Manual

Structures Inspection Manual
Part 3: Structures Inspection Procedures

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Queensland Government

Feedback: Please send your feedback regarding this document to: TMRStructuresInspectionManual@tmr.qld.gov.au

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1 General

1.1 Levels of inspection

The Transport and Main Roads *Structures Inspection Manual Part One – Structures Inspection Policy* has identified the need for a systematic program of inspections based on three levels of inspection.

The three inspection levels are as follows:

- Level 1 – Routine Maintenance Inspection
  - A visual inspection to check the general serviceability of the structure, particularly for the safety of road users, and to identify any emerging problems.
- Level 2 – Condition Rating Inspection
  - An inspection to assess and rate the condition of a structure (as a basis for assessing the effectiveness of past maintenance treatments, identifying current maintenance needs, modelling and forecasting future changes in condition and estimating future budget requirements).
- Level 3 – Special Inspection
  - An inspection to provide improved knowledge of the condition, structural capacity, in-service performance or any other characteristic beyond the scope of other types of inspection. Special inspections may be used to inform/develop the scope of Level 1 and Level 2 inspections. Level 3 inspection categories include:
    - structural engineering
    - asbestos containing material (ACM) identification
    - ACM verification
    - underwater access
    - fracture critical/redundancy
    - sub-standard load rating
    - complex/unique bridges
    - known/suspected deficiencies
    - confined space inspection.

1.2 Safety

All inspections must comply with the requirements of:

- this manual
- any applicable legislation, codes of practice, standards and Transport and Main Roads policy/manuals including but not limited to:
  - *Work Health and Safety Act 2011*
  - Work Health and Safety Regulation 2011
  - MRTS96 *Management and Removal of Asbestos.*

While structure inspections, detailed investigations and maintenance activities may not be categorised as a ‘specified work’ category, documented safe work procedures (for example, Safe Work Method Statements) shall be prepared in order to:

- reduce the risk to staff undertaking field work
- provide documentary evidence that the department has fulfilled its obligation as an employer under the Act.

If inspection is required from water, any vessel used for this purpose and its operation will be required to satisfy the legal obligations of the *Transport Operations (Marine Safety) Act 1994*, other relevant Acts, and associated Regulations.

Where inspections are to be carried out on structures located over or under the assets of other Authorities, the relevant Regulations and Codes of Practice relating to work on or close to their assets must be adhered to and, where necessary, referred to in the safe work procedures developed for the inspection.

1.3 Component designation

General terminology used to label the components of various structure types, irrespective of the level of inspection being undertaken, is shown in Appendix B and Appendix C.

Component location and numbering shall be in accordance with the procedures outlined for Level 2 inspections in Section 3.

1.4 Manual updates

The department’s Bridge Construction, Maintenance and Asset Management (BCMAM) section will update the manual at regular intervals (at least every 12 months) to reflect feedback received and any changes to inspection practice.

A feedback register advising of all current known issues is maintained on the *Structures Inspection Manual* web page. All those required to use the Manual, including inspectors, should check the register at regular intervals for issues/updates.

2 Level 1 – Routine Maintenance Inspection

2.1 Purpose

The purpose of a Level 1 inspection is to check the general serviceability of the structure, particularly for the safety of road users, and identify any emerging problems.

Level 1 inspections may be carried out in conjunction with routine maintenance of the structure and the adjacent pavement.

2.2 Scope

The scope of a Level 1 inspection includes:

- inspection of approaches, waterway, deck/footway, substructure, superstructure and attached services to assess and report any significant visible signs of distress or unusual behaviour, including active scours or deck joint movements
- recommendation of an exceptional Level 2 inspection or a Level 3 inspection if warranted by observed distress or unusual behaviour of the structure

- identification of maintenance requirements that fall outside the expertise and/or available material and equipment resources at hand
- verification of the 'Structural Inventory' data held in the Bridge Information System (BIS) as part of the initial inspection and where requested thereafter (**Structural Inventory Verification forms** are available from the BIS for this purpose).

2.3 Extent of inspections

The Level 1 inspection is a visual inspection which may be carried out in conjunction with routine maintenance of the structure and adjacent pavement and shall cover components above ground and water level listed in the procedure checklist.

Components that need not be inspected for Level 1 inspections are:

i. interiors of box girders or any other structure/component that constitutes a confined space

ii. areas behind abutments that are inaccessible

iii. piles and foundations below ground or water level

iv. piers and pier crossheads located in permanent water

v. components located in spans over permanent water

vi. items requiring special access equipment including boom lifts, underbridge access units, boats, ladders or scaffolding to perform the inspection (unless access is already being provided for routine maintenance requirements)

vii. all components above deck soffit level for bridges crossing over the road network.

These components will be inspected as part of a Level 2 or Level 3 inspection.

No access to the rail corridor is required for Level 1 inspection of road over rail bridges.

A visual assessment of items iv – vi should be made using binoculars where practical.

2.4 Inspection frequency

Level 1 inspections shall be carried out at the frequency specified in Table 2.4.

Table 2.4 – Level 1 inspection frequencies

Structure type	Overall condition state of structure	Inspection frequency (years)
Timber structures and steel culverts (in permanent standing water)	1 – 2	1[1]
	3 – 4	1[2]
Bridges and culverts[4]	1 – 2	1[1]
	3	1[1]
	4	1[2]
Tunnels	1 – 2	1[3]
	3	1[3]
	4	1[3]

Structure type	Overall condition state of structure	Inspection frequency (years)
Busway bridges, including elevated and underground stations and pedestrian overbridges at busway stations	1 – 2	1[3]
	3	1[3]
	4	1[3]
Other bridges over the road network	1 – 2	1
	3	1
	4	1
Retaining structures above/below the road network (excludes retaining structures inspected as part of any other structure)	1 – 2	1[3]
	3	1[3]
	4	1[3]
Large Traffic Management Signs (LTMS) and gantries	1 – 2	1[1]
	3	1[1]
	4	1[2]

[1] Generally not required in the same years as level 2 or level 3 inspections.

[2] Level 1 and level 2 inspections to be staggered by six months to ensure inspections occur every six months.

[3] Or at frequency specified by structure-specific maintenance manual (whichever is greater).

[4] Includes critical ‘minor’ culverts.

All annual inspections shall be completed no less than 10 months and no greater than 14 months after the previous inspection.

Further, a Level 1 inspection is required following major flooding events (bridges and culverts in affected waterways only), fire or accident damage or as recommended in a Structures Management Plan or by BCMAM.

2.5 Inspector accreditation

Inspections shall be conducted by personnel who have extensive practical experience in pavement and structures routine maintenance. They shall be competent to judge the visual condition of structures and the road approaches for visual defects.

Accreditation requirements for Level 1 inspectors are detailed in Appendix E.

2.6 Inspection procedure

2.6.1 Preparation for inspection

Prior to commencing inspections, the inspector shall ensure that all relevant documentation, inspection equipment and safety equipment is in place along with the appropriate arrangements with the relevant road, railway or other Authorities for temporary access as required to carry out the inspection. Safety plans must be prepared and approved.

2.6.2 Inspection

The Level 1 inspection may be carried out in conjunction with Routine Maintenance activities.

When the inspection is carried out as part of Routine Maintenance activities, the Maintenance Contractor shall attend and rectify items requiring attention within the scope and limitations specified in this procedure for plant, equipment and expertise.

Any major defects identified in the course of this inspection must be photographed and/or sketched and recorded on the **Photographs and Sketches Record (A1/2)**.

At the site, the inspector shall proceed in a systematic manner to check the applicable inspection items listed in Table 2.6.2.

Table 2.6.2 – Level 1 inspection items

Approaches	
Signs/delineation	completeness
	loose/missing fixings
	damage
	cleanliness
	orientation
Guardrail	correct height/alignment
	loose or missing fixings
	impact damage
	material deterioration (steel corrosion, timber decay and so on)
	damaged/missing spacer blocks
	connection to bridge barrier (the approach barrier and bridge barrier should preferably be interconnected; if not, note in ‘Comments’ section of report form)
Road drainage	debris/vegetation growth inside drains, channels, inlet/outlet pits and sumps which may obstruct free drainage
	leaking drainage pits/structures
	scour/erosion at drainage outlets, particularly adjacent to abutments/foundations, culvert outlets and deck run-off
Wearing surface	settlement
	depressions
	pot holes
	cracking
Surface over structure	
Wearing surface	settlement
	depressions
	pot holes
	cracking
Footways (if any)	unevenness/trip hazards

Approaches	
Drainage	accumulations of debris on the deck, in gutters, scuppers and drains which may obstruct free drainage
Bridge barrier	correct height/alignment
	loose or missing fixings
	impact damage
	material deterioration (steel corrosion, timber decay and so on)
	damaged/missing spacer blocks
	delineators for completeness, damage, cleanliness, orientation and visibility to road users
Deck joints	loose/missing fixings
	damaged/missing components
	dirt/detritus build-up in joints which may impede free movement
	leakage
	damage/deterioration of nosings
Embankments and waterways	
Embankments	erosion
	scour
	slope stability
Slope/batter protection	undermining
	settlement
	loss of material
Vegetation	bushes, trees within 2.0 m of abutments and wingwalls
	bushes/trees within waterway channel
	vegetation affecting sight distance onto/across structure
Waterway	accumulation of debris against or adjacent to structure
	localised scour adjacent to/beneath the structure
	lateral bank erosion adjacent to/beneath the structure
	channel degrading
	channel aggrading
	structure in permanent standing water

Approaches	
Substructure	
Abutments, piers, wingwalls, retaining structures and foundations	cracking
	splitting
	distortion
	movement
	steel corrosion
	vegetation growth in joints of coursed masonry/fascia panels
	weepholes for blockages affecting free drainage
	timber members for decay, termite activity, marine borer and other insect attack
Headstocks, bearing pedestals and substructure drains	accumulations of dirt and debris which may obstruct free drainage and cause ponding or restrict bearing movement
Bearings	corrosion
	excessive deflection/bulging
	delamination of elastomeric bearings
	damage to pedestals/plinths
	noticeable build-up of deposits of aggressive salts, silt, debris and bird or bat droppings
Superstructure	
Deck/girders	obvious evidence of spalling, cracking, staining, dampness or corrosion
	excessive movement/vibration under load
	for noticeable build-up of deposits of aggressive salts, silt, debris and bird or bat droppings
	blocked vent holes
	timber members for termite activity, rotting, marine borer and other insect attack
	timber members for excessive member deflections
	timber girders and corbels for excessive sniping
	loose joints and fasteners
	propping for tightness of wedges in deck cambering or temporary works
Culvert barrel	distortion/deflection of barrel
	invert corrosion/abrasion
	obvious evidence of spalling, cracking, staining, dampness or corrosion

Approaches	
Large Traffic Management Signs (LTMS) and gantries	
Footings	obvious evidence of spalling, cracking or reinforcement corrosion
	rotation/settlement
	erosion/undermining
Base plates, fittings and hold-down bolts	cracking, spalling or voids in mortar pad
	debris/fill over base plate
	corrosion of fixings/base plate
	loose/missing fixings and thread engagement
Columns	corrosion, buckling, bending, rupture, rotation or misalignment of sections
	impact damage
	verticality of members
	protective coating loss
	loose/missing fixings and thread engagement
Cantilever arms/gantry beams	corrosion, buckling, bending, rupture, rotation or misalignment of sections
	separation/distortion at joints/splices
	sagging of members
	protective coating loss
	loose/missing fixings and thread engagement
Signage and ancillaries	completeness, damage, cleanliness, orientation and visibility to road users
Miscellaneous	
Roadway beneath structure	delineation
	barriers
	road drainage
Services	location and condition of any services attached to or in close proximity to the structure
Appearance	graffiti

2.7 Structural Inventory data

In almost all cases, the Structural Inventory data held in the BIS will have been populated from the drawings when the structure details were first entered into the BIS and, as such, most or all of the fields will have values.

Prior to the inspection, the inspector shall confirm whether a Structural Inventory Verification form has been completed for the structure.

If not, the inspector shall print out a copy of the **Structural Inventory Verification** form and, while on site:

- where the data fields have been populated in the BIS:
  - compare details on the form with those present on site
  - where the populated data is correct the inspector shall initial the data (in the corresponding 'initial' box) to confirm it has been verified
  - where the populated data is incorrect, the inspector shall cross it out and enter the correct information (obtained from the appropriate reference table) in the corresponding box on the form and initial the data (in the corresponding 'initial' box) to confirm it has been verified.
- where the data fields have not been populated in the BIS:
  - fill in empty data fields with the correct value from the appropriate reference table and initial the data (in the corresponding 'initial' box) to confirm it has been verified. If it is not possible to determine or verify the details, then the box should be left blank. The reason for not being able to determine or verify the details should be recorded.

A copy of the form is included in Appendix A3.

2.8 Data recording

All data obtained from the inspection shall be recorded on the relevant **Level 1 Inspection Report (A1/1)**. These forms have been designed to meet the following objectives.

- assist the inspectors carry out and record an inspection within the scope of and to the extent required for this level of inspection
- record the defects and:
  - where the inspection is being conducted in conjunction with routine maintenance and rectification of the defect is covered by the Road Maintenance Performance Contract (RMPC) and is within the capabilities and resources available on the patrol vehicle, record the associated remedial action, or
  - where the inspection is not being conducted in conjunction with routine maintenance or rectification of the defect is outside the scope of the RMPC or the capabilities and resources available on the patrol vehicle, nominate the required remedial action
- nominate the need for monitoring based on concerns regarding the visually assessed condition of the structure
- nominate the need for a higher level of inspection based on concerns regarding the visually assessed condition of the structure
- allow the inspector to expand on issues arising from the checklist items in the comment boxes.

The work order number should be recorded where appropriate, permitting the allocation and tracking of inspection expenditure to a particular structure. Details of maintenance activities that are carried out, or are scheduled to be carried out on the structure, should be recorded on the **Structural Maintenance Schedule (A4)**. This identifies the type, nature and cost of any maintenance work carried out and the maintenance problem areas in a particular structure.

It is intended that an entire inspection be carried out within the scope and to the extent specified for this level of inspection and that all the required data fields in the **Routine Inspection Report** form are completed. If a partial inspection is effected, then the inspector must record those items that could not be inspected, together with the reasons for their omission.

In addition to the completion of the **Routine Inspection Report** form, the inspector should photograph and/or sketch any major defects and record the relevant details on the **Photographs and Sketches Record (A1/2)**.

Completed inspection reports are to be entered into the BIS within 30 working days of the inspection, including:

- date of inspection
- name of inspector
- deficiencies flagged by inspector and required actions
- programmed date for an extraordinary Level 2 or Level 3 inspection if nominated
- any limits on the extent of the inspection.

In addition, the inspector shall ascertain whether or not a **Structural Inventory Verification** form was completed for the structure. If so, the inspector shall forward the completed form, along with the inspection report, to the District office within 30 working days of the Level 1 inspection.

Completed samples of standard Level 1 inspection forms for a variety of structure types are included in Appendix A.

2.9 Post-flood inspections

Level 1 inspections are required to be carried out on bridges and culverts following major flood events. For the purposes of this Manual, a major flood event is defined as a flood with an average recurrence interval (ARI) of five years.

Notwithstanding, where a structure is known to have low flood immunity and there is a history of scour damage, it should be inspected following any flooding event where it is overtopped.

2.9.1 Inspection procedure

The following procedures have been developed to provide guidance to inspectors for the post-flood inspection of structures. They have been prepared to determine if the integrity of structures has been compromised by flood water, and so mitigate the risk to road users. Given the geographical scale of the state, remoteness of many structures and scarcity of resources, it is acknowledged that it is often impossible to complete these checks prior to structures being trafficked. In this instance, operational staff will conduct the checks at the earliest opportunity and will be in a position to observe the response of the structure under traffic to assist in the deliberation of structural safety. It is expected that priority will be given to those structures that are known to be susceptible to flood damage.

- Review current drawings, site investigation reports and BIS inventory, risk and inspection records. Review of the latest scour sounding report is essential.
  - Identify any documented alignment discontinuities.

  - Identify the foundation arrangement, scour susceptibility, structure sensitivity to scour and the ‘safe’ scour level. Typical ‘safe’ levels should be taken as:
    - no scour under spread footing structures
    - where the stream bed consists of scour-prone material, there should be at least 4 m of scour-prone material remaining above the pile toe
    - plot data on general arrangement drawing and/or site investigation report and determine ‘safe’ sounding benchmark for reference at the site.
- Check member and structure alignment for discontinuities:
  - kerb alignment (vertical, longitudinal, horizontal)
  - girder alignment
  - bearings/corbels in contact with headstocks and girders
  - restraint angles (movement or damage)
  - expansion joints (closed unevenly, shearing or not level)
  - **Any emergent or increased discontinuities MUST be investigated prior to opening the structure to traffic.**
- Check for scour at supports:
  - Sound for scour holes in accordance with Section 3.11 and compare readings with last inspection results.
  - The creeks will typically be in flood and flowing swiftly; thus, progressively heavier weights and cables/chains may be required to determine the soundings. The use of sonar depth finders may also be considered where flows are too great for weighted chains and conditions allow. In the event that accurate soundings cannot be ascertained due to excessive stream velocities or debris mats, then traffic access should be denied in the case of the scour-prone structures described above. Where there is some confidence concerning the scour performance of the structure then the incremental loading procedure described below could be adopted.
  - **Any emerging scour issues around supports MUST be investigated prior to opening the structure to traffic.**
  - Check upstream and downstream for bank erosion and depositions that may compromise the structure through redirection of flows.
  - **Any irregularities MUST be investigated prior to opening the structure to traffic.**
  - Check structure for debris accumulation. Program the removal of debris from the deck immediately, then the removal of remaining debris once the flooding has receded.
  - **Any irregularities MUST be investigated prior to opening the structure to traffic.**

A checklist template developed by a RoadTek inspector is included in Appendix A5 as a useful prompt for inspecting and recording this information.

- Prior to opening the structure to traffic, the inspector should also check behaviour of structure under vehicular loading. Observe the performance of the structure under increasing vehicular loads (car, 10 T vehicle, 20 T vehicle, and so on) for any anomalous behaviour. Typically the test vehicle will be restricted to the centreline travel on the first pass with subsequent passes in each of the lanes. If the bridge behaves unusually under load, it should be closed until investigated by suitably qualified personnel (that is, Structures Directorate engineers). In this event, a detailed load test will required as specified by BCMAM.

- The inspector should also be looking for the following issues:
  - Large debris deposits in areas that may impede traffic or stream flows, or may affect the performance of the structure (that is, wedged between the end faces of girders at expansion piers). Note that debris deposits in non-critical areas should also be removed, as they may tend to exacerbate the effects of subsequent flooding and may represent a fire hazard.
  - Scour or deposition of material which includes scour of batter protection, embankment material and scour of bed material adjacent to foundations, resulting in undermining of footings. Depositions of material can alter stream flow, which can result in scour of embankments or foundations. Refer to Appendix D for guidance on allowable scour depths for various components.
  - Uplift and movement of superstructure during flood, normally indicated by differential movement in deck elements over piers (that is, kerbs and or deck surface will be noticeably out of alignment at deck joints).
  - Subsidence of foundations which may be a result of scour or loss of bearing capacity of the substrate material. This is indicated by downwards deflection of the deck/kerbs over the deck joint.
  - Debris impact damage to structural elements (for example, girders, piles) which is most likely present in elements on the upstream side of the structure. Extent of the damage can range from mild abrasion and scratching of components to severe structural damage (cracked or spalled/missing concrete, reinforcement deformed or severed, components knocked out of alignment).

2.9.2 Data recording

Where an accredited inspector is undertaking the inspections, they should be completed as a full Level 1 inspection. In addition, a copy of the **Scour Soundings Report (A2/7)** from the previous Level 2 inspection should be obtained and soundings taken. If there is little or no change in the sounding levels from the previous Level 2 inspection (that is, no increase beyond CS 2, or no change in existing CS 3 and 4 readings in accordance with the criteria shown on the form), then the **A2/7** form should be completed, scanned as an image/PDF file and stored in the Photo/Sketches section of the Level 1 report in the BIS. If the inspector has used the inspection checklist template (Appendix A5) then this can also be scanned and saved to the Photo/Sketches section in the same way.

If significant change is observed in the sounding levels, a full Level 2 inspection should be scheduled immediately and a new set of soundings taken during the course of the Level 2 inspection and recorded as per normal.

Where the inspection is undertaken by non-accredited personnel, they should use the template form provided in Appendix A5. Upon completion of the inspection, the details should be forwarded to suitably qualified personnel for review (that is, an accredited Level 2 bridge inspector or engineer) prior to the opening of the structure to traffic. A copy of the completed form should be saved to the Picture section of the Structure Inventory for the structure.

2.10 Post-earthquake inspections

Level 1 inspections are required to be carried out on bridges and culverts following an earthquake.

2.10.1 Inspection procedure

The same general procedures as routinely undertaken following a flood event (refer Section 2.9) should be undertaken following an earthquake. The difficulty associated with post-earthquake response is choosing structures to be inspected for a given magnitude and location.

Following an earthquake, BCMAM will provide guidance to affected Districts of the areas within which structures should be inspected based on primary and secondary influence zones (refer Table 2.10.1) and the following principles:

- Any structure which is located in an area which shows evidence of earthquake damage must be inspected. Generally such evidence will not be visible except for large earthquakes.
- All structures, irrespective of condition state, located within the primary influence zone must be inspected.
- Any structure in condition state 3 or worse, located within the secondary influence zone, must be inspected.

Table 2.10.1 – Critical distances from earthquake hypocentre for various magnitude earthquakes

Earthquake magnitude (Richter scale)	Primary influence zone limiting radius (r_1)	Secondary influence zone limiting radius (r_2)
5.0	4 km	5 km
5.5	10 km	15 km
6.0	13 km	25 km
6.3	30 km	70 km
6.5	36 km	90 km
7.0	46 km	125 km
7.5	123 km	500 km
8.0	158 km	700 km
8.5	185 km	900 km
9.0	500 km	3500 km

2.10.2 Data recording

Where an accredited inspector is undertaking the inspections, they should be completed as a full Level 1 inspection.

Where the inspection is undertaken by non-accredited personnel, the details should be forwarded to suitably qualified personnel for review (that is, an accredited Level 2 bridge inspector or engineer) as soon as practicable. A copy of the completed form should be saved to the Picture section of the Structure Inventory for the structure.

2.11 Post-tsunami inspections

A tsunami event shall be treated in the same manner as a normal flood event (refer Section 2.9).

The checklist template developed for post-flood inspections (included in Appendix A5) should be used to record post-tsunami inspections.

3 Level 2 – Condition Rating Inspection

3.1 Purpose

The purpose of this level of inspection is to rate the current condition of a structure.

This data will be used as a basis for:

- identifying and quantifying structural defects in the structure or its individual components
- identifying and prioritising maintenance needs and/or other actions
- estimating forward budget requirements arising from the maintenance, rehabilitation or replacement needs determined from the condition inspection
- determining the residual life of the structure and appropriate replacement strategy
- re-rating the structure and components after significant maintenance or remedial works have been carried out
- assessing the effectiveness of historic and current maintenance/refurbishment strategies
- assessing the current load carrying capacity
- monitoring the overall condition of the network.

In addition to these, the condition data may also be used as a basis for modelling and forecasting future changes in condition and residual life.

3.2 Scope

The scope of the Level 2 inspection will include:

- Compiling the component inventory (for new structures) and verifying the inventory for refurbished and existing structures. In compiling/verifying the component inventory, the component matrix shown in Appendix B should be referred to. The matrix lists the codes to be used to identify structure components. It also shows the relationship between component groups and components.
- Identifying the exposure classification in the immediate proximity of each component.
- Visually inspecting components to assess their condition using the standard condition rating system outlined in Section 3.8 and Appendix D.
- Reporting the condition of each component and the extent over which that condition applies.
- Rating the overall condition of the structure.
- Identifying structures and/or components which warrant a Level 3 inspection due to a rapid change in condition or deterioration of critical structural components to Condition Rating 4.

- Identifying components which require closer condition monitoring and observation at the next Level 2 inspection because they have deteriorated to Condition Rating 3, show rapid deterioration or demonstrate other features which warrant reporting.
- Capturing a photographic record of the structure and any deficient or non-standard components identified
- Identifying maintenance requirements and/or deficient maintenance practices.
- Identifying supplementary testing as appropriate in accordance with the guidelines of this Manual.
- Verification of the 'Design Inventory' held in the BIS. Prior to the inspection, the inspector shall confirm whether a *Design Inventory Verification form* from BIS has been completed for the structure. If not, the inspector shall forward a completed form, along with the inspection report, to the District office within 30 working days of the Level 2 inspection.
- As Level 2 inspections may require the use of specialist access (for example, Under Bridge Inspection Unit (UBIU), scissor or boom lifts), it is also recommended that, on such occasions, District personnel take advantage of the availability of such equipment and conduct routine maintenance on those components not normally accessible, such as bearings.

3.3 Extent of inspection

3.3.1 General

The Level 2 inspection typically comprises a visual inspection, within 3 m or equivalent (using telescopic equipment), of all components above ground and water level.

The surface of components to be inspected shall be in good natural or artificial light sufficient to observe fine cracks in concrete.

Where present, all bearings at abutments and piers shall be inspected, and bearings from at least one pier shall be inspected at eye level.

3.3.2 Specialist access

As stated in Section 3.3.1, the Level 2 inspection typically comprises a visual inspection to within 3 m or equivalent of all components above ground and water level.

There may be instances where specialist access, in the form of UBIU, scissor or boom lifts, scaffolding and so on, is required in order to access hard-to-reach components to facilitate hands-on inspection. Where specialist access is considered necessary, justification should be forwarded to BCMAM for approval. Structures requiring specialist access are to be agreed between BCMAM and the inspecting authority.

Furthermore, BCMAM is undertaking a desktop review of all structures where specialist access is currently used to confirm each is an effective use of resources.

3.3.3 Additional requirements

In addition to these, the following additional requirements may exist for certain structures:

- Timber bridges: all timber road bridges are subject to a drilling survey (refer Section 3.10).
- Corrugated metal culverts/steel trough decks: ultrasonic testing of steel culvert barrels and steel trough decking on timber girders may be required (refer Section 3.12).

- ACM identification inspection: this is a one-off inspection undertaken on structures with the potential for ACM, as identified in the departmental Bridge Asbestos Register, to visually confirm the presence of potential ACM (refer Section 4.4).
- Underwater inspection: structures designated as requiring underwater inspection shall be inspected at the frequency and to the extent prescribed by the required Level 3 inspection (refer Section 4.5).
- Fracture critical/lack of redundancy: structures meeting the criteria for fracture critical/lack of redundancy shall be inspected at the frequency and to the extent prescribed by the required Level 3 inspection (refer Section 4.6).
- Sub-standard load rating: structures noted as having a sub-standard load rating shall be inspected at the frequency and to the extent prescribed by the required Level 3 inspection (refer Section 4.7).
- Complex/unique structures: structures meeting the criteria for complex/unique structures shall be inspected at the frequency and to the extent prescribed by the required Level 3 inspection (refer Section 4.8).
- Known/suspected deficiencies: structures/structure families with known or suspected deficiencies shall be inspected at the frequency and to the extent prescribed by the required Level 3 inspection (refer Section 4.9).
- Confined spaces inspection: structures (or constituent components) that constitute a confined space hazard such as the interior of box girders (see Section 4.10).

3.3.4 Exclusions

Components that need not be inspected for Level 2 inspections, except as prescribed by Level 3 inspection are:

- interiors of box girders, closed box sections on steel trusses and any other structure/component that constitutes a confined space (see Section 3.3.3)
- areas behind abutments that are inaccessible
- piles and foundations below ground or water level.

These components will be inspected as part of Level 3 inspections where required.

3.3.5 Photography

The Level 2 inspection includes a photographic record of each structure in order to:

- maintain a chronological photographic record of the original structure, any modifications and the waterway
- maintain a chronological record of the structure condition
- provide up-to-date structure images for the Structure Information System.

Level 2 inspection photographic requirements are:

- Inventory record:
  - one general photograph from top of deck showing alignment, width, kerbs and barriers
  - one elevation of structure showing piers, abutments, waterway, cells, headwalls and so on

  - representative photographs of the main superstructure components (for example, girders), from underneath or side of the structure, used in:
    - the original structure
    - any modifications (widening, lengthening, and so on)
  - photograph of any components that do not fall within the defined component classification
- Component condition:
  - all components with a recorded condition rating of 3 or 4 (where a photograph will illustrate the defect)
  - where the same defect occurs more than once and ongoing monitoring is not required, a typical view of the defect may be sufficient
  - close-up photographs of defects should include the component number/location marked on the component in chalk/crayon to allow future identification
  - where a photograph does not provide sufficient detail of a defect, a detailed sketch should be produced which shows the defect and all relevant dimensions.

All photographs must:

- include a digital time stamp
- be taken in natural light (unless defect is in shadow/dark area)
- be composed such that the subject is central and occupies the whole frame
- photographs of defects and non-conforming components must be taken within 3 m of the surface of the component or equivalent using a telephoto lens.
- Inspection frequency

3.3.6 Initial inspection of new and refurbished structures

All new structures and existing structures subject to major maintenance, strengthening or modification (widening, lengthening and so on) shall be subject to:

- Level 2 inspection prior to handover of structure
- Level 2 inspection four months prior to the end of defects liability period.

This is so the Principal Contractor can rectify any defects resulting from construction/maintenance prior to Transport and Main Roads taking responsibility for ongoing maintenance of the structure.

3.3.7 Existing structures

All existing structures shall be subject to Level 2 inspection at the frequencies specified in Table 3.4.2.

Table 3.4.2 – Level 2 inspection frequencies

Structure type	Overall condition state of structure	Inspection frequency (years)
Timber structures and steel culverts (in permanent standing water)	1 – 2	2
	3	1[1]
	4	1[1,2]

Structure type	Overall condition state of structure	Inspection frequency (years)
Bridges and culverts[3]	1 – 2	5
	3	3
	4	1[1,2]
Ultrasonic testing of steel/aluminium culverts without a structural reinforced concrete invert[4]	1 – 2	Not required
	3	Every 2nd Level 2
	4	Every Level 2
Ultrasonic testing of steel trough decks on timber girders[4]	1 – 2	Not required
	3	Every 3rd Level 2
	4	Every Level 2
Tunnels	1 – 2	5
	3	3
	4	1[1,2]
Busway bridges, including elevated and underground stations and pedestrian overbridges at busway stations	1 – 2	5
	3	3
	4	1[1,2]
Other bridges over the road network	1 – 2	5
	3	3
	4	1[1,2]
Retaining structures above/below the road network (excludes retaining structures inspected as part of any other structure)	1 – 2[5]	5
	3	3
	4	1[1,2]
Underwater components (all components other than steel culverts) permanently submerged	1 – 2[5]	8
	3[5]	1
	4[5]	1[1,2]
Confined spaces inspection (all components representing confined space hazards (for example, interior of box culverts))	1–2[6]	8
	3[6]	1
	4[6]	1[1,2]
Large Traffic Management Signs (LTMS) and gantries	1 – 2	2
	3	1[1]
	4	1[1,2]

[1] Level 1 and level 2 inspections to be staggered by six months to ensure inspections occur every six months.

[2] Or at frequency specified by *Structure Maintenance Manual*/Structures Management Plan (whichever is greater).

[3] Includes critical 'minor' culverts.

[4] These conditions only apply where the overall condition state of the structure is attributable to corrosion of the metal barrel / steel trough.

[5] These conditions only apply where the overall condition state of the structure is attributable to the condition of the underwater components.

[6] These conditions only apply where the overall condition state of the structure is attributable to the condition of the components requiring confined space inspection.

Stated inspection frequencies are the nominal time from last inspection subject to a tolerance of two months either way.

3.4 Inspector accreditation

Inspections shall be conducted by trained personnel who also have extensive experience in the inspection, construction, design, maintenance or repair of road structures.

They shall have extensive practical experience and be competent to judge the condition of structures and the importance of visual defects. These inspectors need not be qualified professional bridge engineers, but should have the backing of such a person to aid in decision making or interpreting visual defects or unusual structural action.

Inspectors must attain accreditation through attending a Level 2 training course for bridge inspectors although partial exemption may be granted to suitably experienced inspectors. In addition, it is a requirement that each inspector must undertake a number of inspections and submit these to BCMAM to enable a desktop review to be carried out. The number of inspections required to be submitted is dependent on the structure and material type, details of which are provided in Appendix E. In most cases as part of the assessment process, this will then be backed up by a field audit, in the form of a Level 3 inspection, to ensure compliance with the *Structures Inspection Manual* reporting requirements.

The inspector accreditation appraisal procedure and appraisal forms are included in Appendix E.

3.5 Inspection procedure

3.5.1 Preparation for inspection

Prior to commencing inspections, the inspector shall ensure that all relevant documentation, inspection equipment and safety equipment is in place along with the appropriate arrangements with the relevant road, railway or other Authorities for temporary access as required to carry out the inspection. Safety plans must be prepared and approved.

3.5.2 Data recording

All information obtained from the site inspection shall be recorded on the following forms:

- Condition Inspection Report (A2/1 and A2/2)
- Defective Components Report (A2/3)
- Standard Procedure Exceptions Report (A2/4)
- Timber Drilling Survey Report (A2/5)
- Photographs and Sketches Record (A2/6)
- Scour Soundings Report (A2/7)
- Design Inventory Verification forms from BIS (if required)
- Structural Maintenance Schedule (A4) (if required).

It is intended that each inspection should be carried out to the extent specified for this level of inspection and all relevant data fields in these forms should be completed.

3.5.3 Inspection

At each site, the inspector shall carry out the inspection in a systematic manner starting at carriageway level, proceeding from 'Approach 1' end of the structure down through the superstructure and substructure to the waterway as appropriate.

Approach 1 is defined as the first approach encountered when travelling in the increasing chainage direction.

The inspector shall complete the following activities in accordance with this procedure and the guidelines given in:

Appendix B: Standard Component Schedule

Appendix C: Standard Component Identification Guidelines

Appendix D: Standard Component Condition State Guidelines.

The results of inspection shall be recorded on the appropriate Inspection Report forms from Appendix A.

- Compile (new structures) or verify (for refurbished and existing structures) the inspection component inventory, with attendant exposure classifications, by designated group, component and unique reference number on the **Condition Inspection Report (A2/1 and A2/2)** form.
- Inspect and rate the condition state of each standard component identified and the extent of the component over which the rating applies.
- Assess the overall condition of the bridge and any modification in accordance with Section 3.8.3.3.
- Record separately on the **Defective Components Report (A2/3)** all those components that:
  - require monitoring or further observation at the next programmed inspection, urgent remedial action or a Level 3 inspection
  - are in condition state 4 or have shown a rapid rate of deterioration since the last inspection and require urgent remedial action and/or a Level 3 inspection.
- The inspector is required to give a brief description of the condition and the approximate quantity of the component affected. A photographic and/or sketch record is also required as outlined in Section 3.3.5.
- Record separately on the **Standard Procedure Exceptions Report (A2/4)** form:
  - Components that could not be defined using the standard methodology. A photograph of the non-standard components is also required as outlined in Section 3.3.5.
  - Components that could not be inspected. Reasons must be stated for these omissions.
  - Components where less than 25% is accessible. The exposed portion must still be rated on the **Condition Inspection Report (A2/1 and A2/2)** form.
  - Components which have been made obsolete but remain in place, such as timber girders/corbels that have been replaced by adjacent members. These components shall only be recorded on **Standard Procedure Exceptions Report (A2/4)** form. Any comments relating to the condition of the obsolete component shall be made in the

comments section of this form. Where the inspector believes the condition of the obsolete component presents a risk to the structure or the public this shall be noted in the 'comments' section of this form and the 'overall inspection comments' field of the **Condition Inspection Report (A2/1)** form. Where the inspector is uncertain if the components are obsolete, guidance shall be sought from BCMAM.

  – Sacrificial components (that is, components used to provide support during construction of primary-load carrying components which do not contribute to the load carrying capacity of that component) such as existing sub-standard or defective concrete slab or steel troughing used as permanent formwork when casting a new deck slab. These components shall only be recorded on **Standard Procedure Exceptions Report (A2/4)** form. Where the primary component is obscured by the sacrificial component, the primary component shall be called up as an exception in the **Condition Inspection Report (A2/1)** form. Both the primary and sacrificial component shall be recorded on the **Standard Procedure Exceptions Report (A2/4)** form. Any comments relating to the condition of the sacrificial component shall be made here. Where the inspector believes the condition of the sacrificial component presents a risk to the structure or the public this shall be noted in the comments section of **Standard Procedure Exceptions Report (A2/4)** form and the 'overall inspection comments' field of the **Condition Inspection Report (A2/1)** form. Where the inspector is uncertain if the components are sacrificial, guidance shall be sought from BCMAM.
  – Any other observation or recommendation not covered by the other forms.

- Record the relevant photographic and sketch details, including reference numbers, locations and descriptions on the **Photographs and Sketches Record (A2/6)** in accordance with the guidelines given in Section 3.3.5.
- Record the results of the timber drilling survey on the **Timber Drilling Survey Report (A2/5)** form where appropriate.
- Record the results of any stream bed profile measurements on the **Scour Soundings Report (A2/7)** form.
- Record the results of any additional inspection requirements (for example, underwater inspection, ACM identification and so on) on the relevant forms.

Completed samples of all standard Level 2 inspection forms for a variety of structure types are included in Appendix A.

3.6 Data transfer

Relevant inspection data shall be entered in the BIS within 30 working days of the inspection. This shall include all photographic records and general descriptive information recorded on the relevant inspection forms, any recommended actions including component inventory amendments, the need for a Level 3 inspection or maintenance action. Photographs shall be saved in JPG file format, and shall be no bigger than one Mb.

Any structurally significant component recorded on the **Defective Components Report (A2/3)** form must be flagged in the BIS as a deficiency, and must remain as such until it has been inspected by a structural engineer and/or rectified.

In addition, the inspector shall ascertain whether or not a **Design Inventory Verification** form from BIS has been completed for the structure. If not, the inspector shall forward a completed form, along with the inspection, to the District office within 30 working days of the inspection.

3.7 Condition rating

3.7.1 General

A fundamental requirement of a systematic inspection procedure, that produces consistent results, is the standardisation and rationalisation of the following variables:

- components that comprise the structure (refer Section 3.8.2)
- condition state descriptions, or level of deterioration pertaining to those components (refer Section 3.8.3)
- classification of the degree of aggressiveness of the environment affecting the rate of deterioration of the component (refer Section 3.8.4).

3.7.2 Compilation of the component inventory

Components and their location shall be designated by:

- modification
- group
- component
- standard component reference

in accordance with the following principles.

3.7.2.1 Modification

Modification refers to the modification status of the structure and is used to associate components with any major modifications undertaken to a structure during its life. Modifications are summarised in Table 3.8.2.1.

Inspection of components that are part of identified widenings are to be assessed and recorded separately to those of the original structure and designated as left or right as viewed from the Approach 1 end of the structure.

Components which are part of other identified modification types are to be assessed and recorded with the original structure, but are to be located with the correct modification classification.

Table 3.8.2.1 – Modification status

Status	Description
O	Original structure
WL_n	Widening to left hand side (when viewed from Approach 1) of structure ‘n’ denotes number of widening; for example, WL_2 would be the second of two widenings on the left hand side of the original structure
WR_n	Widening to right hand side of structure

Status	Description
L_1	Lengthening of structure at Approach 1 end Note that any abutments which are modified in the course of a lengthening will thereafter be included in the lengthening modification and removed from the original component listing
L_2	Lengthening of structure at Approach 2 end.
S_1	Shortening of structure at Approach 1 end Only components modified by the works shall be assigned the 'S' prefix Groups and components removed as part of the works shall be deleted from the inspection inventory
S_2	Shortening of structure at Approach 2 end Only components modified by the works shall be assigned the 'S' prefix Groups and components removed as part of the works shall be deleted from the inspection inventory
Re	Re-decking, referring to a change in decking system as opposed to replacement of existing deck components
Ra	Raising Only components modified by the works shall be assigned the 'Ra' prefix
St	Strengthening (that is, works undertaken to increase the structural capacity of the structure beyond its original design class) Only components added or modified as part of the works shall be assigned the 'St' prefix

Figure B1 and B2 in Appendix B illustrate the concept of modifications.

3.7.2.2 Groups

Principal groups of components comprising approaches (AP), abutments (A), piers (P), spans or culvert cells (S) shall be progressively numbered in the increasing chainage direction of the road.

3.7.2.3 Components

Components as described in Appendix B shall be progressively numbered from left to right as viewed in the increasing chainage direction of the road.

The Component Schedule contained in Appendix B includes a complete listing of standard components along with their corresponding component abbreviations, significance rating, standard reference numbers and units of measurement.

The Standard Component Matrix included in Appendix B shows the association between standard components and groups.

The standard component reference, as defined in Appendix B, must be assigned to the **Condition Inspection Report (A2/1 and A2/2)** form. Standard abbreviations may be used when describing component defects. Where a component observed during the inspection does not conform to one of the predefined components, its details shall be recorded on the **Standard Procedure Exceptions Report (A2/4)** form, the component photographed and the details forwarded to BCMAM for advice.

A series of figures representing the majority of structures likely to be encountered is included in Appendix C to assist with the identification of standard components.

The inspection components are further divided into five material types comprising ‘steel’ (S), ‘precast concrete’ (P), ‘cast insitu concrete’ (C), ‘timber’ (T) and ‘other’ (O). The steel grouping includes aluminium, cast and wrought iron members while the latter comprises brickwork, masonry and any other material not listed.

Precast concrete members can generally be distinguished from cast insitu concrete by the smooth, uniform and dense surface and are typically whiter in colour.

Additionally, when compiling the component inventory for a bridge structure, roadway items such as surfacing, kerbs, joints and bridge railing are typically defined per span. With a culvert structure, this approach is unfeasible due to the significantly shorter span lengths and lack of definitive joints in the deck. For this reason, these components shall be defined per culvert structure and recorded under the Span 1 group, with the corresponding quantities taken from the full length of the structure. Approach items such as guardrail are not affected by this, and are still to be defined separately for both approaches.

In some instances, inspectors may encounter a structure with a configuration that does not fit within the terminology described. Guidance on the designation of groups and components for complex or non-standard structures has been provided in Appendix G, but it is generally recommended that BCMAM be contacted to provide advice on component breakdown of the structure and other related issues.

3.7.3 Condition state criteria

The inspector shall make an assessment of the condition state of:

- each standard component
- the structure as a whole
- any modification.

The condition states have been developed to reflect the discernible stages of deterioration as shown in Table 3.8.3.

Table 3.8.3 – Condition state descriptions

Condition state	Subjective rating	Description
1	GOOD (‘as new’)	Free of defects with little or no deterioration evident
2	FAIR	Free of defects affecting structural performance, integrity and durability Deterioration of a minor nature in the protective coating and/or parent material is evident
3	POOR	Defects affecting the durability/serviceability which may require monitoring and/or remedial action or inspection by a structural engineer Component or element shows marked and advancing deterioration including loss of protective coating and minor loss of section from the parent material is evident Intervention is normally required

Condition state	Subjective rating	Description
4	VERY POOR	Defects affecting the performance and structural integrity which require immediate intervention including an inspection by a structural engineer, if principal components are affected Component or element shows advanced deterioration, loss of section from the parent material, signs of overstressing or evidence that it is acting differently to its intended design mode or function
5	UNSAFE	This state is only intended to apply to the **overall structure rating** Structural integrity is severely compromised and the structure **must** be taken out of service until a structural engineer has inspected the structure and recommended the required remedial action

3.7.3.1 Component condition assessment

The inspector shall make an assessment of the condition of each standard component and the extent over which that condition applies.

In doing so, the inspector shall compare the defects observed in each component with the guidance provided in Appendix D of this Manual for each standard component. These descriptions cannot possibly cover every situation and the inspector is expected to exercise judgement based on his or her knowledge and experience and the guidelines given in Table 3.8.3 to identify the appropriate condition state(s) applicable to each component inspected.

Establishing the mechanism responsible for cracking in concrete elements is crucial to determining the severity of the defect and the corresponding condition of the element. Cracks due to structural and non-structural mechanisms have been differentiated accordingly in Appendix D. If the inspector is unable to determine the mechanism responsible or is not completely confident, then the inspector is to assume the most severe case.

Further guidance on defect identification and causes of deterioration are provided in Part 2 of this Manual.

3.7.3.2 Measurement

The proportion of the component in each condition state shall be determined on the basis of the total visible portion of that component; that is, the portions in each condition state (1, 2, 3 and 4) must add up to the total quantity of that component observed on site. Where there is a single component to be rated (with unit of measurement each), with varying condition state over sections of the component, an estimation can be made of a portion/percentage of area of the component in different condition states. The total value in the ‘quantity field’ must still add up to one.

Each element to be assessed is quantified using one of the following units of measurement:

- number of units making up the element – Each (ea.)
- length of element – Lineal metres (Lin m)
- area of element – Square metres (m2).

The unit of measurement to be used for each of the standard components and associated materials is indicated in Table B-1 of Appendix B.

The percentage of component in each condition state shall be based on the total component that can be observed. Where it is estimated that only 25% or less of the component is visible this fact shall be recorded on the **Standard Procedure Exceptions Report (A2/4)** form, stating the reason why it cannot be fully observed. Such items shall still be assigned a condition state, which shall be based on the visible portion of the component.

In assessing the relative proportions of the component in the various condition states, the inspector should first determine the worst condition affecting the component and its extent then progress through to the best condition pertaining to that component.

A brief description of the defective components shall be recorded in the ‘comments’ field of the **Condition Inspection Report (A2/1 and A2/2)** form. In addition, the inspector should also indicate the urgency of any required action.

Significant defects found in non-critical structural members which expose the road user to risk and require urgent attention should be noted in the ‘comments’ field; for example, defective guardrail and connections to the bridge, damaged or defective bridge railing or loose and insecure assembly joints.

Any component which is found to have defects that could compromise the strength or stability of the component, or the structure as a whole, must be rated as condition 4 over the whole of the component. In this event, the defective component must be recorded in the BIS. Immediate remedial action shall be undertaken for this level of defect in all structures.

Typical defects of this nature include:

- fresh scour holes in excess of 4 m deep at piled foundations or any scour below base of spread footing foundations
- flexural cracks in excess of 0.6 mm wide in concrete members
- impact damage to concrete girders which has resulted in exposed reinforcement or prestressing strands
- visible settlement or rotation of substructure elements
- displaced bearings
- pipe rot in timber girders exceeding 70% of the diameter at midspan and/or 50% of the diameter at the supports
- pipe rot exceeding 50% of the diameter of timber piles or corbels
- edge areas of rot in excess of 20% of the cross-sectional area of timber headstocks, or piping rot with a diameter in excess of 90 mm
- snipes in timber girders with a depth exceeding 30% of the diameter of the girder, or snipes in a timber corbel with a depth exceeding 25% of the diameter of the corbel
- 10% loss of section due to corrosion in steel members, fasteners, reinforcement or prestressing tendons at critical sections
- cracking in welds between plates or loss of rivets or bolts (or their effectiveness) in steel connections.

If further advice is required, either a Level 3 inspection shall be commissioned, or sufficient information shall be sent to BCMAM to enable its personnel to conduct a desk-top assessment of the component or structure.

Information to be supplied includes:

- width, extent and location of cracks; for example, ‘CW 0.3/L0.3/G1 midspan soffit’ denotes a 0.3 mm wide crack, 0.3 m long in the soffit of girder 1 at midspan. Where a number of cracks are present in a single element, this information is best shown in a detailed sketch.
- the area, depth and location of any spalling or loss of concrete cover
- the length and condition of any exposed reinforcement
- residual dimensions of corroded or spalled sections
- lack of connection of guardrail to bridge
- presence of and rate of change of scour depths
- excessive shear deflection or travel on expansion bearings
- magnitude of the forward movement of the top of retaining walls/abutments
- depth of subsidence behind abutments/on approaches
- reference of sketches and/or photographs which detail the magnitude, extent and location of defects.

3.7.3.3 Structure condition assessment

When the inspection of the components has been completed, the inspector shall assess the overall condition of the structure based on observations made at the site in accordance with the condition rating descriptions in Table 3.8.3 and record their assessment(s) on the **Condition Inspection Report (A2/1)** form.

The structure rating shall primarily be based on the condition of the principal structural components such as girders, headstocks, columns, piles and foundations. Principal structural components are those components with a Significance Rating (SR) of 4 specified in Table B-1 of Appendix B.

Except as described in the following, the inspector is expected to exercise judgement, based on his or her knowledge and experience, to determine the appropriate condition state:

- If more than 25% of any principal structural component (Significance Rating 4) in any component group are rated as being in CS 3, then the structure must be given an overall rating of **at least** CS 3. The presence of more serious defects may result in a worse overall rating.
- If more than 25% of any principal structural component (Significance Rating 4) in any component group are rated as being in CS 4, then the structure must be given an overall rating of **at least** CS 4.

Separate ratings for the original structure and any other modifications, comprising widening, lengthening or raising, are required as the construction types and respective conditions are often substantially different.

Where a structure is rated in CS 3 or worse, a summary of the key defects contributing to the assessment should be included in the overall rating comments field on the **Condition Inspection**

Report (A2/1) form. Significant defects found in non-critical structural members which expose the road user and/or general public to risk and require urgent attention should also be noted in the 'comments' field; for example, defective guardrail and connections to the bridge, damaged or defective bridge railing or loose and insecure assembly joints.

Should an inspector consider that CS 5 is the appropriate overall rating of a structure, the inspector **must**, on completion (or partial completion if warranted) of the field work, contact a Senior Inspector at RoadTek Structures Management Services (SMS) to discuss the findings of the inspection. If consensus cannot be reached on the overall condition rating then further advice must be sought from BCMAM. Until such time as SMS has been consulted, and an overall condition rating agreed, the inspection data shall not be finalised in the BIS (that is, marked as 'completed').

3.7.4 Exposure classifications

The exposure classification is a measure of the degree of aggressiveness of the local environment in which the component is situated. If the actual exposure classification is known, as opposed to that assumed in the design, it will assist in assessing the rate of deterioration and/or the residual life of the component or, indeed, the structure.

At the design stage, broad exposure classifications are considered in order to determine and specify the type and quality of materials, protective coating system requirements or amount of cover to the reinforcement and prestressing strands; however, if the quality or integrity of the materials or their protective coatings or cover are compromised, then vulnerable components will become exposed to the local environment. The aggressiveness of that environment will affect the rate of deterioration and, hence, influence the time for repair, rehabilitation or replacement of the component or the structure.

Four exposure classifications approximating those specified for concrete in the Austroads *Bridge Design Code* have been adopted as shown in Table 3.8.4.

Table 3.8.4 – Exposure classification

Exposure classification		Location
Rating	**Environment**	
1	Relatively Benign	Interior of most structures Components above ground on structures located more than 50 km from the coast
2	Mildly Aggressive	Components above ground in structures located between 1 km and 50 km from the coast Components in contact with fresh water or non-aggressive soil[1]
3	Aggressive	Components above ground within 1 km of the coast **not subjected** to direct salt spray Components in very damp environments such as the wet tropics or rainforest areas Any components within 3 m of **permanent** standing water
4	Most Aggressive	Components in tidal or splash zones or those subject to direct salt spray Components in contact with aggressive, contaminated or salt rich soils[1]

[1]The assessment of the aggressiveness of the soil cannot be done accurately without testing but generally can be assumed to be mildly aggressive unless in salt-prone areas, marshes, mangroves, foul smelling soils, landfills or industrial areas. Removal of material around the structure may reveal deterioration indicative of aggressive soils.

3.8 Design inventory data

In almost all cases, the Design Inventory data held in the BIS will have been populated from the drawings when the structure details were first entered into the BIS and, as such, most or all of the fields will have values.

Prior to the inspection, the inspector shall confirm whether the Design Inventory data have been populated and, if so, whether a **Design Inventory Verification** form from BIS has been completed for the structure.

Where the data fields have not been populated in the BIS, the inspector shall notify the relevant regional/District personnel that the data have not been populated in the BIS so that the data can be entered from the drawings prior to the next scheduled Level 2 inspection.

If the data are present but have not been verified, the inspector shall print out a copy of the **Design Inventory Verification** form from BIS and, while on site:

- Compare details on the form with those present on site.
- Where the populated data are correct the inspector shall initial the data (in the corresponding 'initial' box) to confirm data have been verified.
- Where the populated data are incorrect, the inspector shall cross data out and enter the correct information (obtained from the appropriate reference table) in the corresponding box on the form and initial the data (in the corresponding 'initial' box) to confirm data have been verified. If it is not possible to determine or verify the details then the box should be left blank. The reason for not being able to determine or verify the details should be recorded.

A copy of the form is included in Appendix A3.

3.9 Timber drilling survey

Hardwood principal components are subject to additional inspection requirements beyond the scope of a typical Level 2 inspection, the findings of which are recorded on the **Timber Drilling Survey Report (A2/5)** form.

3.9.1 Timber drilling

The purpose of the timber drilling survey is to determine the residual amount of sound timber in a member, normally ascertained by using a drill equipped with a 12 mm diameter bit to bore holes in timber components at critical and suspect locations. The extent and severity of any piping or rot within the component is initially assessed by gauging the resistance to drilling, supplemented by examination of wood shavings. This method relies on the experience and subjective judgement of the inspector and provides information only at the selected drill location.

Test hole locations are probed at subsequent inspections to determine if further deterioration has occurred.

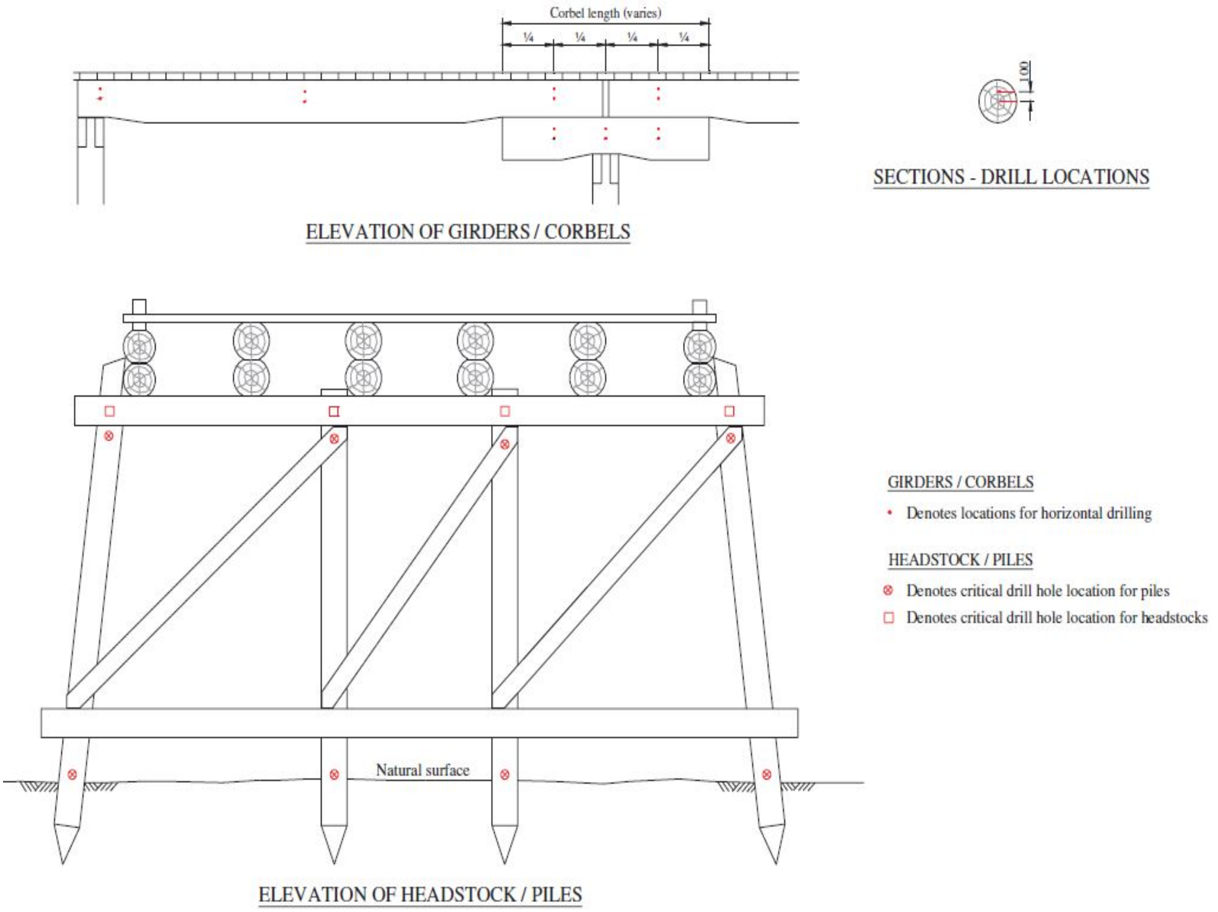
Drilling is carried out at the locations of maximum stress and/or for those areas most susceptible to decay, namely:

- midspan and ends of girders
- ends of corbels
- ends of headstocks

- base and top of end posts
- ground level, normal water level or around connections in piles
- in the upper portion of outer girders beneath the spiking plank
- around bolted connections in general.

Figure 3.10.1 illustrates these critical locations.

Figure 3.10.1 – Timber drilling locations



The following guidelines are provided for the drilling tests:

- At the initial inspection the drilling test holes should be made at the locations illustrated in Figure 3.10.1 and the relevant data recorded on the Timber Drilling Survey Report (A2/5) form.

Note: new timber elements must be drilled at the prescribed locations prior to installation or at the mandatory post-installation inspection.

- All test holes are to be plugged with an approved PVC, coloured plug as follows:
  - assessed condition state CS 1 / CS 2 – blue plug
  - assessed condition state CS 3 / CS 4 – red plug
  - black/yellow plug – not a test hole. Signifies application of pest treatment.

- Care should be taken to avoid drilling completely through members and horizontal drill holes should be inclined slightly upwards to allow drainage.
- Drill holes should be perpendicular to the face of the member so that recorded deterioration is relative to section size.
- Two horizontal test holes are required to be made through the cross-section of girders and corbels (as illustrated in Figure 3.10.1) to detect deterioration in the centre of the member as well as V-shaped deterioration in the top of the member. Note that the component diameter measured is to be the ‘width’ of the component in the direction of drilling at the point of drilling.
- Additional drill holes are required to be made and probed once the ‘% consumed’ calculation at a mandatory drilling location determines the member to be CS 4. The additional drill surveys shall be carried out at 500 mm intervals along the member until the ‘% consumed’ calculation at a mandatory drilling location determines the member to be CS 2. Table 3.10.1 provides guidance on additional drilling requirements for a girder scenario.

Table 3.10.1 – Additional drilling requirements

Drill results @ standard location			Additional drilling requirements
End 1 (E1)	Midspan (MS)	End 2 (E2)	
Pipe / rot (CS 4)	OK (that is, < CS 4)	OK (that is, < CS 4)	500 mm centres from E1 until CS 2 conditions detected
Pipe / rot (CS 4)	OK (that is, < CS 4)	Pipe / rot (CS 4)	500 mm centres from E1 and E2 until CS 2 conditions detected
Pipe / rot (CS 4)	Pipe / rot (CS 4)	Pipe / rot (CS 4)	At ¼ points of the component
Pipe / rot (CS 4)	Pipe / rot (CS 4)	OK (that is, < CS 4)	At ¼ points between E1 and MS and 500 mm centres from MS – E2 until CS 2 conditions detected

For each test location, the inspector is required to capture the component location (‘Modification’, ‘Group’, ‘Component’ and ‘Standard Number’ as per the **Condition Inspection Report (A2/1 and A2/2)** form along with the ‘Component Diameter’). In addition the test details and test results are recorded as follows:

Test details:

- Location: this is the position of the drill hole on the component being drilled. Guidance is provided on the **Timber Drilling Survey Report (A2/5)** form.
- Diameter: this is the diameter of the hole drilled.
- Orientation: orientation of the test hole (Horizontal (H), Vertical (V) or Other (O)).

Test results:

- Solid: diameter of solid remaining timber.
- Rot: depth of rot detected.
- Pipe: diameter of piping decay detected.

Using these, the % of component diameter consumed is calculated by the BIS which, for piles, girders and corbels, can be used to determine the condition state. Guidance for calculation of condition state is provided for each component type in Appendix D.

3.9.2 Snipe depth measurement

In addition to drilling of timber components, the inspector is required to measure the depth of snipes located at the ends of girders and/or corbels and record the measured value in the 'Snipe Depth' column.

The allowable snipe depth ranges outlined in Appendix D are used to determine the appropriate condition state due to the snipe depth.

When horizontal cracks propagating from the root of the snipe are present, the length of crack must be recorded in the 'comments' field on the **Timber Bridge Drilling Survey Report (A2/5)**. In addition, the presence of anti-splitting bolts (or any other treatment to limit splitting) installed at the girder end must also be recorded.

3.9.3 Undersize girders

Where the measured girder diameter is less than that shown on the Standard Drawings by more than 20 mm, then the 'undersize' check box should be ticked and the required girder diameter recorded in the 'comments' field.

In addition, undersized girders should also be noted in the 'overall inspection comments' field on the **Condition Inspection Report (A2/1)** form.

3.9.4 Timber member condition rating

For each test location, the inspector shall record the worst condition state (due to drill results, measured snipe depth or girder size).

Where the worst condition state recorded for each component is more critical than the observed condition state (from the visual inspection), this shall be recorded on the **Condition Inspection Report (A2/1)** form.

3.9.5 Alternatives to drilling

A number of alternative 'non-destructive' technologies have been trialled by the department to determine if more accurate testing results can be obtained. These technologies are:

- ground penetrating radar (non-destructive)
- nuclear densometer (non-destructive)
- resistograph (quasi-destructive).

The radar method records reflected radar signals to produce a continuous readout over the length of a member. Interpretation of results is difficult but it is claimed that calibrated tests on a number of decommissioned girders have proven that an experienced operator can identify the extent and location of internal defects. This method is not considered suitable, given the expert interpretation required.

The second method uses an isotope source and detector which also gives a continuous readout along a member. This method returns a measure of soundness by determining the average density along a member. Site trials on decommissioned girders were encouraging although some limitations were identified in relation to calibration, requirement for mounting on a centralising jig/bracket and the need to undertake additional testing to verify results.

The resistograph method uses a 2 mm diameter drill bit to drill the member at a constant feed rate and rotational speed. The unit measures resistance encountered as the bit advances into the timber to detect decay, voids and other irregularities in the member. When these trials were originally carried out, measurements were output to a paper trace. The current resistograph units' have on-board storage as well as a real-time electronic display of results. The trials indicated that the resistograph method provides an accurate portrayal of internal soundness but, as for conventional drilling, only provides results at discrete drilling points.

A full report on the trials is included in Appendix D of the *Timber Bridge Maintenance Manual*. This includes recommendations for the appropriate use of these technologies to supplement conventional drilling.

3.10 Scour survey

Some types of scour, such as that caused by gradual degradation of the stream bed over a period of years or a number of flood events, can be difficult to identify due to factors such as vegetation regrowth.

The reliable and consistent checking of the waterway profile for channel degradation, aggradation and localised scour progression over time can only be made by a measurement of the stream bed level from a permanent local reference point.

The following process, referred to as 'sounding', shall be adopted as an integral part of a Level 2 inspection. Figure 3.11 illustrates the application of this process.

- If the stream bed is exposed, then the sounding height from the top of the kerb or other convenient permanent feature (such as the top of a concrete parapet) is to be measured down to the stream bed at midspan and at either end of each span on the downstream and upstream sides of the structure.
- If there is standing water at a bridge site, then the sounding height from the kerb or other permanent reference feature on the superstructure is to be measured down to the water surface, and then down to the stream bed at midspan and at either end of each span on the downstream and upstream sides of the structure.
- Where localised scour holes are identified, the inspector shall take stream bed measurements at 1.0 m intervals in the vicinity of the area in which the local scour was identified. Measurements shall be taken until the extent of the localised scour has been determined. A 'localised scour' will satisfy the following criteria:
  - A significant change in scour depth is noted at a particular measurement location. This may be at a midspan location, an abutment or at a particular pier (in which case, both of the adjacent span ends may have been affected).
  - Both the upstream and downstream points for the particular location may have been affected.
  - The 'change' tapers off rapidly, to the extent that soundings taken at adjacent locations show little or no change from previous/first readings.

  - For example, if referring to Figure 3.11, both the existing 'localised scour' and the added scour hole shown in red would be considered as 'localised scour'. As such, they will be rated in accordance with the local scour criteria. All other soundings will be rated in accordance with the 'change in depth' criteria.

- At abutment spillthroughs, measurements shall be taken at the top of the abutment protection (to act as a known ‘reference’ point for investigation of the spillthrough – shown as ‘O’ in Figure 3.11) and approximately 500 mm beyond the point where the waterway bed meets the spillthrough (the second ‘reference’ point). The approximate measurement locations and anticipated distances should be determined from design drawings and, where possible, the initial reference readings should be taken in ‘dry’ conditions so that distances may be confirmed visually. During or immediately after flood events, the abutment spillway shall be dipped at a few locations (between (and including) the first and second reference points). If the dipping reveals that the abutment protection is exposed to a depth significantly greater than previously recorded, the full set of measurements are to be forwarded to the Director (BCMAM) for further advice.

After the first round of ‘soundings’ has been completed, inspectors shall ensure that they document stream bed ‘sounding’ depths from the previous inspection for comparison with readings obtained during the current inspection.

The recorded condition state for each scour sounding is the highest condition state determined from the difference between the current reading and the previous inspection or the first (as-constructed) sounding.

In the event that reconstruction/rehabilitation of the abutment protection or channel bed is undertaken, the new bed levels shall be captured (as part of the required Level 2 inspection following refurbishment). Details of any such bed modification shall be recorded as follows:

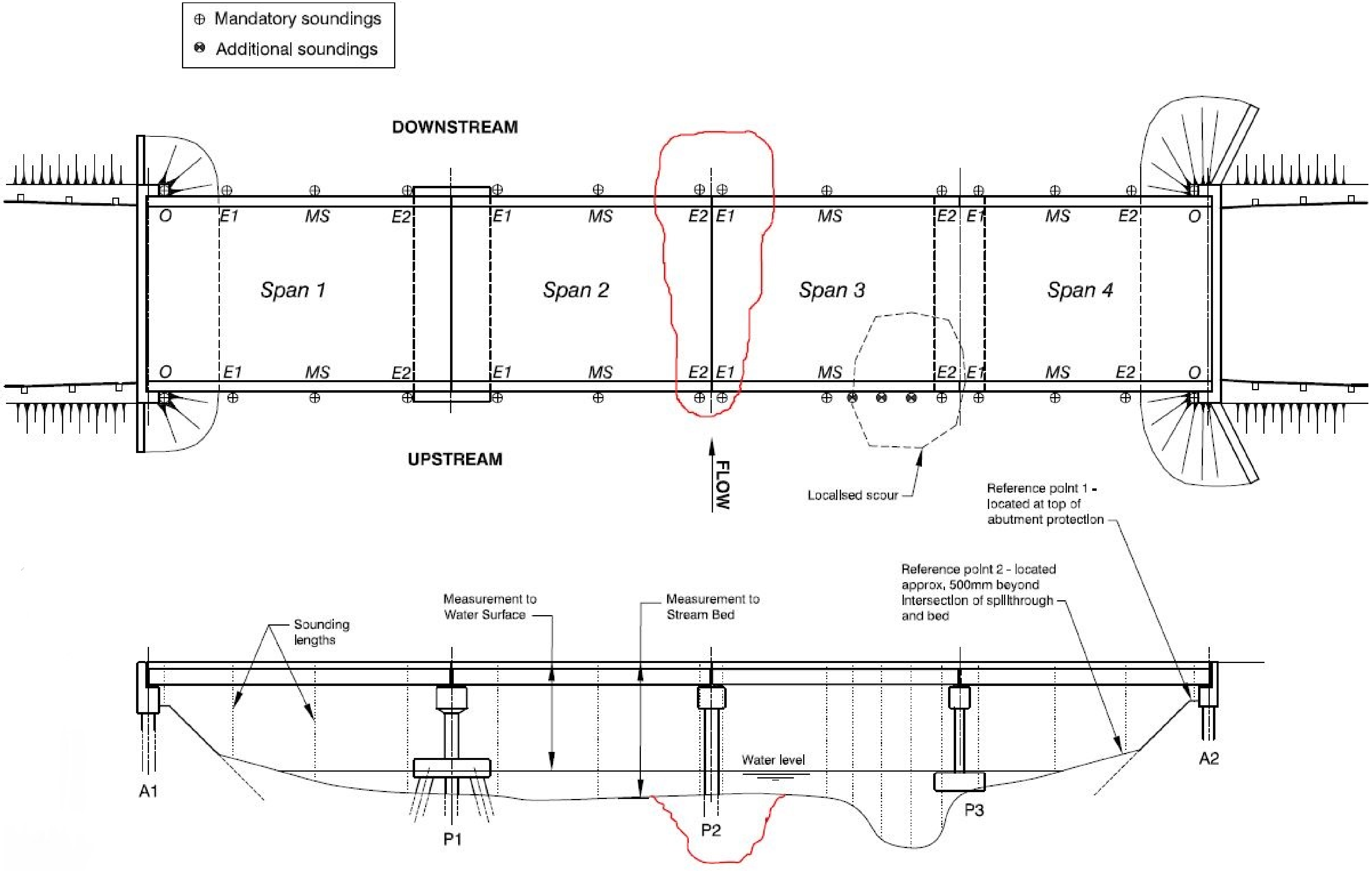
- Tick the ‘Rehab’ check box for each measurement indicating reconstruction/rehabilitation has been performed at the measurement point.
- Once the ‘Rehab’ check box is ticked, the ‘First’ and ‘Previous’ measurements are removed and the condition state reset to CS 1.
- The sounding taken as part of the post-rehabilitation Level 2 inspection is used as the ‘First’ reading for all subsequent inspections.

Measurements shall be taken using a standard measuring tape with a small weight (1 – 2 kg approx.) fastened to the end. Sonar depth-finders have been used successfully in post-flood conditions (fast flowing water), with the transducer attached to a rigid pole and submerged, where standard ‘dipping’ with a weighted tape is not possible. As these units operate on sonar, they are, however, susceptible to the presence of debris or heavily silted water so consideration must be given to the conditions on site at time of inspection.

Results of the ‘soundings’ shall be recorded on the **Scour Soundings Report (A2/7)**.

The locations from which the ‘soundings’ are measured shall be recorded on the form, with the precise locations marked discretely on the structure using epoxy or other suitable material (experience has shown that paint/pen marks tend to be erased when submerged). Inspectors shall endeavour to take measurements from the same locations at future inspections.

Figure 3.11 – Scour soundings



3.11 Ultrasonic testing

The department manages a large number of thin-walled buried corrugated metal culverts which are considered high-risk structures due, in part, to the potential for corrosion along the top of the wetted perimeter or in the invert. Corrosion of these culverts is expected in-service and a large proportion of the wall thickness is provided to both assist stability of the culvert barrel during construction and to act as a sacrificial component; however, if left unattended, corrosion of the culvert walls can result in longitudinal perforations in the culvert and loss of structural integrity. Furthermore, compacted backfill surrounding the culvert can also be lost through erosion, destabilising the culvert.

In addition to these culverts, the department also manages a number of timber bridges with steel trough decking systems. This decking system is also susceptible to corrosion and, while this may not constitute as high a risk as in buried corrugated metal culverts, corrosion usually occurs on the non-visible face, making it difficult to detect corrosion.

Inspectors are, therefore, required to actively monitor the residual thickness of culvert walls and steel trough decking as part of the Level 2 inspection at the frequencies specified in Table 3.4.2. Traditionally, this was undertaken by drilling small diameter holes and measuring remaining thickness. Non-destructive ultrasonic testing (UT) is now the preferred approach.

UT should only be undertaken by operators trained and familiar in the use of the UT equipment being employed. Furthermore, it is essential that the correct probe is employed to ensure accurate results. The following is provided to assist with equipment selection:

- The probe needs to be a small diameter twin crystal of high frequency. As the thickness of the culvert walls and deck troughing can be up to 10 mm, a probe with a 10 MHz frequency or higher is required.
- To calibrate the probe, a step-block is required. A step-block is a certified piece of metal containing ‘steps’ of various thickness. The use of this calibration tool eliminates the need for drilling proof holes in the structure. For testing of the structures previously mentioned, a block containing steps of 1 to 10 mm in thickness would be suitable.

The process following provides some guidance as to how to carry out UT:

- Before arriving on site, prepare sketches and/or tables to record the locations of the scans and results. Refer to Appendix A6 for a template suitable for both structures and guidance on test locations.
- To assist with monitoring the deterioration of the structure, it is recommended that comprehensive records of the scan locations and recordings are kept and attached in the BIS with the inspection. Additionally, reference points on the structures should be marked so future scans can be carried out at the same locations.
- Using a grinder, remove any protective coating (for example, galvanising) from at least two areas of sound material. If no coating is present, then remove any residue to expose a clean surface. For aluminium culverts, care should be taken to avoid damaging the protective oxide coating.
- Apply couplant to the cleaned areas, scan and record the readings.
- Identify corroded areas requiring scanning and repeat the process outlined previously.

- Following scanning, touch up cleaned areas using a cold galvanising paint included in the list of approved products.

Note: no zinc-rich compounds are to be used to repair aluminium culverts.

To ensure the level of deterioration of a culvert base is accurately recorded, it is important to carry out the scanning when no water is present. This can be achieved by either timing the inspection to coincide with dry conditions, locally diverting the water within the test barrel, diverting flow into another cell or damming the inlet and dewatering.

Where diversionary/dewatering or access requirements are significant, careful consideration shall be given to the benefits and frequency of UT testing. This needs to take into account such factors as age, environment, observed condition and the like.

3.11.1 Culverts with invert linings

For culverts containing structural invert linings (that is, the lining renders the underlying metal culvert redundant), no testing is required.

For culverts with an AC or shotcrete lining, it is necessary to test the culvert invert at discrete locations using an approved method to remove the lining without risk of damage to the underlying metal wall.

Test locations

The following locations in each pipe will be tested (refer to Appendix A6 for further details):

- Testing shall be undertaken at the following locations:
  - in the middle of the pipe (this location is MANDATORY)
  - at points 1 – 2 m in from either end of the pipe; if the pipe is short enough so that coming in 2 m from the end will bring you within 2 m of the middle core location, then these end cores are not required
  - for pipes with a length greater than 15 m, it may be necessary to take a single set of intermediate cores between the middle and end locations; this will be dependent on the condition of the exposed portions of the pipe at the other core locations
  - if test results are consistent between middle and end cores, then additional intermediate cores will not be required
  - significant variation in results between middle and end cores may require additional intermediate cores to be taken; this decision will be made at the discretion of the inspector.
- At each of these locations, cores shall be extracted:
  - at the culvert invert (Test Point 1)
  - approximately 200 – 300 mm below the top of the invert lining (Test Points 2 and 3).

3.11.2 Other issues

- Evidence of scour and water flows under the invert should be investigated and reported. Any voids should be backfilled as soon as practicable and an insitu concrete invert formed over the corroded/missing section.

- Any structural deformation or evidence of deformation of the road surface must be regarded as an indication of failure and should be investigated by an engineer immediately and referred to BCMAM for advice. Inspectors should ensure that the road surface immediately above the pipe is checked for deformation, thus special care should be taken to ensure the alignment of skewed culverts is correctly determined using ranging poles or similar.
- In the event of surface deformation, particularly following wet weather and/or high water flows, then propping or road closure should be considered.
- If the culvert contains permanent standing water due to deformation of the invert or poor design, then the structure should be regarded as very high risk and a Structure Management Plan should be developed to manage it. In all cases, the presence of permanent standing water should be recorded during inspections and reported to District maintenance personnel, and maintenance activities programmed to ensure that water can flow freely through the culvert (that is, clear inlets and outlets). Particular attention should be paid in coastal agricultural areas, where the chemical composition of the run-off water (that is, sulphates) is likely to exacerbate the deterioration of the culvert.

4 Level 3 – Special Inspection

4.1 Introduction

Level 3 inspections are detailed engineering investigations that generally include a combination of field investigation and theoretical analysis. They generally target or address a specific issue relevant to an individual structure or a class of structures.

Level 3 inspections are intended to provide improved knowledge of the condition, load carrying capacity, in-service performance and other characteristics that are beyond the scope of Level 1 and Level 2 inspections.

4.2 Detailed structural engineering inspection

4.2.1 Purpose

This is an extensive inspection carried out by a structural engineer, which may include physical testing and structural analysis in order to:

- assess the structural condition and behaviour of a structure
- identify and quantify the current and projected deterioration
- develop appropriate management strategies.

4.2.2 Scope

The scope of the detailed structural engineering inspection will include:

- review of any previous inspection and testing reports
- review of traffic counts, traffic studies, Culway or WIM records and planning reports which include the structure
- review of environmental factors (REFs) including contaminated site records
- determination and programming of equipment and resources required for the inspection (in conjunction with the District) including preparation of a safety plan

- detailed inspection of all relevant bridge components including such measurements, testing and analyses as necessary to supplement the visual inspection
- determination of material properties and structural behaviour
- identification of components which are limiting the performance of the structure due to their current condition and capacity or are likely to deteriorate to such a level within the next five years
- identification of the probable causes and projected rate of deterioration and the effects of continued deterioration on the performance, durability and residual life of the structure
- identification of factors which will influence the dynamic load allowance to be used in load rating; these factors include the geometry and quality of the bridge approaches, surface discontinuities at deck joints and the dynamic response of the bridge
- examination of the hydraulic performance of the structure including any signs of siltation, scour, debris impact or build-up, bank or embankment erosion and tree and vegetation encroachment.

4.2.3 Inspector accreditation

Detailed structural engineering inspections shall be carried out by or under the supervision of an experienced Registered Professional Engineer of Queensland (RPEQ) bridge engineer. Inspections must be arranged through the Director (BCMAM) of the department’s Structures Directorate. Structures Directorate is the preferred supplier of inspection services.

4.2.4 Inspection frequency

Unlike Level 1 and Level 2 inspections that are undertaken at predetermined frequencies, a Level 3 inspection or investigation is undertaken on an as-needs basis.

A detailed engineering inspection will be carried out in one of the following circumstances:

- in order to assess the condition of a structure prior to carrying out programmed works such as rehabilitation, strengthening or widening
- as the result of recommendations in a Level 2 Bridge **Condition Inspection Report (A2/1 and A2/2)** form which has rated the structure condition as poor or a principal component in condition state 3 or 4
- to provide a load rating for the structure
- to examine the difference between a theoretically structural deficient bridge to determine if the bridge exhibits distress compatible with the calculations; in some circumstances, bridges may be grouped in families of similar structures
- to prepare a Structures Management Plan (SMP1) or other reports.

4.2.5 Extent of inspections

A project-specific brief for the detailed structural engineering inspection shall be prepared by the District Director's delegate in consultation with a Principal Engineer from Structures Directorate.

4.2.5.1 Field inspection

As a minimum, the field inspection component will comprise a visual examination of all readily accessible components of the structure, supplemented, where necessary, by examinations, testing or analyses specified in the project-specific brief such as:

- underwater inspection of submerged components
- geotechnical investigation including drilling, instrumentation and monitoring
- hydraulic investigation of dynamic flood effects including assessments of flood forces, scour sedimentation, debris size, formation and impact
- location of reinforcement using cover meter
- coring and testing of concrete to assess strength and durability parameters including compressive strength, density, aggregate reactivity and depth of penetration of carbonation and chlorides
- measurement of half-cell potential and resistivity of reinforced concrete components
- examination of steel members using methods such as dye penetrant, magnetic particle, radiographic, ultrasonic or x-ray
- measurement of corroded member dimensions
- static or dynamic load testing of the structure.

4.2.5.2 Structural analysis

A load capacity assessment may be included in the brief to determine the repeated live load capacity for the remaining service life of the structure. The assessment shall be based on:

- original design drawings and specifications
- 'as-built' construction records (including pile driving, material testing, modifications, amendments and defect records)
- material properties, workmanship, condition and loading determined by field inspections, tests and direct measurement.

4.2.6 Data recording in the field

Data recording requirements will be in accordance with those specified by the project-specific brief.

As a minimum, data recording will be similar to that required for a Level 2 inspection with additional references to record the identification references, types and locations of all testing and sampling conducted as part of the inspection.

Component designation and condition rating shall be in accordance with the requirements of Section 3.

4.2.7 Reporting

A written report shall be submitted to the District Director, with a copy to the Principal Engineer (BCMAM) of Structures Directorate, within 60 days of the inspection and shall include the specific requirements outlined in the project brief.

The District Director shall consider the recommendations of the report and generally shall initiate the necessary actions. If the District Director does not agree with the recommendations, a response to that effect shall be given in writing to the inspecting engineer and copied to the Principal Engineer (BCMAM) within 30 days of receipt of the inspection report.

A copy of the final report shall be forwarded to the Principal Engineer (BCMAM) who shall be responsible for entering the following salient details into the BIS within 30 days of completion of the report:

- an executive summary of the written report, including the distribution list
- a summary of all other reports produced in order to supplement the Level 3 inspection, such as diving surveys and materials testing
- rating of all primary defects, identification of deterioration mechanisms and determination of the overall condition of the structure
- results of any load capacity assessment conducted (desktop assessment, or static and/or dynamic load testing)
- Bridge Equivalence Ratings (if required in accordance with the brief).

A record of the photographs are to be included in the written report. Photograph size and quality is to be in accordance with Section 3.7.

If, on completion of the detailed engineering inspection, the condition rating of the component(s) of concern and/or the overall rating condition of the structure are found to differ from the Level 2 report that generated the request for further detailed inspection, then a new Level 2 inspection report shall be produced as follows:

- Generate a new inspection report with revised condition ratings for the components inspected.
- All other components shall be recorded with the same condition ratings as noted at the last Level 2 inspection.
- Date of inspection shall be noted as the date of the detailed engineering inspection.
- A statement similar to the following shall be recorded in the ‘overall inspection comments’ field.

  This inspection report has been generated to reflect revised condition ratings for the [Insert component name here] *which were subject to a detailed engineering inspection on the above date. No other components other than* [Insert component name here] *were inspected and condition ratings for all other components are as recorded on* [Insert date of last Level 2 inspection here], *which is the last ‘full’ Level 2 inspection.*
- The date of the next inspection shall be recorded as the appropriate frequency from the previous ‘full’ Level 2 inspection; that is, if the next inspection, based on revised overall condition rating is three years then the next inspection is to be scheduled for last full inspection date + three years.

4.3 Asbestos containing material identification inspection

4.3.1 Background

The hazards associated with exposure to airborne asbestos fibres are well documented and there are numerous documents available relating to the management of asbestos. To effectively mitigate any risks associated with potential asbestos exposure when inspecting/working on highway structures, Transport and Main Roads has prepared MRTS96 *Management and Removal of Asbestos* which outlines the roles, responsibilities and necessary steps required when working in the presence of ACM.

In accordance with legislative requirements to prepare and maintain an asbestos register, the BIS has been amended to register ACM in structures and is being maintained up-to-date by BCMAM.

Asbestos may be present in highway structures constructed before 2003. Possible locations of ACM include:

- permanent/sacrificial formwork between girders on concrete and steel girder constructed bridges
- deck unit constructed bridges with cast insitu bridge decks (that is, no post-tensioning)
- external and internal service mains pipelines such as stormwater and sewer pipes
- service pits
- internal service conduits
- half pipes for drainage channels
- drainage systems on bridges or in close proximity to bridge
- asbestos bonded buried corrugated metal culverts.

It is almost certain that any compressed fibre products used on structures constructed and completed prior to 1985 will contain asbestos. The probability that asbestos is impregnated in compressed fibre products declines from 1986 – 2003. ACM is unlikely to be present in the following:

- transversely stressed precast deck unit superstructures
- concrete box girder superstructures.

Note: The presence of ACM does not in itself represent a hazard to the safety of employees or the community at large. Inhalation of airborne fibres represents the safety concern and, hence, it is only when ACM is disturbed either accidentally (for example, vehicle impact) or intentionally through activities such as strengthening, refurbishment or demolition that the ACM becomes a hazard. No disturbance can reasonably be expected to occur through routine maintenance activities or inspections (Level 1 and Level 2).

4.3.2 Purpose

The role of BCMAM, through the Program Manager, Statewide Structures Management Project is to facilitate the identification of structures with the potential for ACM.

The purpose is to identify the potential permanent/sacrificial inclusion of asbestos on departmental structures. These inspections will be conducted to ensure that the department's asbestos register is up-to-date with the Work Health and Safety counterpart.

4.3.3 Scope

For structures other than those where there are reasonable grounds to believe asbestos is not present, the Program Manager will make arrangements for a visual inspection by an experienced Level 2 Transport and Main Roads bridge inspector.

This is a one-off inspection undertaken on structures with the potential for ACM, as identified in the department's bridge asbestos register, to visually confirm the presence of potential ACM. Under no circumstances shall suspected ACM be disturbed during the inspection.

The inspection may be undertaken as part of programmed Level 1 or Level 2 inspections, subject to the inspector being made aware of this requirement prior to the inspection.

This inspection will not involve hands-on practices (that is, using Under Bridge Inspection Unit (UBIU) or similar equipment).

4.3.4 Procedures and inspector accreditation

ACM identification inspections shall be carried out in accordance with these procedures.

The outline procedure to be followed is illustrated in Figure 4.3.6a.

ACM identification inspections must be completed by a Transport and Main Roads-accredited Level 2 inspector.

4.3.5 Frequency

The inspection will be undertaken once only, at the earliest available opportunity, as part of the Level 1 (subject to experience/accreditation of person undertaking the inspection) or Level 2 inspection program.

4.3.6 Data recording

It is essential that the existence of a potential asbestos containing product at a bridge be identified to ensure that departmental staff or contractors and consultants who may be engaged to work on the bridge are aware of the hazard. The results and data obtained by the inspection shall be recorded in the BIS asbestos register managed by BCMAM.

On completion of the ACM identification inspection, the following actions shall be completed:

- If no elements, that may contain asbestos, are identified:
  - the asbestos register shall be updated with the following statement:

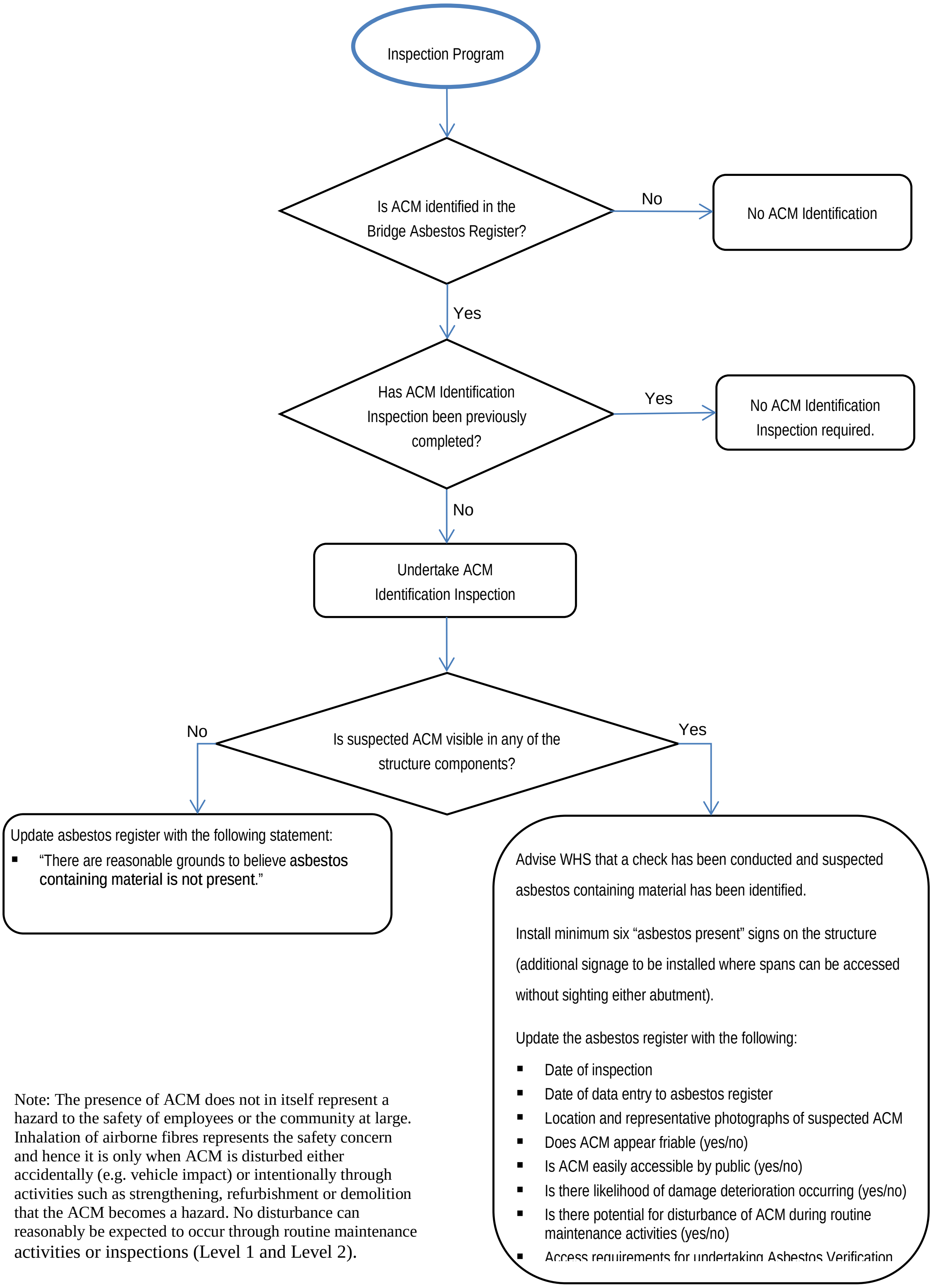
    There are reasonable grounds to believe asbestos containing material is not present.

- If elements are identified that may contain asbestos:
  - advise Workplace Health and Safety that a check has been conducted and potential asbestos containing material has been identified
  - place a minimum of six 'Asbestos Present' signs on the structure (refer Figure 4.3.6b), one sign to be located at each corner of the structure and one on each abutment (or equivalent) clearly visible from beneath the structure; where access to any span of a multi-span structure is feasible without sighting either abutment, then signage shall also be erected on the face of each pier facing the accessible span

- update the asbestos register with the following information captured during the inspection:
  - date of inspection
  - date of data entry to asbestos register
  - location and representative photographs of elements suspected of containing asbestos
  - approximate quantity of ACM and unit of measurement (m^2, m, number)
  - does element appear friable? (yes/no answer based on visual assessment only)
  - is ACM easily accessible by public? (yes/no answer)
  - is there a likelihood of damage or deterioration occurring? (yes/no answer based on judgement)
  - is there potential for disturbance of material during routine maintenance activities? (yes/no answer)
  - access requirements for undertaking asbestos verification inspection
  - exceptions report identifying areas of the structure with potential ACM that were not inspected
  - is the presence of asbestos able to be confirmed based on the visual inspection only? (for example, testing already undertaken on similar components on identical structures constructed on same length of highway under the same contract).

- In addition, the asbestos register shall be updated with the date that 'Asbestos Present' warning signs were installed on site.

Figure 4.3.6a – Procedure for asbestos containing material identification inspection



Note: The presence of ACM does not in itself represent a hazard to the safety of employees or the community at large. Inhalation of airborne fibres represents the safety concern and hence it is only when ACM is disturbed either accidentally (e.g. vehicle impact) or intentionally through activities such as strengthening, refurbishment or demolition that the ACM becomes a hazard. No disturbance can reasonably be expected to occur through routine maintenance activities or inspections (Level 1 and Level 2).

Figure 4.3.6b – Asbestos hazard warning sign

4.4 Asbestos verification inspection

4.4.1 Purpose

This requires the Program Manager, Statewide Structures Management Project to engage an accredited National Association of Testing Authorities (NATA) inspector to conduct tests under ISO 17020.The purpose of the asbestos verification inspection is to confirm the presence of asbestos in suspected ACM where the material may be disturbed through any proposed activity on the structure.

This procedure is in accordance with the relevant Acts, Regulations and Codes of Practice.

4.4.2 Scope

This inspection will involve hands-on practices (that is, using under bridge inspection unit (UBIU) or similar equipment) to gain access to the areas of concern and may involve the breaking back of limited areas of concrete to facilitate removal of samples for testing by a NATA-accredited laboratory under ISO 17020.

4.4.3 Procedures and inspector accreditation

Asbestos verification inspections shall be carried out on any structure with suspected ACM (as noted in the asbestos register) where proposed activities may result in disturbance of the suspected ACM.

Inspections must be undertaken in accordance with these procedures.

The outline procedure to be followed is illustrated in Figure 4.4.5.

Asbestos verification inspections must be undertaken by a licensed asbestos assessor and testing must be undertaken by a NATA-accredited laboratory.

4.4.4 Frequency

The inspection will be undertaken once only, during the planning stage for the activities that may result in the disturbance of the suspected ACM.

4.4.5 Data recording

It is essential that presence of asbestos be identified to ensure that departmental staff or contractors and consultants who may be engaged to work on the bridge are aware of the hazard and that appropriate control measures can be implemented.

The results and data obtained by the inspection shall be recorded in the BIS asbestos register managed by BCMAM.

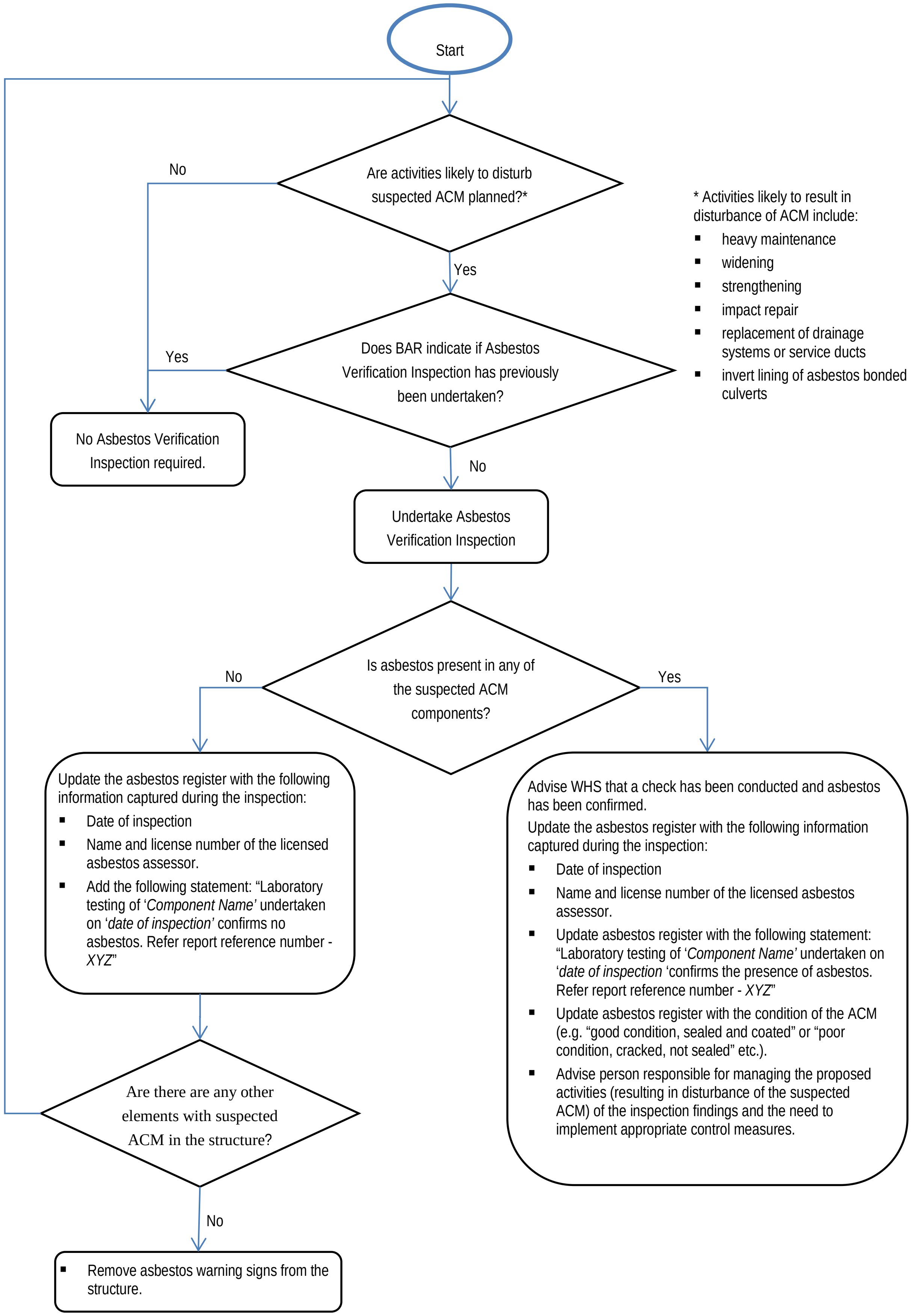
On completion of the asbestos verification inspection the following actions shall be completed:

- update the asbestos register with the following information captured during the inspection:
  - date of inspection
  - name and licence number of the licensed asbestos assessor
  - is asbestos present? (yes/no answer).
- In addition, a copy of the inspection report shall be uploaded into the BIS.
- Where no traces of asbestos are found in the suspected ACM:
  - update asbestos register with the following statement:

    Laboratory testing of [insert Element Name here] *undertaken on* [insert date of inspection here] *confirms no asbestos. Refer report reference number* [insert report reference number here]*.*
- If there are no other elements with suspected ACM in the structure, remove asbestos warning signs from the structure.
- If asbestos is detected in the suspected ACM:
  - advise Workplace Health and Safety that a check has been conducted and asbestos has been confirmed
  - update asbestos register with the following statement:

    Laboratory testing of [insert Element Name here] *undertaken on* [insert date of inspection here] *confirms the presence of asbestos. Refer report reference number* [insert report reference number here].
  - update asbestos register with the condition of the ACM (for example, 'good condition, sealed and coated' or 'poor condition, cracked, not sealed' and so on)
  - advise person responsible for managing the proposed activities (resulting in disturbance of the suspected ACM) of the inspection findings and the need to implement appropriate control measures.

Figure 4.4.5 – Procedures for asbestos verification inspection



4.5 Underwater inspection

4.5.1 Background

Underwater inspections are a fundamental component of the inspection program and, as such, must be conducted for all structures located in permanent standing water at the frequency stated in Table 3.4.2 of this Manual. They should also be conducted in conjunction with the Level 2 inspection undertaken prior to the end of the defect liability period for new structures, so as to identify construction-related damage and to provide a benchmark for future inspections.

Underwater inspection of permanently submerged components are required where the submerged components cannot be satisfactorily inspected visually or by tactile means. Any structures with components meeting this criteria shall have the underwater inspection field checked in the BIS.

4.5.2 Scope

The scope of an underwater inspection is generally identical to those of an above ground Level 2 inspection as detailed in Section 3; however, there are specific requirements associated with underwater inspections which require a structure-specific plan to be developed in order to ensure that the appropriate level of detail is captured.

Underwater inspections will generally include:

- engagement of qualified divers
- mapping of local scour around piers, abutments and banks using an approved reference grid; for structures in deep water, the banks shall also be inspected 20 m upstream and downstream of the structure
- metal corrosion
- reinforced concrete cracking and spalling
- prestressed concrete splitting
- timber infestation and rot
- pile loss and residual section
- departures from designed line and level in structural members
- debris mapping
- clearance of organic growth and minor debris to permit visual inspection
- extensive photographic record achieved using local fresh water infusion or target isolation using clear polythene bags filled with fresh water
- extraction of core and other samples underwater as directed.

Additionally, tidal and splash zone areas should also be inspected and scour soundings undertaken by an accredited Level 2 inspector while access is available.

The inspection will typically be undertaken as part of a programmed Level 2 inspection, subject to the inspector being made aware of this requirement prior to the inspection in order to ensure all required resources are available.

4.5.3 Procedure

The general procedure for an underwater inspection is as follows:

- BCMAM is to draft a structure-specific brief to define the scope of works for the engagement of a diving contractor. The brief shall include:
  - a detailed scope of works outlining:
    - what is to be inspected
    - how it is to be inspected
    - supplementary testing requirements (coring and so on)
    - level of reporting required
    - inventory of standard components using Appendix C: Standard Component Identification Guidelines on **Condition Inspection Report (A2/1)** form based on the bridge drawings and other records
    - relevant standard condition state descriptions guidelines from Appendix D
    - inspection pro forma sketches
- An approved diving contractor shall be engaged to undertake works, ensuring that access equipment is sufficient for an accredited Level 2 inspector to undertake scour sounding and inspection of tidal and splash zones.
- The Contractor is to submit proposal/quotation, together with method statements, equipment schedule, key personnel schedule, work history and references (for contractors other than approved diving contractors).
- The Contractor is to complete the inspection with an accredited Level 2 inspector in attendance. The Contractor must advise the inspector of any serious defects or structural anomalies on detection and seek advice as to the need for scope changes such as coring or other sampling. It is envisaged that the inspector will be conducting the scour sounding and inspection of the tidal and splash zones while the diver undertakes the inspection.
- The accredited Level 2 inspector shall review the data collected by the diver and ensure that the required level of detail has been recorded for reporting purposes before the diver leaves site.
- The District is to contact BCMAM or other Structures Directorate section for guidance in the event that serious defects or structural anomalies are identified.
- The Contractor is to compile a draft report that includes the compilation of standard inspection forms and supplemented with a written report as required by the brief.
- The District and BCMAM are to review the report and order amendments or supplements as required.
- The District is to enter inspection reports in the BIS, comprising the condition of underwater, tidal and splash zone components, scour sounding and any material testing results.
- The District is to compile a performance report on the performance of the Contractor and forward to BCMAM.

A list of approved diving contractors is available from BCMAM on request.

4.6 Fracture critical/lack of redundancy

4.6.1 Background

There have been numerous international examples of the catastrophic collapse of bridges due to failure of members where no load redundancy exists. In response to high-profile failures in the United States, the Federal Highway Administration (FHWA) requires a special inspection of fracture critical members in fracture critical bridges. The FHWA *National Bridge Inspection Standards* (NBIS) define a fracture critical member as 'a steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse'. Essentially, the intention is to identify and inspect, to a higher level, fracture critical members in bridges with no load path redundancy.

Example structures of this type include:

- truss bridges (through, half-through, deck truss and so on)
- through girder
- tied arch
- two girder bridges
- suspension / cable-stayed spans
- drop-in/suspended spans.

4.6.2 Scope

Clearly the increased significance of the failure of fracture critical members in bridges with reduced load path redundancy justifies higher level inspection. The fracture critical/lack of redundancy inspection is intended to enhance the Level 2 inspection process detailed in Section 3.

For these structures, it is important that critical members, and likely failure indicators, are identified and mapped out on a bridge-by-bridge basis to ensure that the critical components receive the appropriate level of inspection. This may include non-destructive testing such as magnetic particle inspection or eddy current techniques as required.

A detailed inspection plan outlining inspection and testing requirements and frequency will need to be developed by BCMAM on a case-by-case basis, depending on the nature of the structure.

The inspection will typically be undertaken as part of programmed Level 2 inspection, subject to the inspector being made aware of this requirement prior to the inspection, in order to ensure all required resources are available.

4.6.3 Procedures and inspector accreditation

Fracture critical/lack of redundancy inspections shall be carried out by or under the supervision of an experienced RPEQ bridge engineer.

All specialist inspection activities must be undertaken by suitably qualified and experienced practitioners. All testing must be undertaken by parties with appropriate NATA accreditation (where applicable).

The inspection procedure will be as specified by the structure-specific inspection plan contained within the SMP1.

4.6.4 Inspection frequency

The inspection frequency will be as specified in the structure-specific inspection plan contained within the SMP.

4.6.5 Extent of inspections

The extent of the inspection will be in accordance with the structure-specific inspection plan.

4.6.6 Data recording in the field

Data recording requirements will be in accordance with the structure-specific inspection plan.

4.6.7 Reporting

Reporting will be in accordance with the structure-specific inspection plan.

4.7 Sub-standard load rating

4.7.1 Background

Transport and Main Roads has recently completed load ratings on all bridges on their ‘B-double and road train’ routes. This involved high-level assessment of all bridges with grillage analysis undertaken on a representative sample. This rating exercise identified a potentially large number of structures with a theoretical sub-standard load rating and also highlighted potential detailing issues and / or lack of redundancy in structural form.

4.7.2 Scope

A detailed scope for the Level 3 investigation and inspection of structures with a theoretical sub-standard load rating is presented in *Level 3 Inspection Criteria for Potentially Structurally Deficient Bridges* (Issue 1.06, May 2014).

4.7.3 Procedures and inspector accreditation

Outline procedures and inspector accreditation are outlined in *Level 3 Inspection Criteria for Potentially Structurally Deficient Bridges* (Issue 1.06, May 2014).

4.8 Complex/unique structures

4.8.1 Background

Most unique, complex structures require more detailed reporting than the standard Level 2 inspection report allows. Guidance on enhancing Level 2 inspections for complex structures is provided in Appendix G of this Manual; however, the specific inspection requirements / procedures and additional inspector skills / experience required for such structures are not covered indepth.

Complex structures are usually those that, because of their size or complexity, require significantly greater inspection effort / resource than a normal Level 2 inspection. Typically, specialised access equipment and / or greater engineering knowledge will be required to accurately determine the condition of various components. Examples of complex structures include:

- suspension
- cable stayed
- curved box girders

- large bridges comprising multiple structure forms (for example, Riverside Expressway) or complex components (for example, mechanical pot bearings, pin and hanger connections, cable systems and so on) with specific servicing / inspection requirements.

4.8.2 Scope

Any structure classified as ‘complex’ should have its own detailed inspection plans (developed by BCMAM), similar to fracture critical/low redundancy structures, which define areas requiring enhanced access/inspection requirements and appropriate inspection frequencies.

The inspection will typically be undertaken as part of a programmed Level 2 inspection, subject to the inspector being made aware of this requirement prior to the inspection, in order to ensure all required resources are available.

Most complex and unique structures are outside the maintenance funding of Element 19; hence the District is required to arrange special funding from other sources for routine, scheduled and special maintenance of these structures.

Some bridges of these bridges require repainting. The cost of repainting one of these bridges is large, requires special funding and needs to be planned some years prior to repainting.

4.8.3 Procedures and inspector accreditation

Complex/unique structure inspections shall be carried out by or under the supervision of an experienced RPEQ bridge engineer.

All specialist inspection activities must be undertaken by suitably qualified and experienced practitioners. All testing must be undertaken by parties with appropriate NATA accreditation (where applicable).

The inspection procedure will be as specified by the structure-specific inspection plan contained within the SMP.

4.8.4 Inspection frequency

The inspection frequency will be as specified in the structure-specific inspection plan contained within the SMP.

The specialist inspection and the associated inspection frequency needs to be documented in the SMP.

Complex and unique bridges often have their own gantries and equipment. The maintenance of this equipment is critical from both a safety and operational perspective and needs to be documented.

4.8.5 Extent of inspections

The extent of the inspection will be in accordance with the structure-specific inspection plan.

4.8.6 Data recording in the field

Data recording requirements will be in accordance with the structure-specific inspection plan.

4.8.7 Reporting

Reporting will be in accordance with the structure-specific inspection plan.

4.8.8 Budget

Most complex and unique bridges do not receive maintenance funding from Element 19. Consequently, it is necessary to prepare a budget with a duration of:

- 50 years if the bridge has bearings
- 40 years if the bridge requires painting
- 20 years if there is no painting and no bearings.

4.8.9 Example for requirements for complex/unique bridges

An example of the requirement for complex and unique bridges is shown in Appendix H.

4.9 Known/suspected deficiencies

4.9.1 Background

Another of the outcomes of the 'B-double and road train' exercise was the identification of structure types / families with possible deficiencies (design or detailing) or a lack of redundancy. These structure types include:

- portal frame piers/abutments
- headstocks with cantilevers > 0.7 m in length
- pre-1965 precast deck units with span = 8.23 m (27')
- simply supported spans > 30 m and designed to MS18 + 25% or T44 design loading
- shear and torsion related issues in all concrete box girder bridges
- bridges with shear reinforcement significantly less than the current code minimum.

4.9.2 Scope

A detailed scope for the Level 3 investigation and inspection of structures with a theoretical sub-standard load rating is presented in *Level 3 Inspection Criteria for Potentially Structurally Deficient Bridges* (Issue 1.06, May 2014).

4.9.3 Procedures and inspector accreditation

Outline procedures and inspector accreditation are outlined in *Level 3 Inspection Criteria for Potentially Structurally Deficient Bridges* (Issue 1.06, May 2014).

4.10 Confined space inspection

4.10.1 Background

Confined spaces pose dangers because they are usually not designed to be areas where people work. Confined spaces often have poor ventilation which allows hazardous atmospheres to quickly develop, especially if the space is small. The hazards are not always obvious and may change from one entry into the confined space to the next.

The risks of working in confined spaces include:

- loss of consciousness, impairment, injury or death due to the immediate effects of airborne contaminants
- fire or explosion from the ignition of flammable contaminants

- difficulty rescuing and treating an injured or unconscious person
- asphyxiation resulting from oxygen deficiency or immersion in a free-flowing material, such as liquids, grain, sand, fertiliser or water.

A confined space means an enclosed or partially enclosed space that:

- is not designed or intended primarily to be occupied by a person
- is, or is designed or intended to be, at normal atmospheric pressure while any person is in the space and
- is or is likely to be a risk to health and safety from:
  - an atmosphere that does not have a safe oxygen level
  - contaminants, including airborne gases, vapours and dusts, that may cause injury from fire or explosion
  - harmful concentrations of any airborne contaminants, or
  - engulfment.

4.10.2 Scope

The scope of confined space inspection is generally identical to those of an above ground Level 2 inspection as detailed in Section 3; however, as the space has been determined to be a ‘Confined Space’ under the Workplace Health and Safety Regulation 2011, there are specific requirements associated with these inspections which require a structure-specific plan to be developed in order to ensure that the appropriate risk assessment, management and control procedures are implemented.