

### 1.3.8.2 Underwater Probing/Visual Inspection Frequency

It is recommended that an Underwater Probing/Visual Inspection be performed every 24 months. Because of this recommended frequency, it is often performed at the same time as the Routine Inspection. An Underwater Probing/Visual Inspection is also required as part of the Initial Inspection, as well as during an Underwater Dive Inspection.

## 1.3.9 Interim Inspection

### 1.3.9.1 Purpose

Interim inspections can be considered Special Inspections which are defined under CFR 650.305 as: *An inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency.*

An Interim Inspection is performed when a structure requires more frequent inspection than is given by the Routine Inspection cycle, but not all of the structure is being inspected.

A structure requiring Interim Inspections would typically have a known defect or condition severe enough to warrant extra scrutiny. Examples include load posted bridges, actively tipping or rotating substructures, advanced section loss, etc.

**Figure 1.3.11.1-1:** Tendon Section Loss at the Bottom of a Prestressed Channel and Pier Section Loss.

## 1.3.9.2 Precision

The inspector must make sufficient measurements and observations to answer the following questions:

1. What are the physical and functional conditions of the structure with the known or suspected deficiency?

2. Are there any developing problems such as foundation settlement, scour, or erosion of the slopes, scour at the supports, ice damage, or other problems that, if left unchecked, would degrade the load-carrying capacity of the structure?

3. Can the structure continue to satisfy its present service requirements?

The results of the inspection should be recorded in a brief written report or by noting on the last inspection report (with a signature and the date) that an Interim Inspection was performed and that the known deficiencies were investigated. The paperwork should be kept in the structure owner's file. If the deficiency has become more severe, it may be necessary to notify the owner and re-evaluate the structure's load rating.

Interim Inspections need not be performed by certified bridge inspectors. An Inspection Team Member can be sent out to perform specific inspection or measurement tasks under the direction of a Team Leader. Such tasks might include measuring a crack, photographing a weld, measuring section loss on specific members, etc.

#### 1.3.9.3 Interim Inspection Frequency

In general, Interim Inspections are scheduled at the discretion of the individual responsible for structure inspections for the unit of government that owns the structure.

### 1.3.10 Damage Inspection

#### 1.3.10.1 Purpose

A Damage Inspection is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions. Flood damage, barge impact, and vehicle impact are common examples of events that may call for a Damage Inspection.

**Figure 1.3.12.1-1:** Impact Damage to a Steel Girder Bridge.

**Figure 1.3.12.1-2:** Failed Wingwall.

## 1.3.10.2 Precision

The scope of a Damage Inspection should be sufficient to determine whether there is a need for emergency load restrictions or closure of part or all of the structure to traffic. The inspector should also assess the level of effort necessary to repair the damage. The amount of effort expended on this type of inspection may vary significantly and depends on the extent of the damage. If major damage has occurred, inspectors should evaluate fractured and cracked members, determine the extent of section loss, make measurements for misalignment of members, and check for any loss of foundation support. A structure inspection form should be filled out and submitted for entry into the HSIS database with addenda and pictures, if necessary, with all the information mentioned above. This inspection may be supplemented by a timely In-Depth Inspection to document more fully the extent of damage and the urgency and scope of repairs. Proper documentation, verification of field measurements and calculations, and perhaps a more refined analysis to establish or adjust interim load restrictions are required follow-up procedures. The ability to make on-site calculations to establish emergency load restrictions may be desirable. A particular awareness of the potential for litigation must be exercised in the documentation of Damage Inspections. Therefore, all documentation should be legible and thorough.

## 1.3.10.3 Damage Inspection Frequency

A Damage Inspection is an unscheduled inspection that is performed to determine if significant damage has been done to the bridge. Generally, a law enforcement officer on the site of an accident involving a structure will notify the appropriate individuals and request a Damage Inspection be performed to determine if the bridge should be closed. A Damage Inspection may be followed up by an In-Depth Inspection to document the full extent of the damage.

## 1.3.11 Complex Bridge Inspection

### 1.3.11.1 Purpose

CFR 650.305 and WisDOT defines both cable stayed and movable bridges as Complex Bridges. Complex bridges are subject to specialized inspection procedures, and additional inspector training and experience is required to inspect these types of structures. These inspections require greater engineering knowledge and/or expertise to accurately and fully determine the condition of the various bridge elements. They may also require specialized equipment or climbing to access all parts of the bridge.

CFR 650.313(f) establishes the requirement for all complex structures to have an inspection procedure in place.

This requirement is described and elaborated on in the NBIS *Metrics for Overview of the National Bridge Inspection Program.* Metric #19: Inspection procedure – Complex Bridges states:

> Complex bridges have the following identified:
>
> - Specialized inspection procedures which clearly identify the complex features, specify the frequency of inspection of those features, describe any specific risk factors unique to the bridge, and clearly detail inspection methods and equipment to be employed.
> - Additional inspector training and experience required to inspect complex bridges.
>
> Complex bridges are inspected according to those procedures.

Movable structures should normally receive the same types of inspections as fixed structures, as described in the foregoing. Furthermore, most movable bridges will require additional specialized inspections, such as NSTM, in-depth, underwater diving, and underwater survey inspections. In addition to the structural systems, the operating systems need to be inspected on a routine basis. It is typically most advantageous to perform the annual movable systems inspection in early spring. Specific inspection tasks relative to movable structures are described in detail in Part 3 of this Manual.

## 1.3.12 Closed Bridge Inspection

### 1.3.12.1 Purpose

All structures closed to highway traffic that remain in the HSI system as highway bridges shall continue to receive Routine inspections. The inspection shall include an evaluation of the closure system(s) and recorded under Assessment 9036 – Bridge Closure Systems.

Special inspections (NSTM, Complex, Underwater, etc.) are no longer required for the closed structure unless those inspections are crucial to ascertaining the stability of the structure in the field. The Regional PM shall be consulted to determine if these inspection types are required for individual bridges.

1.3.12.2 Frequency

Closed bridge inspections shall be conducted every 12 months and shall be entered as a Routine Inspection in the HSI system.

### 1.3.13 Load Posted Verification

1.3.13.1 Purpose

A Load Posted Verification is a review of the signage associated with a load posted bridge. Bridges not able to carry the State legal loads, as determined by the Statewide Program Manager (SPM), are load posted for reduced live load capacity. These bridges may have been designed for a truck load that is lighter than what is allowed by law today. Otherwise, these bridges may have suffered some sort of deterioration or damage that has reduced the load capacity below the legal statutory allowable load. In either regard, load posted bridges should be monitored regularly to ensure their serviceability and safety.


**Figure 1.3.13.1-2:** Load Posted Truss Bridge.

1.3.13.2 Precision

The inspector shall review the signage for the load posted bridge on-site to determine:

- Are all of the required load-posting signs (including advanced warning signs) in the proper locations?
- Are the signs legible, and do they have the correct load posting displayed?
- Does the HSI system have the correct load posting recorded in the data?

The results of the inspection should be recorded as a Load Posted Verification activity in HSI, including photos of ALL of the Signs. This type of activity does not need to be performed by certified bridge inspectors. An ITM can be sent out to perform specific inspection or measurement tasks under the direction of an Inspection Team Leader (ITL).

#### 1.3.13.3 Frequency

This activity only needs to be performed when load postings change on the structure. Load posting signs must follow the Wisconsin Manual on Uniform Traffic Control Devices and shall be installed no later than 30-days after the owner is notified of the need for the posting change. For structures that have a load posting at any level, form DT2122 – Bridge Load Posting Field Verification must be on record in HSI and must display the current signage. A new form is required when a form is not on file or the load posting has changed. This form shall be submitted immediately after sign installation.

### 1.3.14 Deck Evaluation

#### 1.3.14.1 Purpose

Over time, bridge decks deteriorate. Routine inspectors use various methods of inspection (both visual and audible) to detect defects in bridges decks.

Chain dragging is a common audible method to help detect delaminations and shall be recorded in HSI under the Deck Evaluation activity. Only when one hundred percent of the wearing surface is chain dragged shall the Deck Evaluation activity be selected in HSI.

A sketch of the delaminated areas shall be uploaded into HSI for the activity. Often times, more in-depth methods are required to ascertain condition. Common methods employed by WisDOT include:

- Ground Penetrating Radar (Part 5, Chapter 10)
- Infrared Thermography (Part 5, Chapter 11)
- Chloride Ion testing (Part 5, Chapter 16)

When these testing methods are used, they shall be recorded in HSI under the Deck Evaluation activity and all reports from the testing shall be uploaded into the activity.

#### 1.3.14.2 Precision

Refer to Part 5 of this manual for anticipated precision of each method.

#### 1.3.14.3 Frequency

For state-owned structures, frequency of deck evaluations is based on the Deck Scanning Policy in Part 1 Appendix A. Local bridge owners may choose to follow a similar frequency to aid in the selection of appropriate bridge treatments.

### 1.3.15 Scour Plan of Action

#### 1.3.15.1 Purpose

The National Bridge Inspection Standards (NBIS) regulation, 23 CFR 650.313, requires that bridge owners identify bridges that are scour critical (coded 0, 1, 2, or 3 in Item 113) and to prepare a plan of action (POA) to monitor known and potential deficiencies.

Bridges that are scour critical require that the HSI bridge file have a POA document on file.

#### 1.3.15.2 Precision

In general, a plan of action should focus on providing information that the inspector needs when out in the field. The plan should refer to plans, previous inspector reports, UW-Profile data, and other items pertinent to the bridge.

The POA should detail the foundation type, previous scour history, and monitoring benchmarks for the inspector to assess while in the field. It should also include a bridge closure plan that details when the bridge should be closed, who's responsible for the closure, when the bridge can be re-opened and what detour route should be used during the closure.

#### 1.3.15.3 Frequency

The POA document shall be updated every four calendar years or after significant flooding events. This requires a new POA activity entry into HSI.

### 1.3.16 Vertical Clearance Measured Activity

#### 1.3.16.1 Purpose

The clearances on or under a bridge shall be measured periodically to determine changes in clearance that affect the mobility of Oversize/Overweight vehicle traffic.


**Figure 1.3.15.1-1:** Vertical Clearance Photo

### 1.3.16.2 Precision

Clearances should be taken in every lane, at edge of lanes, edge of paved shoulders, and at barrier edges to determine the low point for vehicular travel.

### 1.3.16.3 Frequency

This activity shall be completed every time there is a construction project on or under a bridge. In addition, after a bridge is hit the inspector conducting the damage inspection should determine if they need to re-measure clearances and if so, enter a vertical clearance verification along with the damage report.

## 1.3.17 Critical Findings Activity

### 1.3.17.1 Purpose

A critical finding is defined by WisDOT as “A defect on a bridge which threatens public safety and/or the structural stability of the bridge and is of such severity that immediate partial or full closure of the structure is required”. See Part 1, Chapter 7 for more details.


**Figure 1.3.16.1-1:** Critical Finding Photo

## 1.3.17.2 Precision

When the severity of the finding is deemed Unsafe or Serious (as defined by Part 1, Chapter 7), a critical findings activity shall be entered into HSIS with a completed DT2026 form attached.

## 1.3.17.3 Frequency

This activity is entered into the HSI System on an as-needed basis.