City of Saint John

Condition Rating Manual

Version 4.0

December 19, 2018

SAINT JOHN

© 2019, City of Saint John. All Rights Reserved.

The preparation of this report was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

TABLE OF CONTENTS

1.0 INTRODUCTION

This manual outlines the framework, methodologies and processes for establishing a condition rating program for municipal assets and assessing the physical condition of municipal assets. The manual is intended to serve as a reference document for City staff, external contractors and other parties to determine the standard methodology to conduct condition assessments and provides some guidance in the implementation of a condition rating program for each asset.

2.0 CONDITION RATING FRAMEWORK

For the purposes of asset management, condition ratings are used to determine the physical state of repair of an asset and is often used as an indicator for the relative time until corrective action (rehabilitation, or replacement) is required. The City of Saint John uses a 1 to 5 condition rating scale for all assets, with 1 indicating a like new state-of-repair (very good condition) and 5 indicating imminent corrective action is required (very poor condition). The following criteria will be evaluated to determine the overall condition ratings for all City assets:

1. Physical condition
2. Expected service life

The primary driver for condition ratings will be the “physical condition” of an asset. The “expected service life” criteria are primarily reserved for special cases where replacement and/or renewal is required by law due to safety or regulatory considerations (e.g. fire suppression/sprinkler systems in a facility, firefighting protective equipment, etc.)

When evaluating assets, the highest score of the two criteria is used to determine the overall asset condition rating (i.e. a physical working condition score of 2, and an expected service life of 5, will result in an overall condition rating for the asset of 5). Please note, the expected service life of some assets may be prescribed (i.e. a Scott air pack needs to be replaced after a regulated number of years in use) or may be limited for operational (e.g. computer equipment or vehicles) or safety reasons (e.g. disinfection equipment in a water treatment plant). These assets would score a 5 (very poor condition) despite being in excellent working condition.

Formalized condition rating definitions for the five-point scale have been established and are presented in Table 4.1.1.

Table 4.1.1 - Condition Rating Framework

Condition Rating	Physical Condition	Expected Service Life
1 - Very Good	Excellent working condition. No signs of deterioration.	Like new. *(>65% life left)*
2 - Good	Minor signs of deterioration.	Approaching or at mid-stage of life. *(65% - 40% life left)*
3 - Fair	Some elements exhibiting major deficiencies.	Beyond mid-stage of life. *(40% - 20% life left)*
4 - Poor	Significant deterioration with localized areas of failure.	Needs to be replaced in the short-term. *(20% - 5% life left)*
5 - Very Poor	Asset is beyond repair and, generally, has completed failed.	Needs to be replaced almost immediately. *(<5% life left)*

It should be noted that for the purposes of asset management, condition ratings are generally based on visual observations and/or operating knowledge, are intended to provide an objective way to rank and compare the need for corrective actions on assets across different departments and services and should not be interpreted as safety certifications.

There are three types of methods available to evaluate the condition of an asset, presented below.

1. Theoretical Condition

The theoretical condition of an asset compares the asset's age to its estimated useful life. Using a deterioration curve (shown in Figure 1), the theoretical condition of an asset can be determined. The deterioration curve presented in Figure 1 is a generalized curve used for all assets and is intended to mimic how an asset's deterioration is accelerated in the final stages of its life. Equation (1) is used to calculate the percentage of life (%LC), which is then converted to a condition rating of 1 – 5 using Table 2. The theoretical condition is considered the least reliable estimate as it only relies the data available for each asset and is not based on any experience or direct observations.

$$\%LC = \frac{(Current\ Year - In\ Service\ Year)}{Estimated\ Useful\ Life} \quad (1)$$

Figure 1 - Universal Asset Deterioration Curve

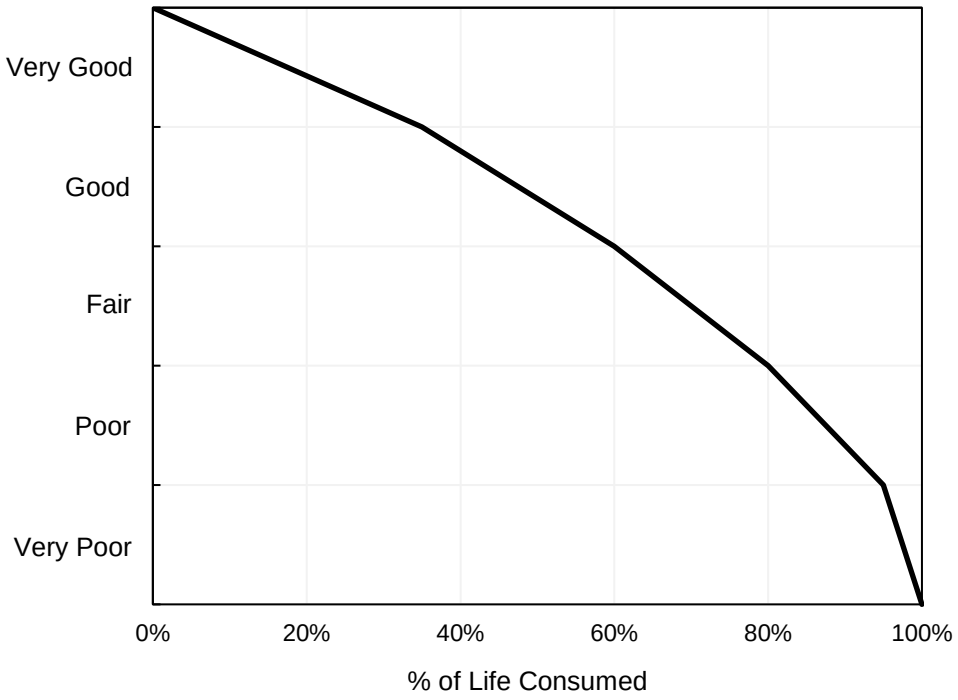


Table 2 - Theoretical Condition Rating Thresholds

Rating	Condition	%LC Thresholds	
		Upper	Lower
1	Very Good	0%	≤ 35%
2	Good	35%	≤ 60%
3	Fair	60%	≤ 80%
4	Poor	80%	≤ 95%
5	Very Poor	95%	≤ 100%

2. Operator Experience

The second method to estimate condition relies solely on operator knowledge and does not rely on any documented observations of the asset. Operators are asked to simply estimate, based on their experience, what the current condition of an asset is using the condition rating framework presented in Table 4.1.1.

3. Documented Observations

Documented observations are considered the most reliable method to estimate condition as they are based on systematic observable deficiencies of an asset. This method relies on asset

specific methodologies and often requires staff training to ensure assets are evaluated on a common standard. The goal is to minimize subjectivity and rely on the methodologies prescribed to guide the evaluation process. Section 4.0 of this report contains additional guidance to conduct these assessments for selected assets.

In addition to identifying methodologies to evaluate assets, this report provides additional guidance for the City to establish a formalized condition rating program for assets, found in the Section 3.0. Items to consider in establishing a condition rating program are:

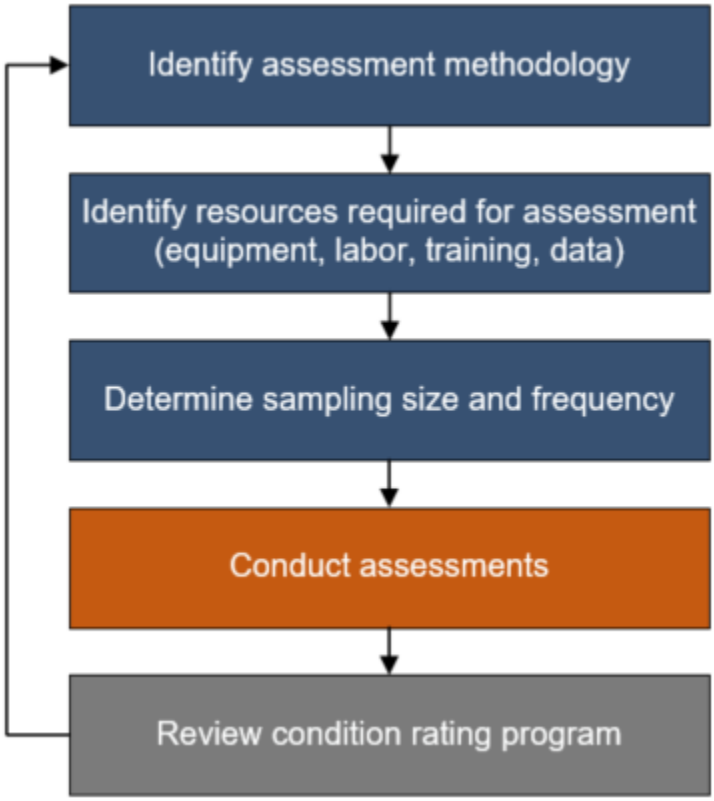
- Identifying a condition rating methodology.
- Identifying resource requirements to conduct assessments.
- Determining a sampling size and frequency of assessments.

Once a condition rating program is establish, City staff should conduct the assessments for the year, and review the program to identify any shortcomings and adjust as necessary.

3.0 ESTABLISHING A CONDITION RATING PROGRAM

Condition data collection can often be a significant resource requirement and data collection efforts can account for up to 90% of the total costs of an asset management program. As a result, a formal condition rating program and techniques should be well planned and managed to maximize the cost effectiveness of staff resources. The process defined in Figure 2 is recommended to establish a condition rating program for each asset:

Figure 2 - Establish Condition Rating Program Process



1. Identify and select assessment methodologies

   The first step in establishing a condition rating program is to investigate and select a methodology to evaluate the current condition of each asset type. Included in this manual are recommended methodologies to evaluate the condition for various asset types (Appendix 1). **For all assets where a specific methodology has not been provided, City staff should use the descriptions in Table 4.1.1 to evaluate asset condition.**

2. Identify resources required for assessment

   For each methodology, City staff will be required to identify the resources required to execute the assessments. Examples of resource requirements include: labor, tools and

templates used to collect data, data storage locations, and training or safety requirements. In some cases, assets would require specialized expertise to evaluate the condition. For these assets, a rough estimate of the cost to conduct these assessments should be prepared. As an example, the resource requirements for road surfaces is shown below.

Table 3 - Resource Requirements for Road Surfaces

Asset	Road Surfaces
Methodology	ASTM D6433 – 18: Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys
Labor[1]	2 FTE
Training	1-day in-house course on ASTM D6433 – 18
Assessment tool	MicroPaver mobile collector
Storage location	MicroPaver database

1 – The labor required to evaluate the entire inventory of assets.

3. Determine sampling size and frequency.

When there are large numbers of assets and assessment costs are high, it may be more cost-effective to adopt a sampling approach. In this case a detailed condition assessment is undertaken on a sample of similar assets and the findings are extrapolated across the larger asset base.

Sampling sizes can range depending on the asset's criticality, estimated useful life or service provision. As a minimum, it is recommended that assets be evaluated at quarterly intervals of their estimated useful lives (e.g. assets with an estimated useful life of 20 years would undergo an evaluate at year 5, 10, 15, and 20).

Asset sampling should only be considered if the cost to evaluate the condition of each asset far exceeds the annual benefits. For most assets, a 100% survey is recommended each year. It is the requirement of City to staff to evaluate the costs and benefits of these assessments and identify the most appropriate sampling frequency.

4. Conduct assessments

With the methodology selected, resources identified, and sampling size/frequency determined, City staff is now able to conduct its annual condition rating program.

5. Review condition rating program

At the end of each year, asset managers should gather with assessment staff to review and evaluate the current condition rating program. Questions which should be considered are:

- Does the prescribed methodology give us a good sense of the current condition of our assets? Do we want to adjust the current methodology or identify an alternative?
- What was the total cost to evaluate the prescribed sample size? Should we reduce or increase the size for next year?
- Do we have the right tools and training to conduct these assessments? Do we need to improvement our data management tools?
- Are the assessments cost-effective?

4.0 CONDITION RATING METHODOLOGIES

For selected assets, additional reference material has been prepared on the methodologies to assess current the condition of assets (see Appendix 1). **For all assets which have not been included, City staff is recommended to use the condition rating framework shown in Table 4.1.1 to estimate the condition of its assets.** Alternatively, City staff may recommend a different methodology to meet the needs of their assets.

A summarized list of reference material available for City assets is shown below with detailed methodologies presented in Appendix 1.

Asset	Source	Page
Sidewalks	Seattle Department of Transportation (SDOT): 2018 Sidewalk Condition Assessment Report	11
Fences	Local Government & Municipal Knowledge Base (LGAM): Fence Condition Rating Reference Sheet	14
Retaining Walls	U.S. Department of Transportation (US DOT), Federal Highway Administration (FHWA): Retaining Wall Inventory and Condition Assessment Program (FHWA-CTL/TD-10-003)	16
Road Surfaces	ASTM D6433 – 18: Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys	21
Culverts	U.S. Department of Transportation (US DOT), Federal Highway Administration (FHWA): Culvert Assessment and Decision-Making Procedures Manual (FHWA-CFL/TD-10-005)	22
Storm/Sanitary Sewers and Manholes/Catchbasins	(1) National Association of Sewer Service Companies (NASSCO), Pipeline and Manhole Assessment Certificate Program (PACP & MACP) (2) City of Alameda, California: Sewer Master Plan, Chapter 4 – Condition Assessment	68

Guiderails	American Association of State Highway and Transportation Officials (AASHTO): Manual for Bridge Inspection	71
Facilities	ASTM E1557 – 09: Standard Classification for Building Elements and Related Sitework—UNIFORMAT II	74
Water/Sanitary Pressure Pipes	*US EPA: Primer on Condition Curves for Water Mains, Contract No. EP-C-05-057*	77

APPENDIX 1

Condition Rating Methodologies

4.1 Sidewalks

Reference: Seattle Department of Transportation (SDOT): 2018 Sidewalk Condition Assessment Report

A simple visual assessment can be performed to determine the condition rating of sidewalks. Table 4.1.1 provides descriptions and picture references to assist in the determination of condition ratings for sidewalks.

Table 4.1.1 - Sidewalk Condition Rating Guide

Condition	Description	Picture Reference
1 - Very Good	No observable issues along the pedestrian clear zone.	
2 - Good	Minor issues along the pedestrian clear zone: sidewalk extends the full length of the block with no discontinuities. may have minor uplifts and ≤ 5% of the sidewalk requires slab replacement.	
3 - Fair	Issues are of medium severity; discontinuities exist that may impact mobility; ≤ 25% and > 5% of the sidewalk may need replacement.	

Condition	Description	Picture Reference
4 - Poor	Issues are severe; discontinuities exist that may impact mobility; ≤75% and >25% of the sidewalk may need replacement.	
5 - Very Poor	Widespread severe issues; discontinuities exist that impact mobility; between 100% to 76% of the sidewalk needs replacement; may have a width < 12 inches and/or a primary cross slope > 8%.	

4.2 Fences

Reference: Local Government & Municipal Knowledge Base (LGAM): Fence Condition Rating Reference Sheet

A simple visual assessment can be performed to determine the condition rating of fences. Consideration should be given to ensure the condition rating selected for the fence represents the average condition for the entire fence structure. Some fences may have small localized sections with varying states of repair and should be considered when evaluating the overall condition rating. Table 4.2.1 provides descriptions and picture references to assist in the determination of condition for fences.

Table 4.2.1 - Fence Condition Rating Guide

Condition	Description	Picture References
1 – Very Good	Fence is in brand new condition.	
2 – Good	Fence still in good condition, structurally sound but does not appear to be new.	
3 – Fair	Fence starting to show some wear, but no significant damage present.	

Condition	Description	Picture References
4 – Poor	Significant damage to fence, has holes and is unsightly.	
5 – Very Poor	Fence no longer functional, falling down and generally in very poor condition.	

4.3 Retaining Walls

Reference: U.S. Department of Transportation (US DOT), Federal Highway Administration (FHWA): Retaining Wall Inventory and Condition Assessment Program (FHWA-CTL/TD-10-003)

The physical condition of a retaining wall is evaluated by assessing various primary and secondary wall elements and numerically rate each element. In addition to the element assessment, the overall performance of the wall system is evaluated and rated considering the "Global" aspects of wall performance. Finally, all element and global ratings are weighted and combined to arrive at a final wall condition rating.

Wall Elements

Wall elements are divided into two categories: Primary and Secondary, and are summarized below. Additional descriptions regarding each of these wall elements can be found in the referenced document.

Primary Wall Elements

1. Piles and Shafts
2. Lagging
3. Anchor Heads
4. Wire/Geosynthetic Facing Elements
5. Bin or Crib
6. Concrete
7. Shotcrete
8. Mortar
9. Manufactured Block/Brick
10. Placed Stone
11. Stone Masonry
12. Wall Foundation Material
13. Other Primary Wall Element

Secondary Wall Elements

1. Wall Drains
2. Architectural Facing
3. Traffic Barrier/Fence
4. Road/Sidewalk/Shoulder
5. Upslope
6. Downslope
7. Lateral Slope
8. Vegetation
9. Curb/Berm/Ditch
10. Other Secondary Wall Element

To evaluate the condition rating of each wall element, the element rating definition guide in Table 4.3.2 is used:

Wall Performance

To provide a measure of the performance of wall elements that cannot be directly observed, as well as an evaluation of the overall earth retaining system, a "Wall Performance" rating is provided for all walls. This allows the inspector to assess the combined performance of all wall elements acting together, including global wall distresses (rotation, settlement, translation, displacement, etc.) and/or evidence of prior repairs that may further indicate component problems or functional improvements. Table 4.3.3 provides general guidance on defining overall

wall performance. The inspector should use this guide in conjunction with the wall element rating guide provided in Table 4.3.2 when determining an appropriate wall performance rating.

Overall Condition Rating

To calculate an overall condition for a retaining wall, the various retaining wall elements and wall performance condition ratings are multiplied by weighted factors. “Primary Wall Elements” and “Wall Performance” each receive a standard weighting of 8 while “Secondary Wall Elements” receive a weighting factor depending on the element condition. A summary of weighting factor for each of the retaining wall evaluations is summarized in Table 4.3.1.

Table 4.3.1 - Secondary Wall Element Weighting Factors

Evaluation	Weighting Factor
Primary Wall Elements	8
Secondary Wall Elements (element condition)	
1	0.5
2, 3 or 4	1.0
5	5.0
Wall Performance	8

Note, the final condition rating should be rounded to the nearest integer (1.0, 2.0, 3.0, 4.0 or 5.0) to be consistent with the City’s condition rating framework. Figure 3 demonstrates an example to calculate the overall wall condition by weighing individual wall elements and performance.

Figure 3 - Example Overall Wall Condition Rating Calculation

Item	Condition Rating	Weighting Factor	Weighted Condition Rating
Wall Performance	3	8.0	24
Primary Wall Elements			
Bin or Crib	2	8.0	16
Wall Foundation Material	2	8.0	16
Secondary Wall Elements			
Wall Drains	1	0.5	0.5
Traffic Barrier	5	5.0	25
Lateral Slope	3	1.0	3
		Total Score (TS)	84.5
		Max Score (MS)	152.5
		Wall Condition Rating = (TS/MS) * 5	**(3.0) 2.8**

Table 4.3.2 - Element Rating Definition Guide

Condition Rating	Element Rating Definition
1 - Very Good	Defects are minor, are within the normal range for newly constructed or fabricated elements and may include those resulting from fabrication or construction.
2 - Good	Distress does not significantly compromise the element function, nor is there significant severe distress to major structural components. Indicate highly functioning wall elements that are only beginning to show the first signs of distress or weathering.
3 - Fair	Distress present does not compromise element function, but lack of treatment may lead to impaired function and/or elevated risk of element failure in the near term. Indicate functioning wall elements with specific distresses that need to be mitigated in the near-term to avoid significant repairs or element replacement in the longer term.
4 - Poor	Distress present threatens element function, and strength is obviously compromised, and/or structural analysis is warranted. The element condition does not pose an immediate threat to wall stability and closure is not necessary. Indicates marginally functioning, severely distressed wall elements in jeopardy of failing without element repair or replacement in the near-term.
5 - Very Poor	Element is no longer serving intended function. Element performance is threatening overall stability of the wall at the time of inspection. Indicates a wall that is no longer functioning as intended and is in danger of failing catastrophically at any time.

Table 4.3.3 - Performance Rating Definition Guide

Condition Rating	Performance Rating Definition (check if any apply)
1 - Very Good	• No or minor combinations of element distresses are observed indicating unseen problems or creating significant performance problems. • No or minor history of remediation or repair to wall or adjacent elements is observed.
2 - Good	
3 - Fair	• Some observed global distress is not associated with specific elements. • Some element distress combinations are observed that indicate wall component problems. • Minor work on primary elements or major work on secondary elements has occurred improving overall wall function.
4 - Poor	• Global wall rotation, sliding, settlement, and/or overturning is apparent. • Combined element distresses clearly indicate serious stability problems with components or global wall stability. • Major repairs have occurred to wall structural elements, though functionality has not improved significantly. • Severe distresses are apparent on adjoining roadways.
5 - Very Poor	

4.4 Road Surfaces

Reference: ASTM D6433 – 18: Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

Table 4.4.1 below summarizes how to translate the **Pavement Condition Index (PCI)** values obtained for asphalt or pavement concrete road surfaces using ASTM D6433 - 18 to a 1 – 5 condition rating. Detailed directions regarding the methodology to obtain the PCI of road surfaces can be found in the referenced document.

Table 4.4.1 - PCI Translation Table

Condition Rating	Condition	PCI Thresholds
1	Very Good	100 – 86
2	Good	85 – 70
3	Fair	69 – 55
4	Poor	54 – 40
5	Very Poor	39 – 0

4.5 Culverts

Reference: U.S. Department of Transportation (US DOT), Federal Highway Administration (FHWA): Culvert Assessment and Decision-Making Procedures Manual (FHWA-CFL/TD-10-005)

The physical condition of culverts is evaluated by assessing various elements of each culvert barrel. There are a varying number of culvert elements to evaluate depending on the pipe material, shown in Table 4.5.1. In addition to evaluating the culvert barrel, guidance has been provided to evaluate culvert appurtenances (**only** to be used if the City tracks appurtenances independently).

Table 4.5.1 - Culvert Elements to Evaluate, by culvert material

Elements	Concrete / RCP	Metal	Plastic	Timber	Masonry
Invert Deterioration	X	X	X	X	X
Joints and Seams	X	X	X	X	
Corrosion / Chemical	X	X			
Cross-Section Deformation	X	X	X		X
Cracking	X				
Liner / Wall			X		
Mortar and Masonry					X
Rot and Marine Borers				X	

Appurtenances:

1. Headwall / Wingwall
2. Apron
3. Flared End Section
4. Pipe End
5. Scour Protection

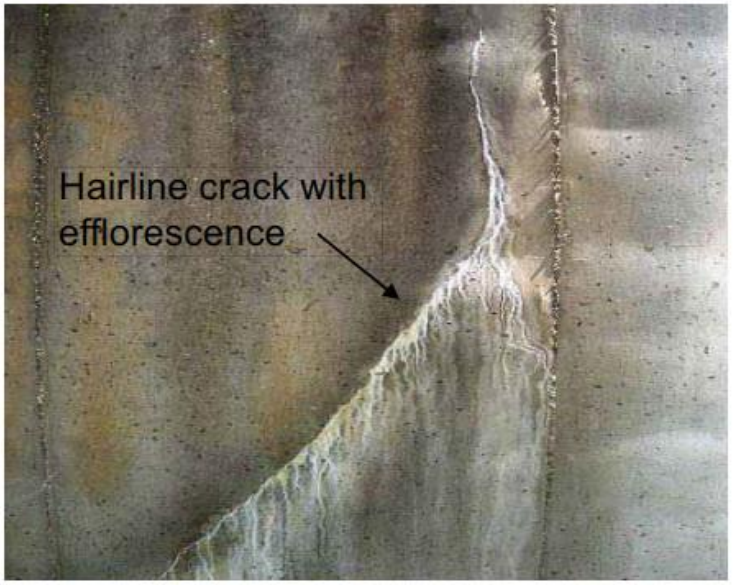
To determine the overall condition of a culvert, the element with the worst condition rating for the culvert determines the overall condition rating. Appurtenances are evaluated independently from the pipe barrel.

For each culvert material type, a condition evaluation matrix has been prepared to guide the evaluation each of the potential elements. Additionally, several photographs have been prepared to give a visual indication of the Good, Fair, Poor and Very Poor ratings for the deficiencies listed.

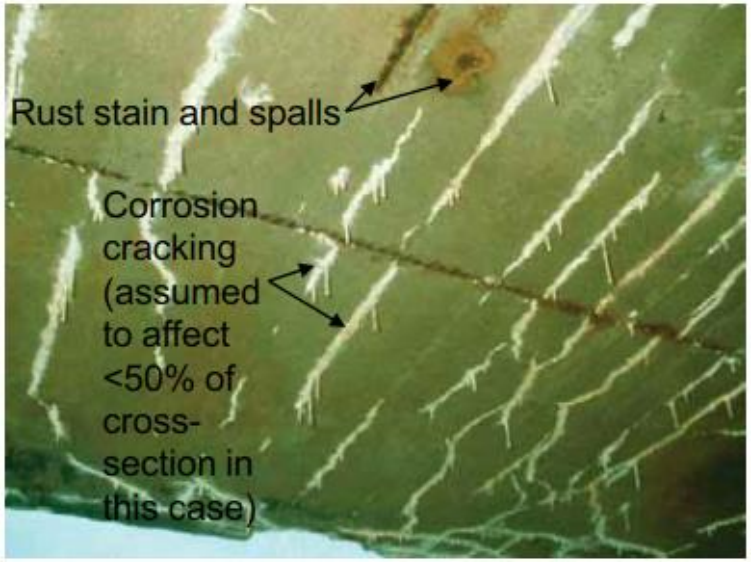
Table 4.5.2 - Concrete / RCP Condition Matrix

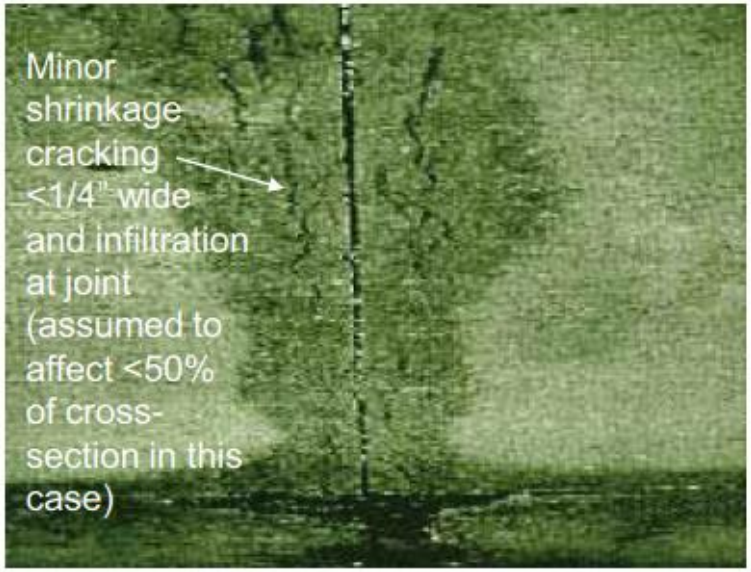
Element	Very Good	Good	Fair	Poor	Very Poor
Invert Deterioration	No abrasion.	Little or no abrasion, with light scaling and exposed aggregate.	Moderate abrasion and scaling with minor aggregate loss but no exposure of steel reinforcement.	Heavy abrasion and scaling with exposed steel reinforcement.	Holes or section loss with extensive voids beneath and embankment or roadway damage.
Joints and Seams	Smooth, tight joints.	Minor chips and cracks on joints.	Open or displaced with minor infil/exfil of water and/or soil.	Open or displaced with significant infil/exfil of soil and/or water and voids visible.	Broken open or separated > 4” gap with extensive voids and embankment or roadway damage.
Cross-Section Deformation	None observed.	None observed.	Cracks present, but no perceptible cross-section deformation.	Longitudinal cracks in crown, invert and/or haunches, with perceptible cross-section deformation.	Deformation and cracking has led to extensive infiltration of backfill soil, structural failure or embankment and/or roadway damage.
Cracking	No cracking.	Boxes/Arches: Minor hairline or map cracks due to shrinkage <= 1/8” wide at isolated areas, not at the crown or spring lines, with <25% cross-section coverage. RCP: No cracks	Boxes/Arches: Minor cracks = ¼” wide, with minor spalls and infil/exfil of water or soil, along crown or haunches, <50% cross-section coverage any size. RCP: Few airline cracks, not at crown or haunches.	Boxes/Arches: Open cracks > ¼” wide with significant infil/exfil and voids, or >50% cross-section coverage any size. RCP: Cracks > 1/8” wide, or any along crown or haunches, or >25% cross-section coverage any size.	Resultant displacement at cracks has led to extensive infiltration of backfill soil, structural failure and/or resultant embankment and/or roadway damage.
Chemical / Corrosion	No efflorescence.	Boxes/Arches: Efflorescence present. RCP: No efflorescence.	Boxes/Arches: Rust staining at cracks and spalls. RCP: No rust staining.	Boxes/Arches: Exposed steel reinforcement. RCP: Rust staining or exposed steel reinforcement.	Significant section loss of steel reinforcement that causes pipe deformation, holes in pipe walls and embankment and/or roadway damage.

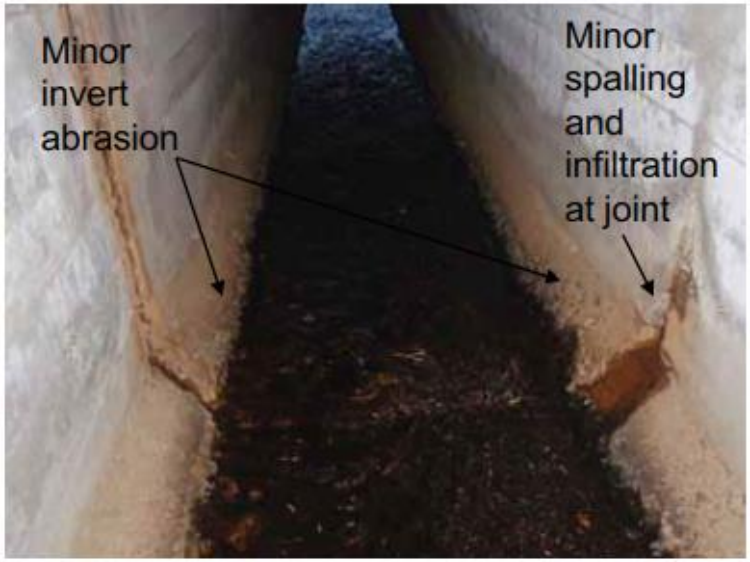
CONCRETE BOX / ARCH – GOOD



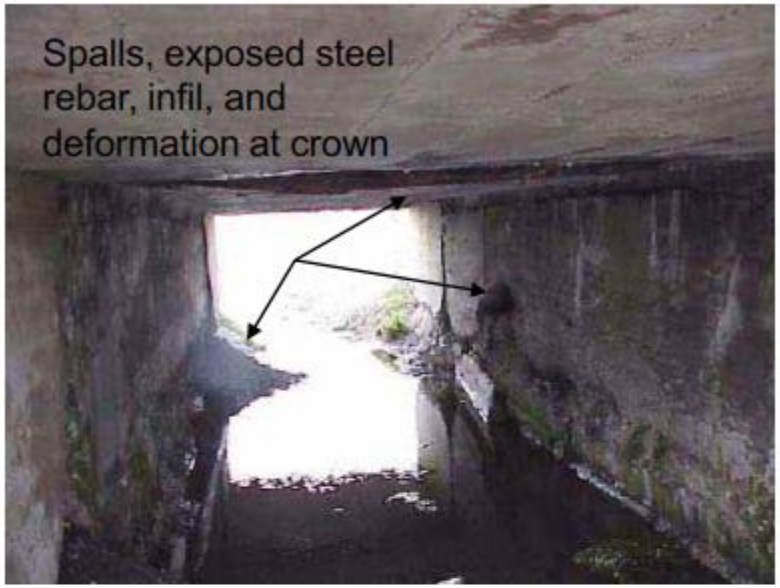
CONCRETE BOX / ARCH – FAIR

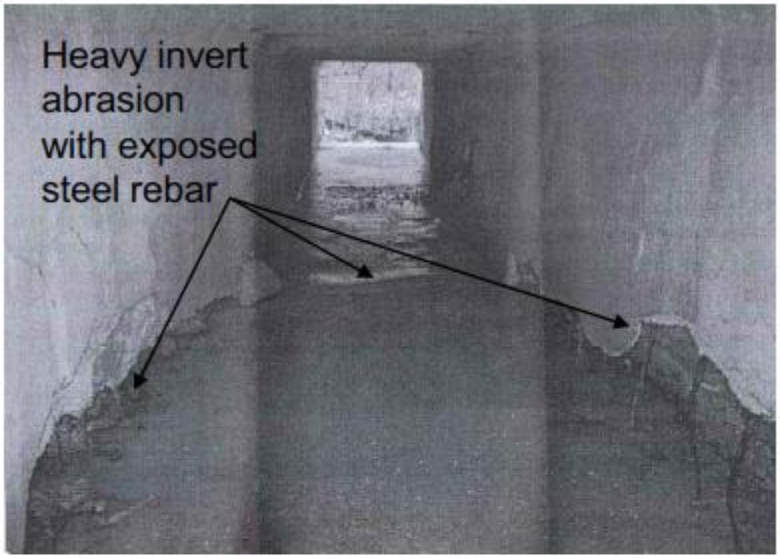


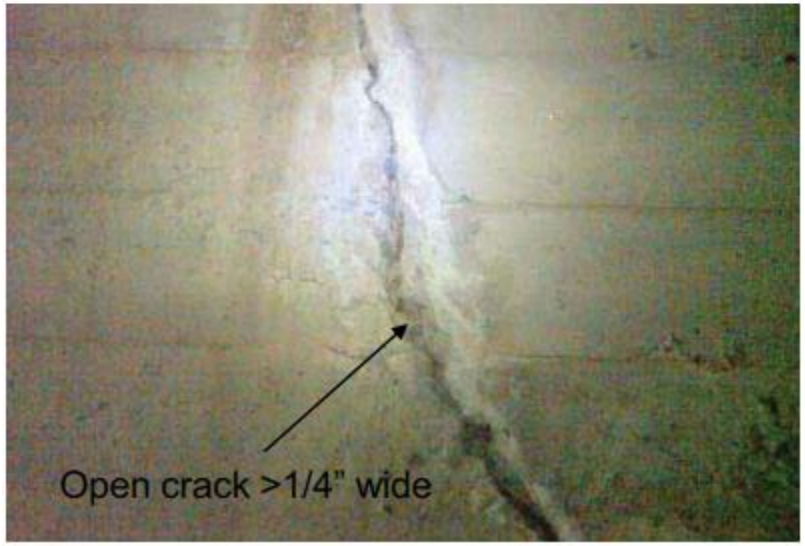




CONCRETE BOX / ARCH – POOR

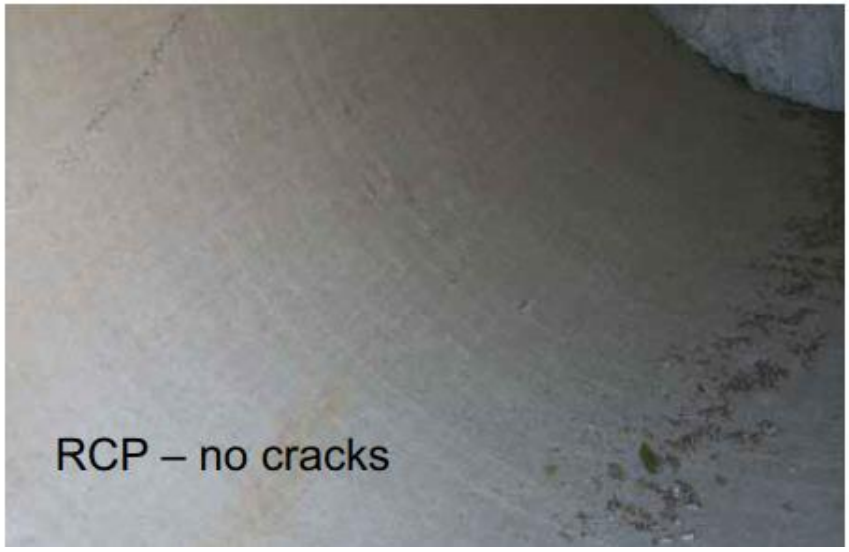


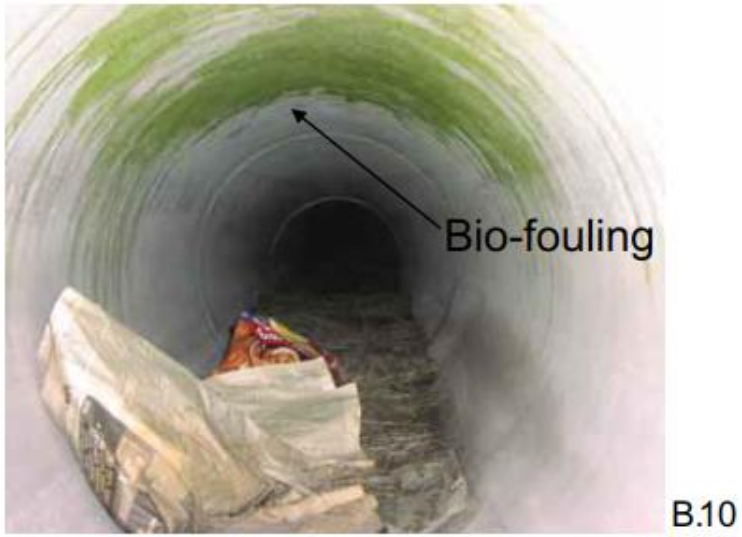




CONCRETE BOX / ARCH – VERY POOR

REINFORCED CONCRETE PIPE – GOOD



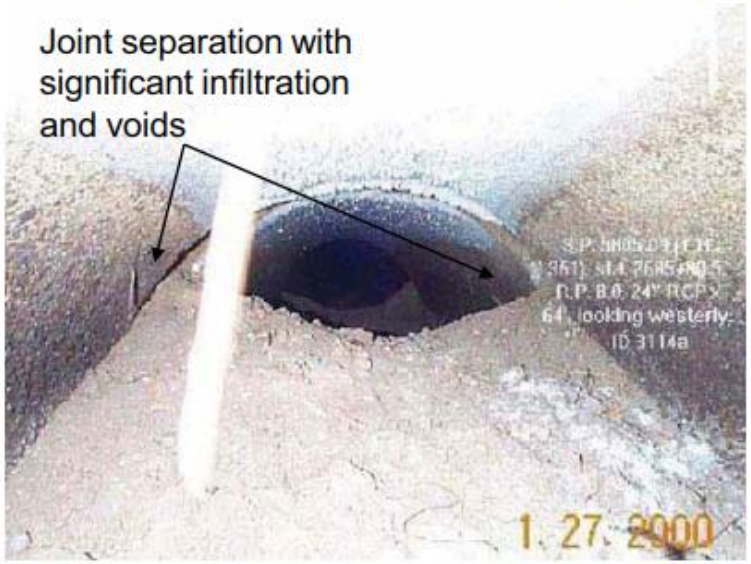


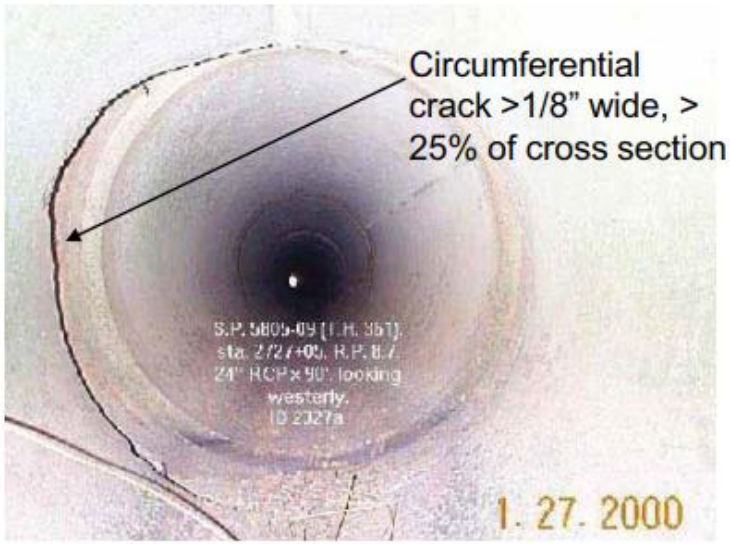
B.10

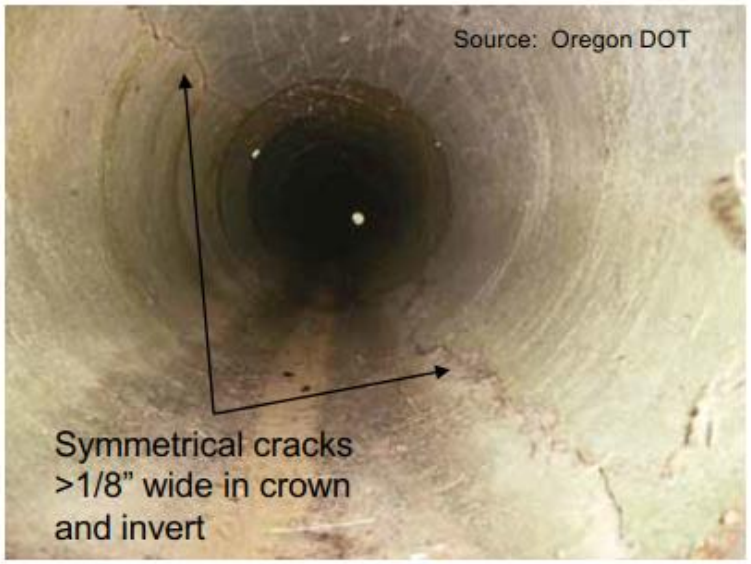
REINFORCED CONCRETE PIPE – FAIR

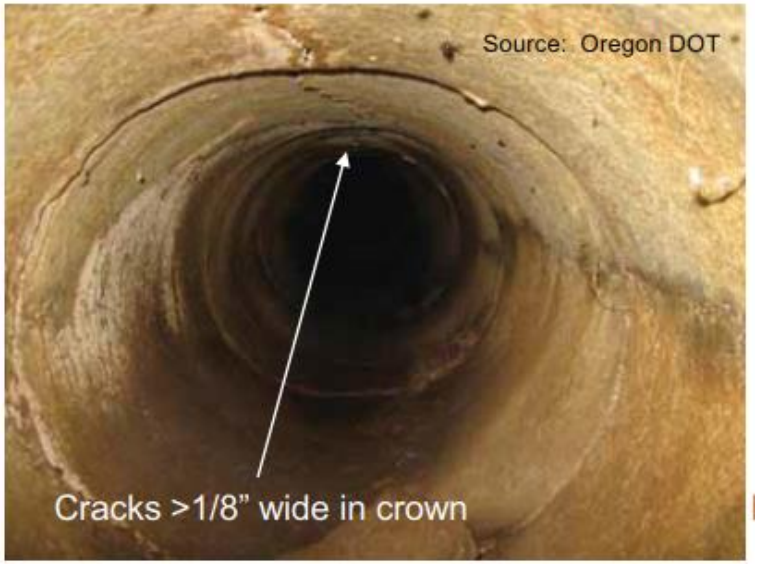
B.11

REINFORCED CONCRETE PIPE - POOR

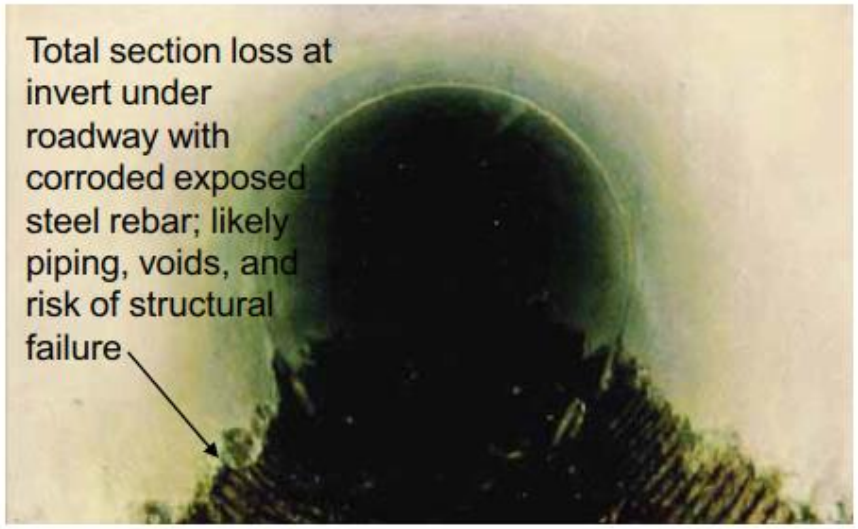


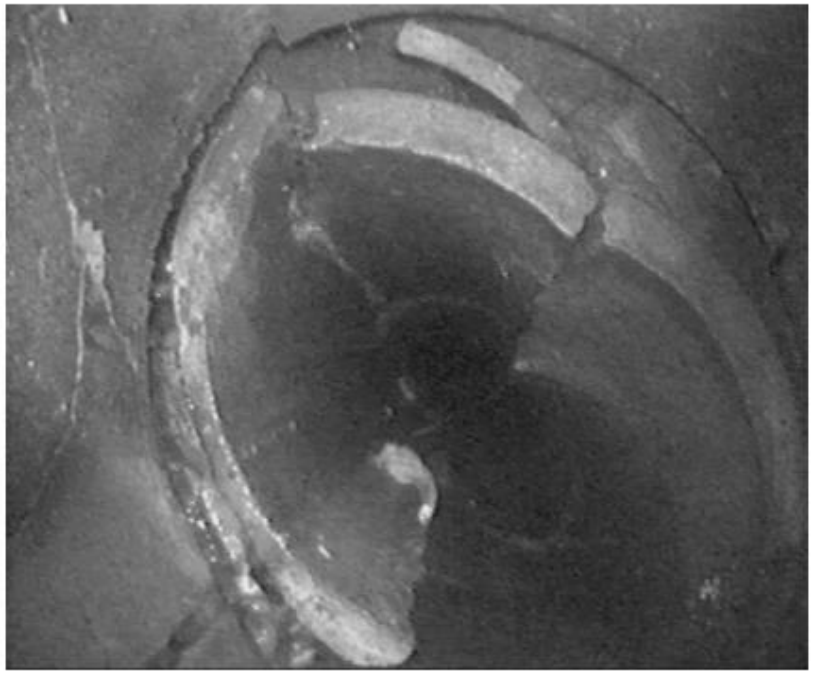






REINFORCED CONCRETE PIPE – VERY POOR





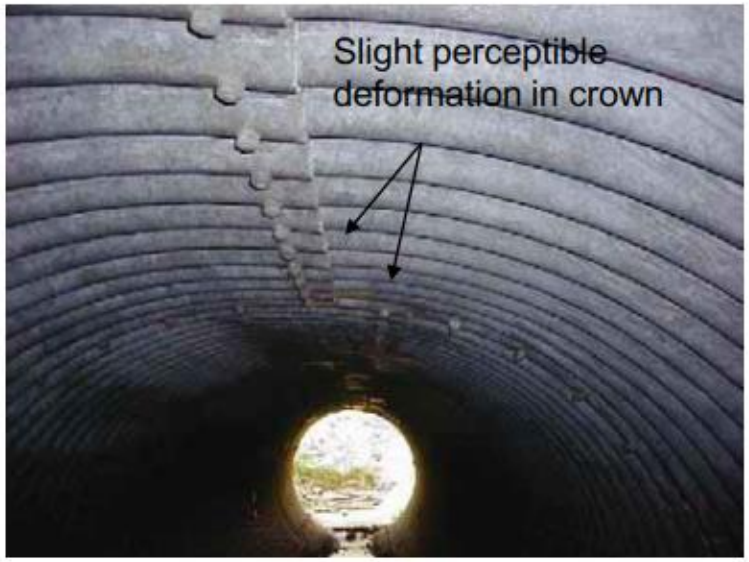
B.17

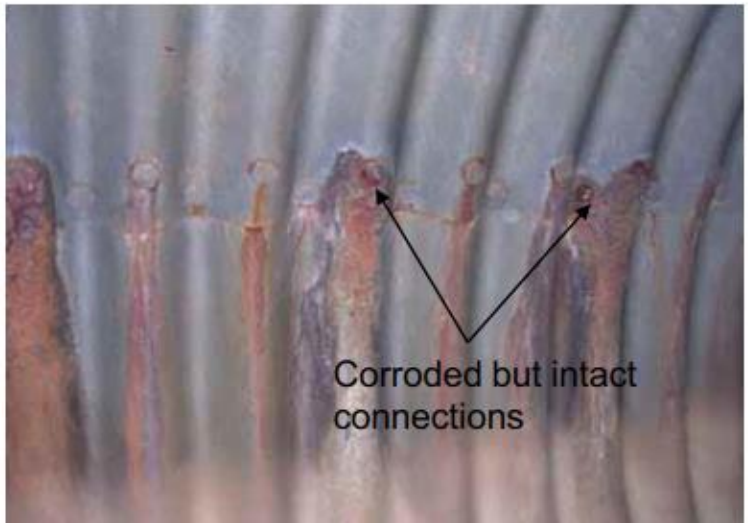
Table 4.5.3 – Metal Condition Matrix

Element	Very Good	Good	Fair	Poor	Very Poor
Invert Deterioration	No coating loss.	Little or no coating loss, and/or light rust staining, but no metal section loss.	General corrosion, scaling or pitting with coating loss, but significant remaining metal section.	Perforations visible or easily made by hammer test strike in invert area.	Significant section loss in invert beyond perforations resulting in extensive voids beneath invert.
Joints and Seams	Smooth, tight joints.	Minor damage with no separation gaps.	Open or displaced with minor infil/exfil of water and/or soil.	Open or displaced with significant infil/exfil of soil and/or water and voids visible.	Open or displaced with significant infiltration of backfill soil, and accompanying embankment/roadway damage.
Cross-Section Deformation	None observed.	None observed.	Slight perceptible deformation at worst section, or local bulging.	Deformation with accompanying longitudinal cracking or crushing in crown, invert or spring lines.	Excessive deformation resulting in extensive infiltration of backfill soil, void and piping with resultant embankment or roadway damage.
Corrosion (above invert)	No surface rust. No coating loss.	Little or no surface rust. Little or no coating loss.	Minor surface rust and limited pitting. Connection hardware corroded but intact.	Perforations visible or easily made by hammer strike above the invert. Connection hardware failing.	Significant section loss resulting in extensive infiltration of backfill soil, voids and embankment and/or roadway damage.

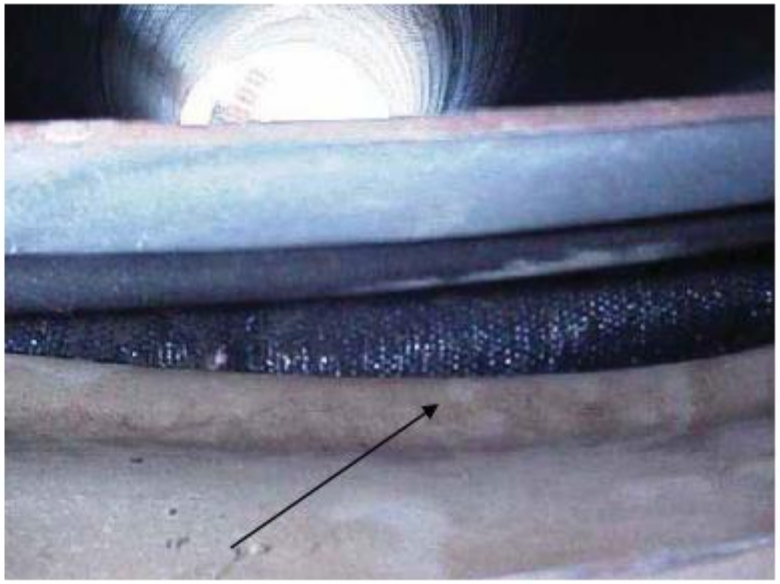
CORRUGATED METAL PIPE – GOOD

CORRUGATED METAL PIPE – FAIR





B. 20



B. 23

CORRUGATED METAL PIPE – POOR

B. 27


Deformation of crown with
possible seam damage

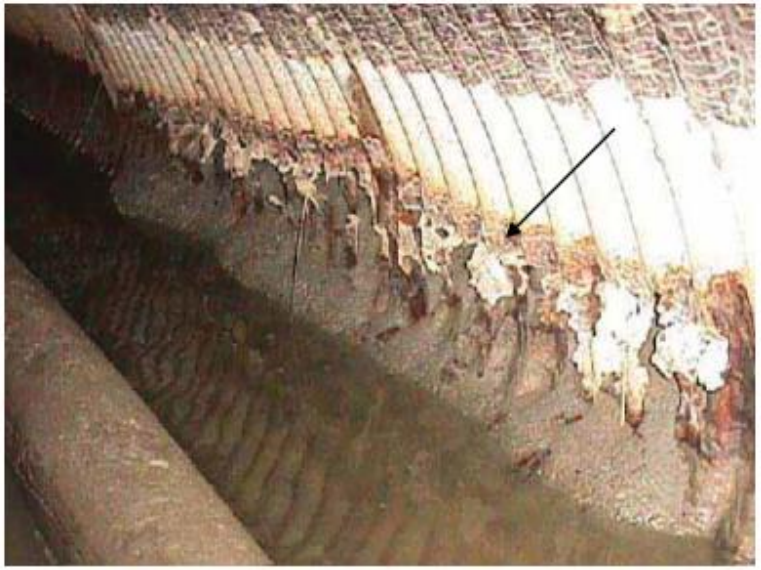

Invert perforation

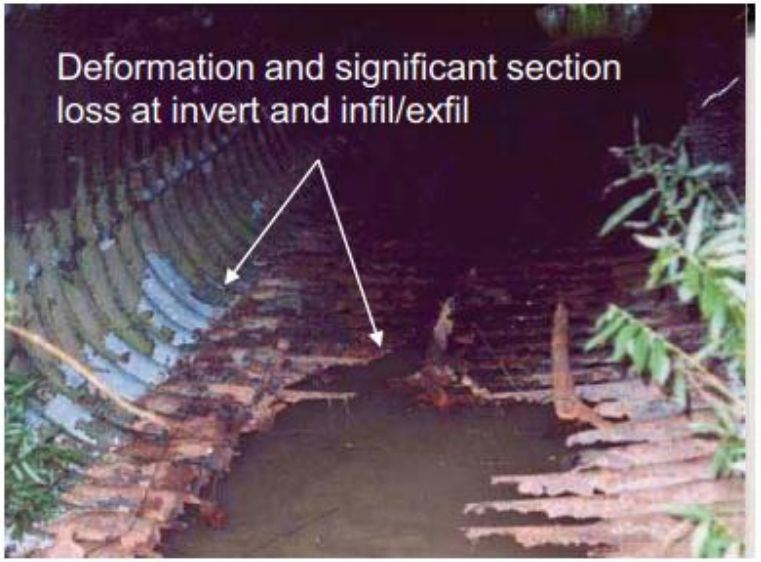

Significant soil infiltration from open joints

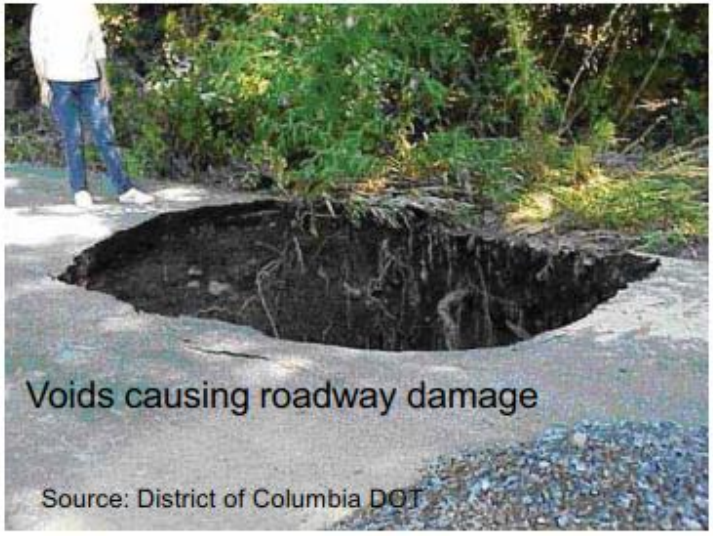

Significant open joints and deformation
11/7/2001

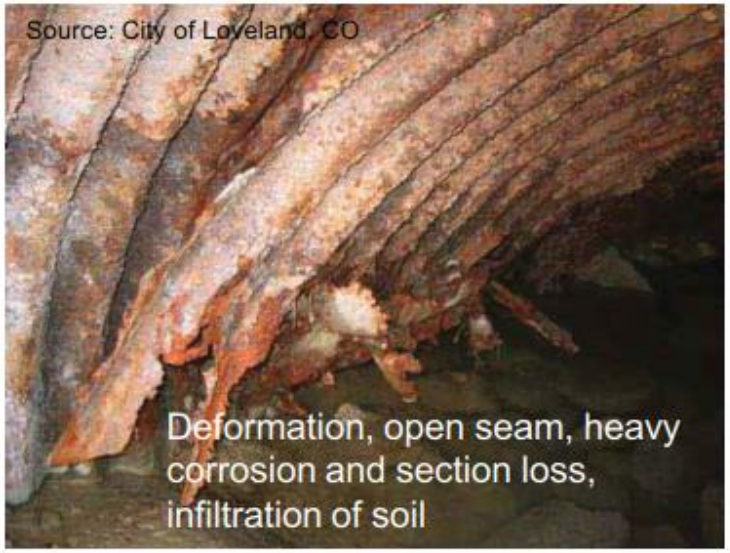
B. 28

CORRUGATED METAL PIPE – VERY POOR

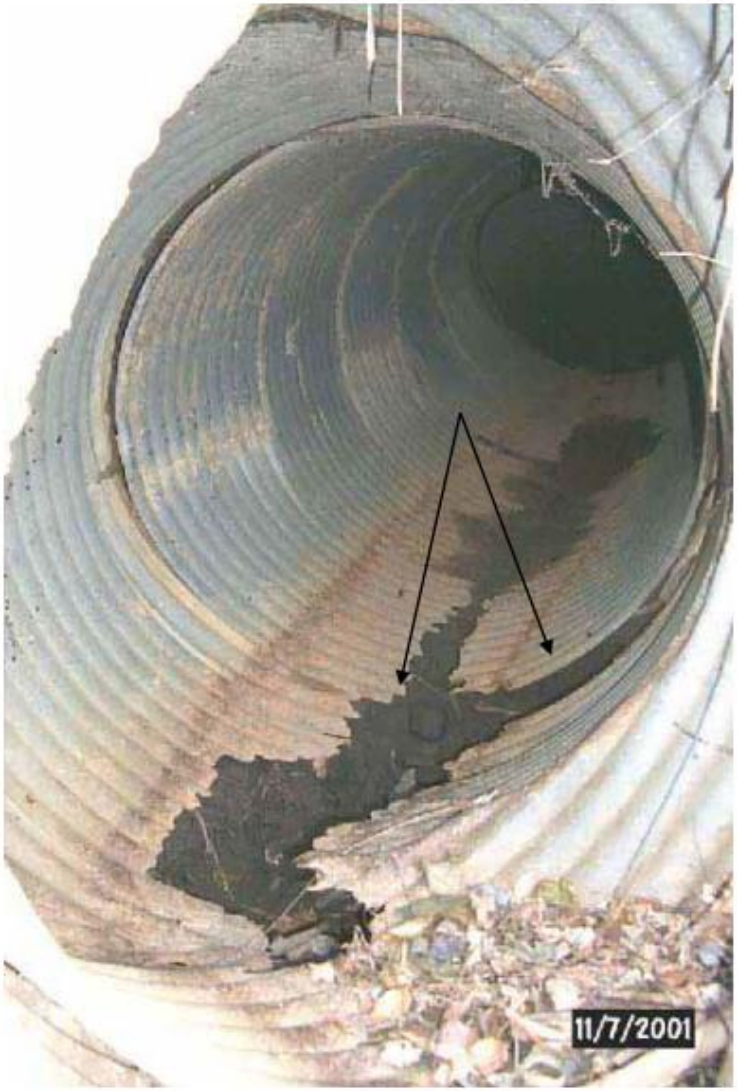








B. 29



B. 30

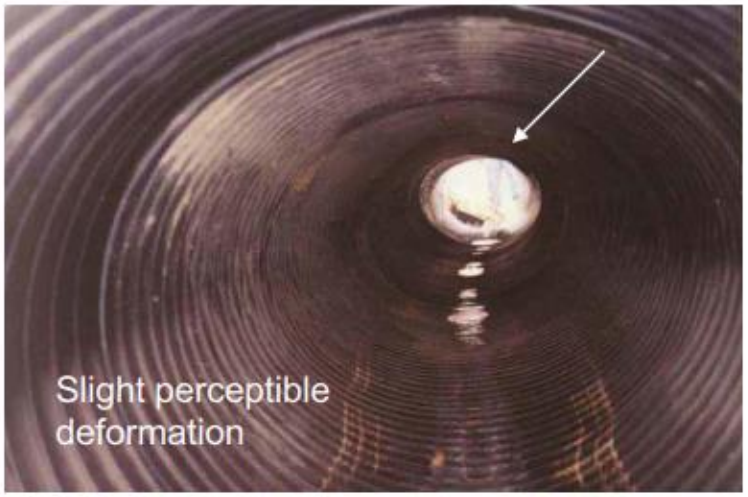
Table 4.5.4 – Plastic Condition Matrix

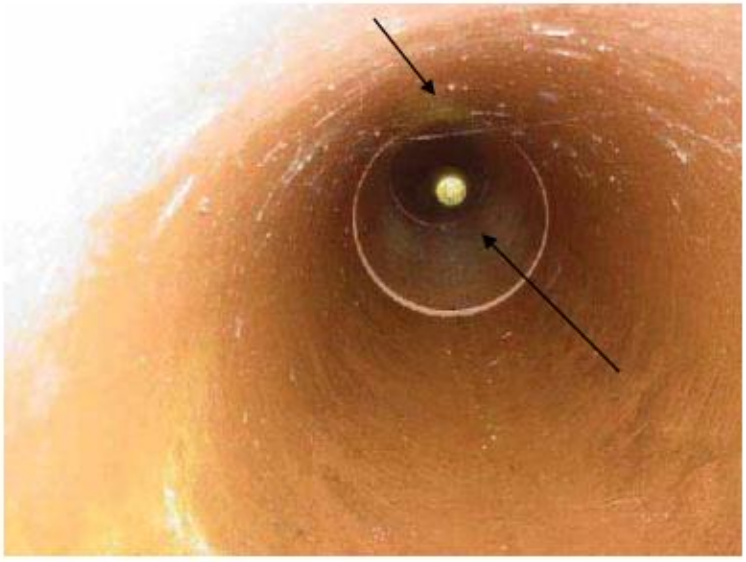
Element	Very Good	Good	Fair	Poor	Very Poor
Invert Deterioration	None.	None.	Minor wear or abrasion.	Significant wear and perforations.	Significant section in invert through outer wall of pipe resulting in voids beneath invert and/or embankment/roadway damage.
Joints and Seams	Smooth, tight joints.	Minor damage with no separation gaps.	Open or displaced with minor infil/exfil of water and/or soil.	Open or displaced with significant infil/exfil of soil and/or water and voids visible.	Open or displaced with significant infiltration of backfill soil, and accompanying embankment/roadway damage.
Cross-Section Deformation	None observed.	None observed.	Slight perceptible deformation at worst section, or local bulging.	Significant perceptible deformation.	Excessive deformation resulting in extensive infiltration of backfill soil, void and piping with resultant embankment or roadway damage.
Liner	Liner is smooth with no signs of re-corrugation.	Liner is smooth with no signs of re-corrugation.	Slight re-corrugation of inner liner or wall buckling. Splits, tears, and cracks <=6” long at limited sections.	Significant re-corrugation of inner liner or wall buckling. Splits, tears, and cracks at several locations >6” long.	Excessive tears, splits and/or bulges resulting in extensive infiltration of backfill soil, voids and piping with resultant embankment/roadway damage.

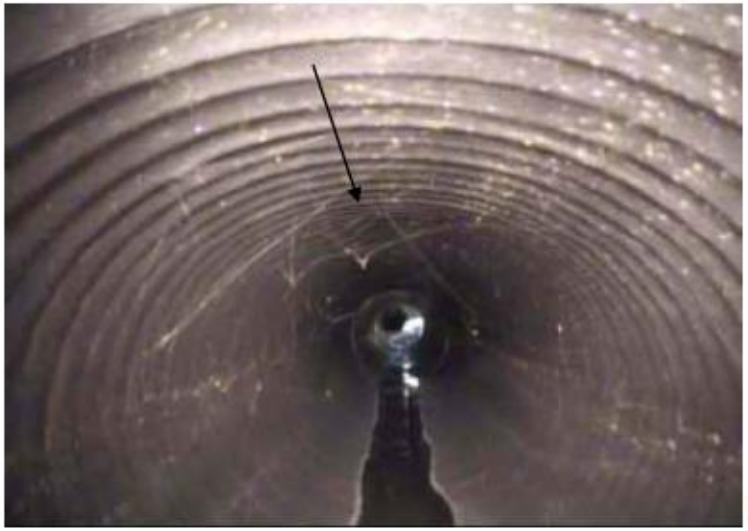
PLASTIC – GOOD

B. 33

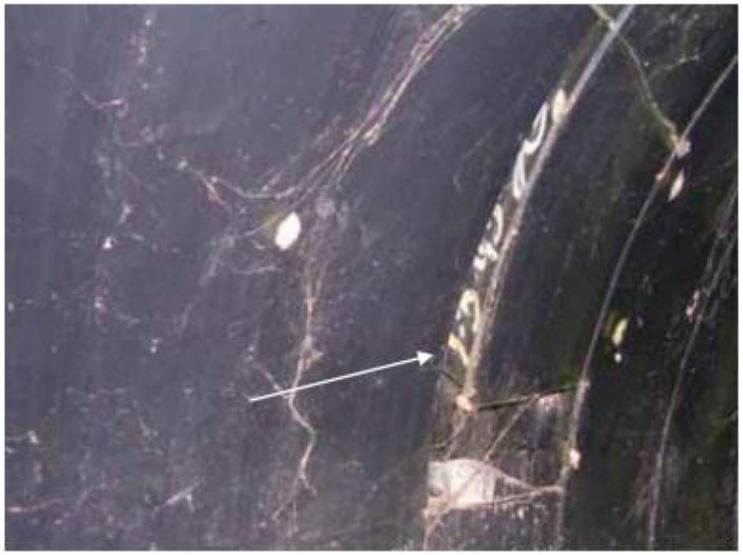
PLASTIC – FAIR

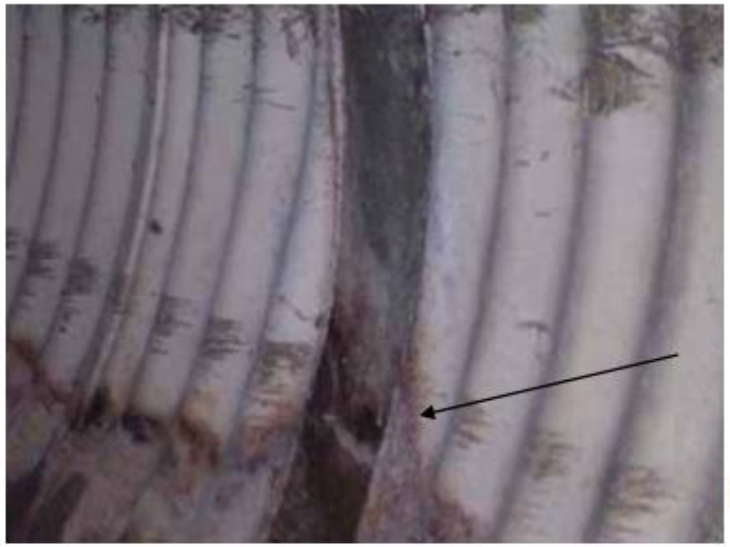






B. 34

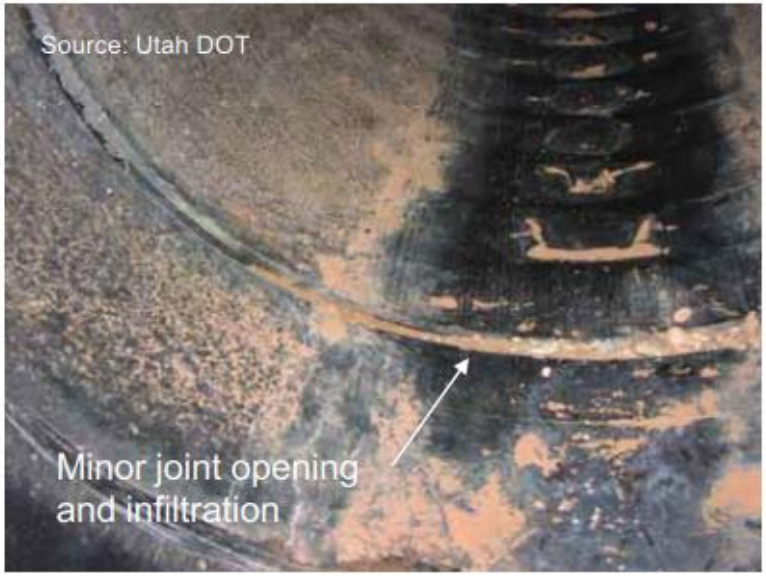




B. 35


Minor abrasion and
flattening corrugation

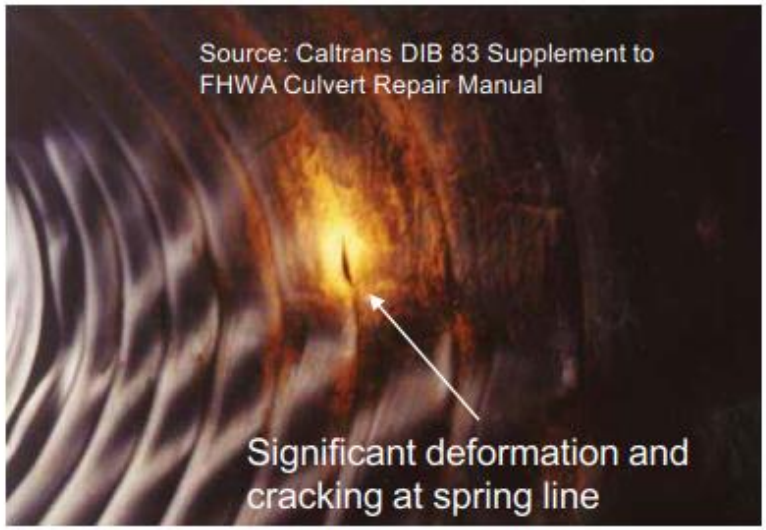

Slight recorrugation
of inner lining and
possible sediment
maintenance
(performance) issue

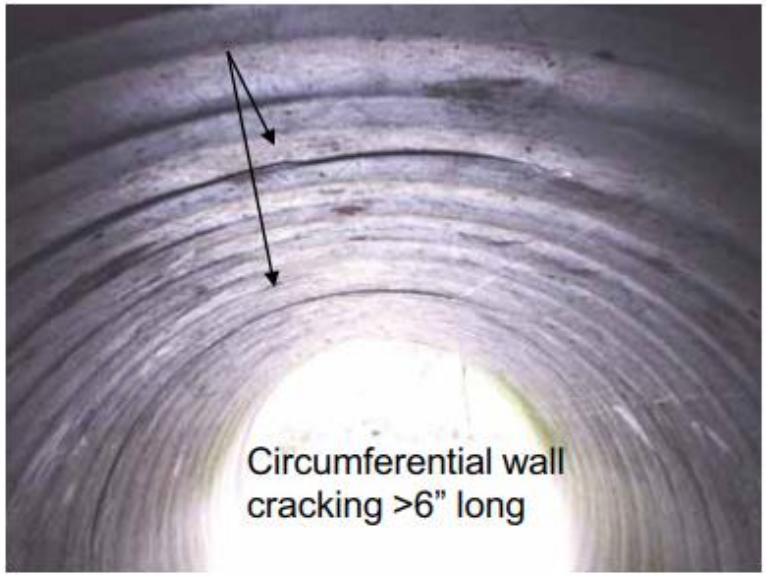

Source: Utah DOT
Minor joint opening
and infiltration


Minor wall tear <6" long
Source: Nevada DOT

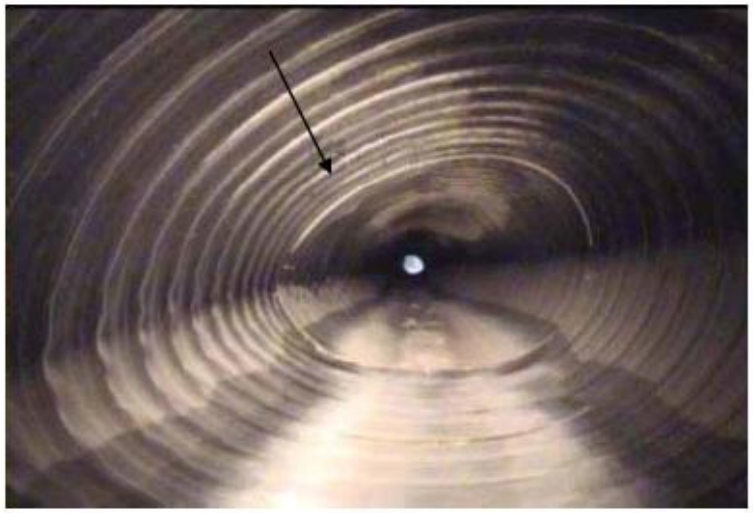
B. 36

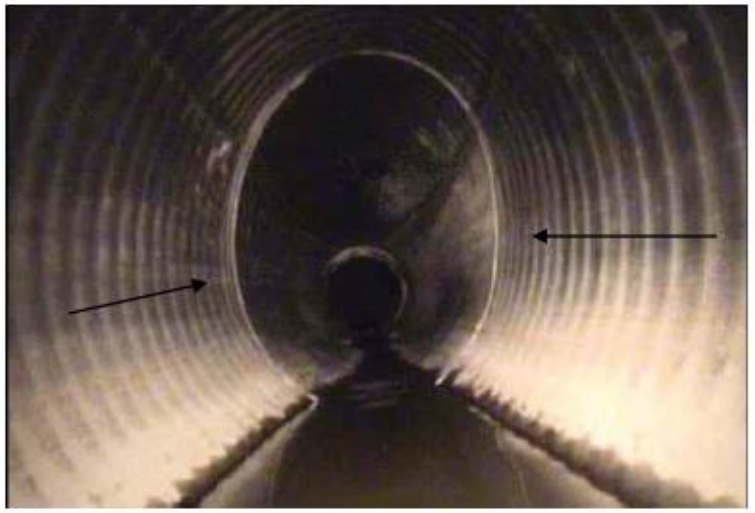
PLASTIC – POOR

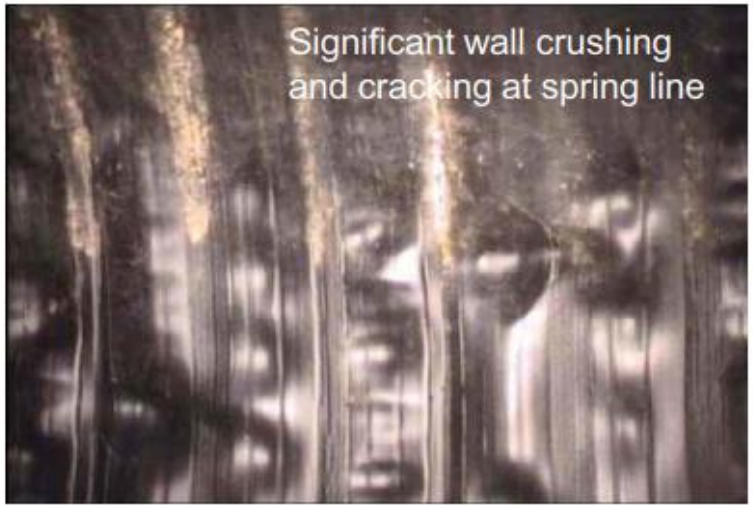


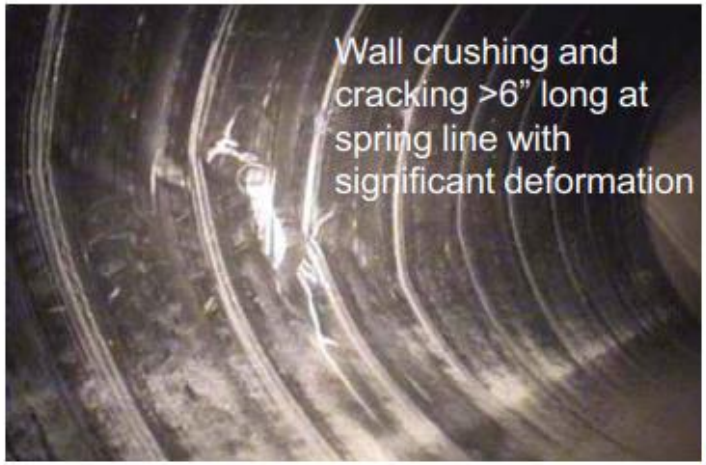


B. 38






Significant wall crushing
and cracking at spring line


Wall crushing and
cracking >6” long at
spring line with
significant deformation

B. 39

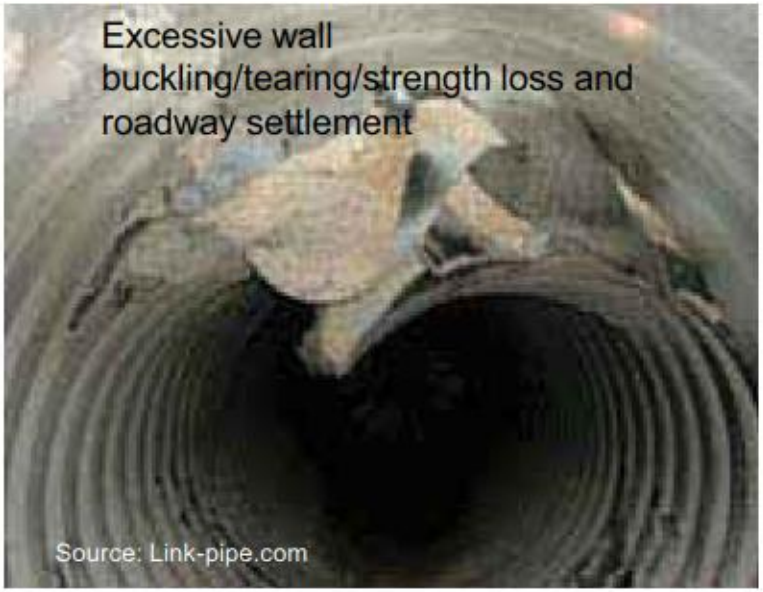

Excessive joint
displacement w/infiltration


Excessive joint
displacement w/infiltration


Crack/tear
> 6" long
Source: Oregon DOT

B. 40

PLASTIC – VERY POOR



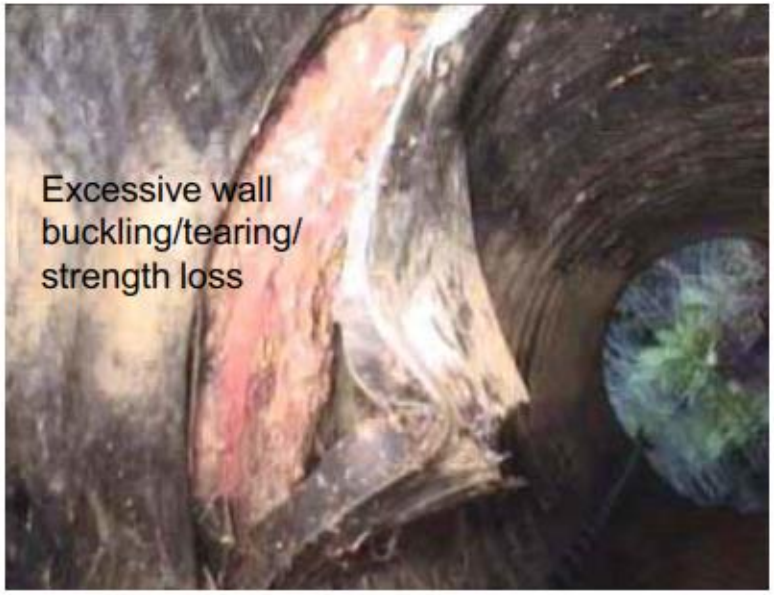


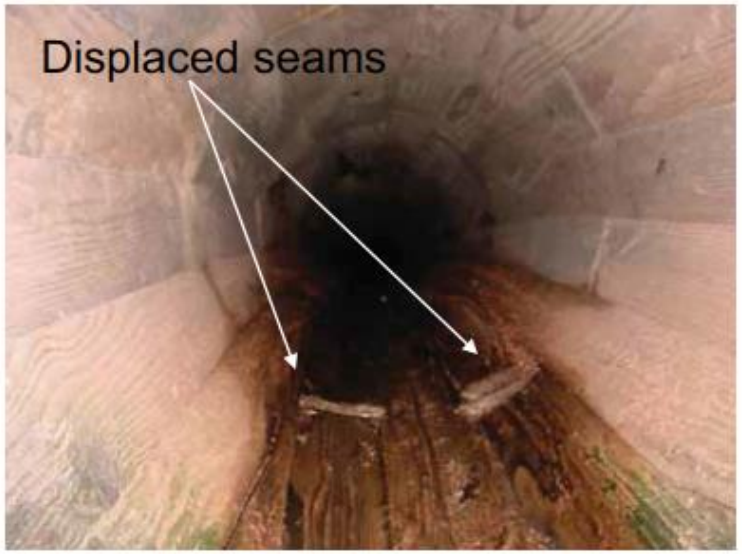
Table 4.5.5 – Timber Condition Matrix

Element	Very Good	Good	Fair	Poor	Very Poor
Invert Deterioration	None.	None.	Minor section loss with no perforations.	Significant section loss/perforations present with accompanying infiltration and voids.	Complete loss of section at invert resulting in extensive voids beneath invert/embankment/roadway.
Joints and Seams	None.	Minor damage with no separation gaps. Surface rusting of connection hardware.	Displaced or separated with minor infil/exfil, but no visible voids. Connection hardware corroded but intact. Perceptible deformation/ warping with minor crack	Open or displaced with significant infil/exfil of soil and/or water and voids visible.	Open or displaced with significant infiltration of backfill soil, and accompanying embankment/roadway damage.
Cross-Section Deformation	None observed.	None observed.	Slight perceptible deformation at worst section, or local bulging.	Significant perceptible deformation.	Excessive deformation resulting in extensive infiltration of backfill soil, void and piping with resultant embankment or roadway damage.
Liner	Liner is smooth with no signs of re-corrugation.	Liner is smooth with no signs of re-corrugation.	Slight re-corrugation of inner liner or wall buckling. Splits, tears, and cracks <=6” long at limited sections.	Significant re-corrugation of inner liner or wall buckling. Splits, tears, and cracks at several locations >6” long.	Excessive tears, splits and/or bulges resulting in extensive infiltration of backfill soil, voids and piping with resultant embankment/roadway damage.

TIMBER – GOOD

B. 43

TIMBER – FAIR

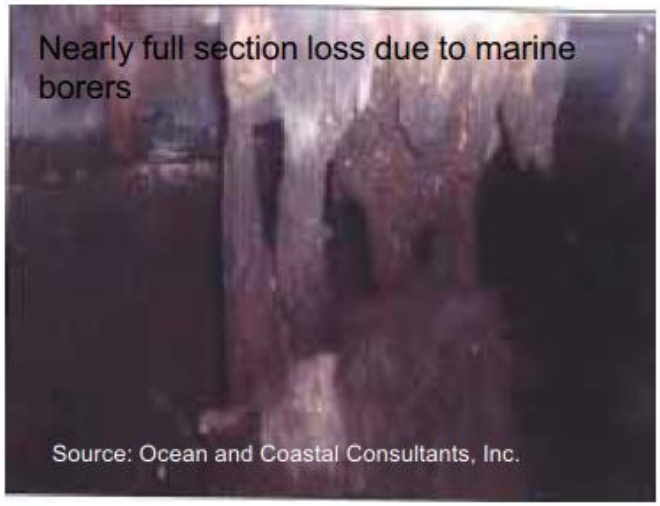


B. 44

TIMBER – POOR

B. 45

TIMBER – VERY POOR



B. 46

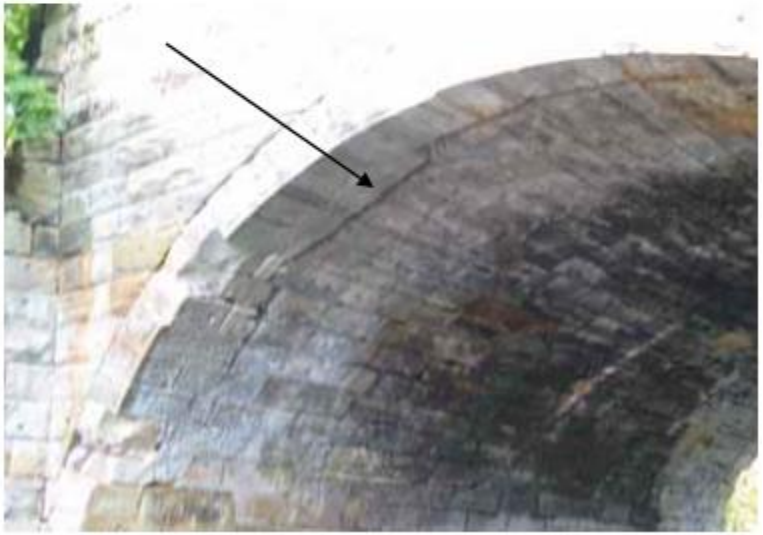
Table 4.5.6 – Masonry Condition Matrix

Element	Very Good	Good	Fair	Poor	Very Poor
Invert Deterioration	None.	Minor scaling of joint material or blocks in invert area.	Mortar/block crushing and loss, loose blocks.	Displaced mortar/blocks, holes in invert area.	Significant holes and section loss at invert resulting in extensive voids beneath invert/embankment/roadway.
Cross-Section Deformation	None observed.	None observed.	Minor cracking visible, but no perceptible deformation.	Perceptible deformation, and longitudinal cracks in crown, invert or spring lines.	Holes and gaps have led to extensive infiltration of backfill soil and resultant embankment/roadway damage.
Mortar and Masonry	No deterioration.	Isolated, minor mortar deterioration. All blocks in place and stable.	Mortar/block crushing and loss, loose blocks. Minor infil/exfil of soil.	Missing or displaced blocks. Infiltration and voids.	Widespread holes have led to extensive infiltration of backfill soil, voids, and piping with resultant embankment/roadway damage.

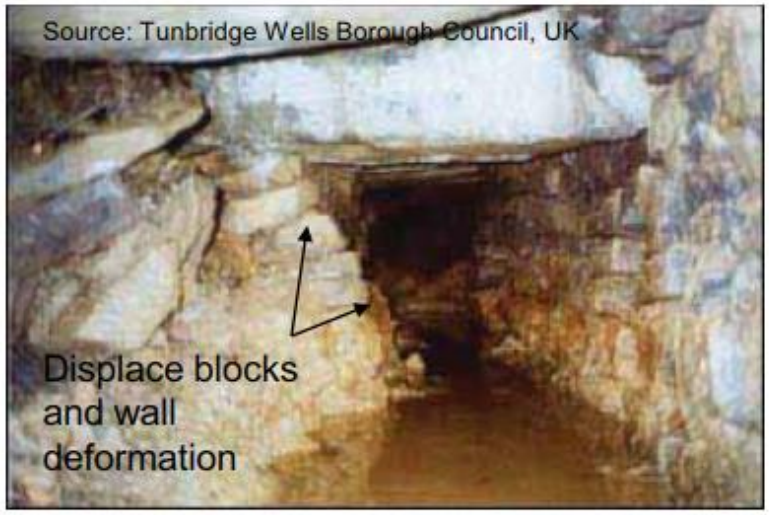
MASONRY – GOOD

B. 47

MASONRY – FAIR

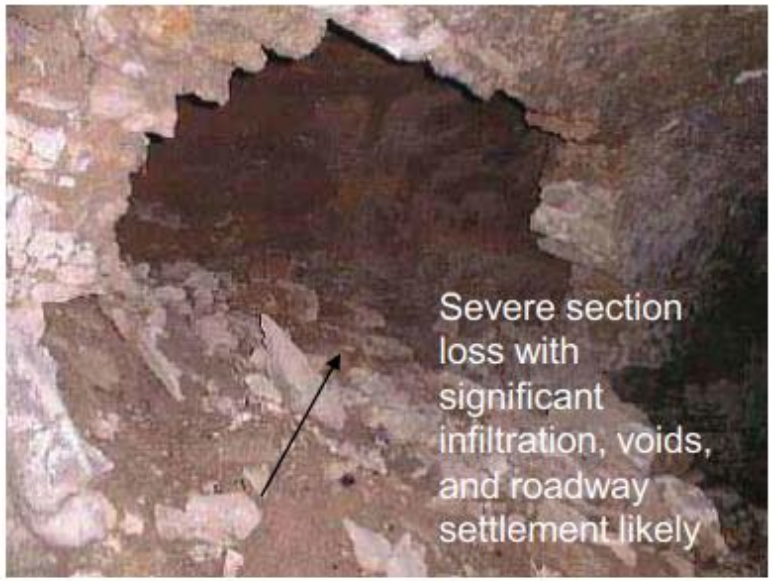


MASONRY – POOR



B. 49

MASONRY – VERY POOR



B. 50

Table 4.5.7 – Appurtenances Condition Matrix

Element	Very Good	Good	Fair	Poor	Very Poor
Headwall / Wingwall	No cracking, rotation, or displacement. No surface deterioration (timber rot, metal corrosion or scaling). No footing exposed.	Little cracking, rotation or displacement. Light surface deterioration. No footing exposed.	Minor cracks and spalls in concrete. Minor rotation/displacement with gap in barrel seam. Minor footing exposed.	Area affected by cracking and spalling is >50% and/or rebar exposed. Significant displacement at cracks or wall rotation causing a gap at the wall-to-barrel interface >4”. Footing exposed and undermined.	Partially or totally collapsed, with resultant damage to embankment/roadway.
Apron	None.	None.	Minor cracking but no visible piping or undermining.	Significant cracking affects >50% of apron. Significant piping or undermining.	Partially or totally collapsed, significantly effecting performance and/or causing embankment/roadway damage.
Flared End / Pipe End Section	No visible cracking, deterioration, or deformation. No undermining,	Little visible cracking, deterioration, or deformation. No undermining,	Minor cracking, deterioration or deformation. Minor undermining.	Significant cracks, piping or undermining affects >50% of appurtenance. End crushed or separated from barrel.	Deterioration is significantly affecting performance and/or causing embankment/roadway damage.
Scour Protection	None.	Little or no displacement or undermining of individual rip rap or armor units. Tight interface with culvert structure.	Localized displacement of individual rip rap or armor units, undermining or deterioration. Slight separation at culvert interface.	Significant displacements, undermining or deterioration effecting the performance of the counter measure and culvert structure.	Partially or totally failed, significantly effecting performance and/or causing embankment/roadway damage.

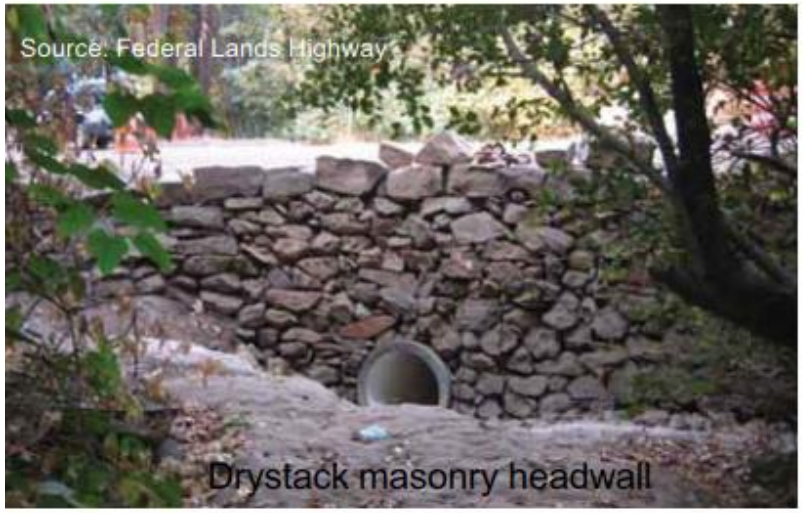
APPURTENANCES - GOOD

B. 51

B. 52


Surface corrosion staining of mitered end
Source: Federal Lands Highway


Drystack masonry headwall
Source: Federal Lands Highway


Source: Federal Lands Highway
Drystack masonry headwall


Projecting end section and gabion headwall
Source: Federal Lands Highway

B. 53


Minor edge spall at headwall joint
Source: Federal Lands Highway

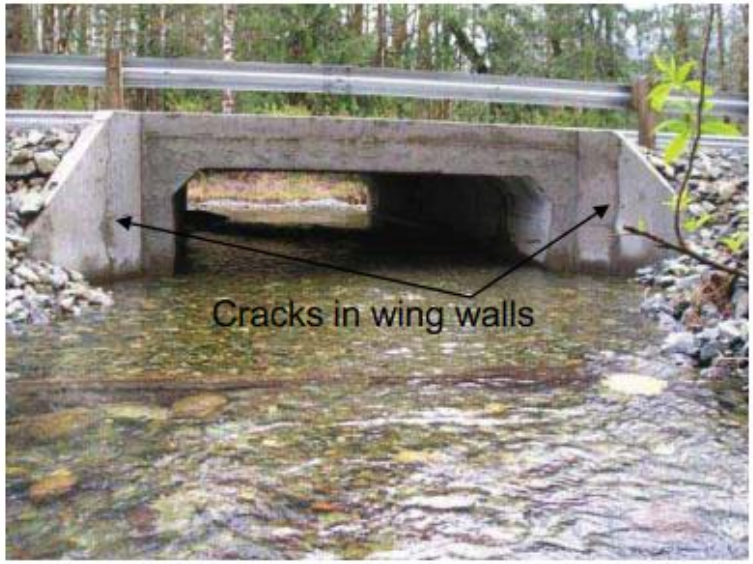

Grouted masonry apron

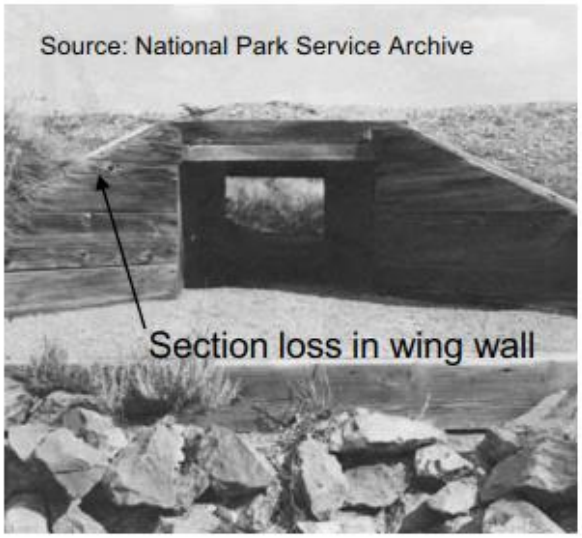

Metal flared end section
Source: Utah DOT


Plastic flared end section
Source: Utah DOT

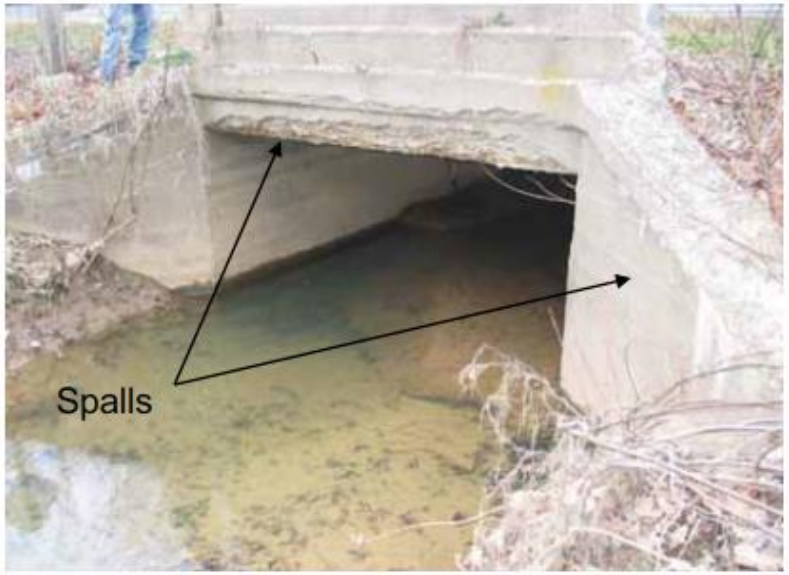
B. 54

APPURTENANCES - FAIR





B. 55


Spalls

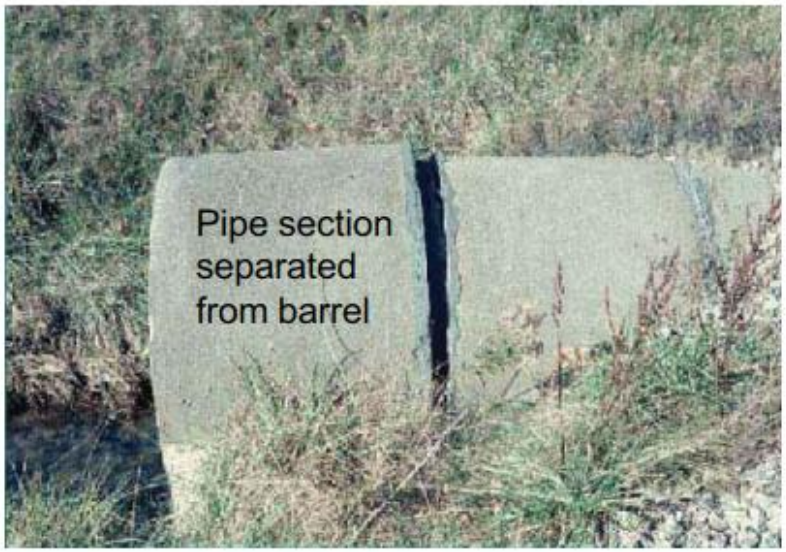

Cracks and spalls

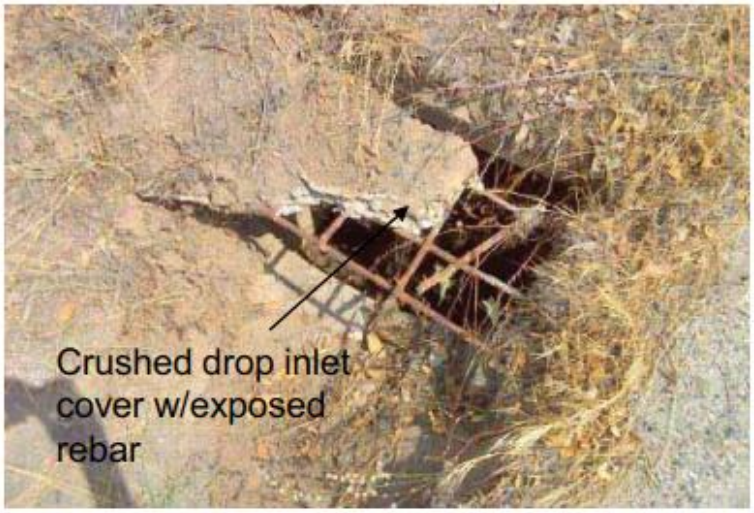

Localized holes <6" long
Source: Utah DOT


Source: Utah DOT
Minor pipe end section damage not affecting performance

B. 56

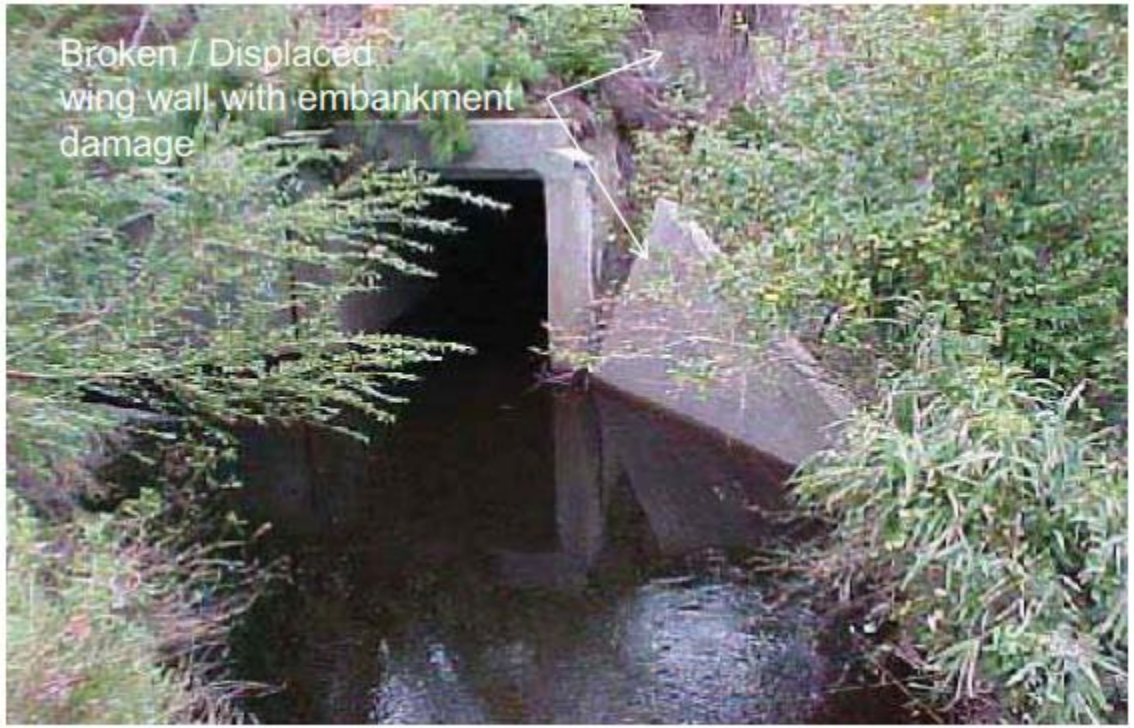
APPURTENANCES – POOR





B. 57

APPURTENANCES – VERY POOR



4.6 Storm/Sanitary Pipes and Manholes/Catchbasins

References:
(1) National Association of Sewer Service Companies (NASSCO), Pipeline and Manhole Assessment Certificate Program (PACP & MACP)
(2) City of Alameda, California: Sewer Master Plan, Chapter 4 – Condition Assessment

NASSCO PACP and MACP is the North American standard for pipeline and manhole defect identification and assessment. Under the PACP standard, all structural defects are assigned a Structural Grade of 1 to 5, with Grade 5 representing severe defects and Grade 1 representing minor defects. (Maintenance defects are assigned similar O&M grades.) The grades for individual defects observed on a pipe segment or manhole can be combined in various ways to determine an overall structural condition rating for the pipe. The PACP manual suggests several approaches for this purpose, including summing the grades of all defects or averaging the grades. While such approaches may be useful for screening pipes or manholes in terms of overall condition, they may not be particularly useful for prioritizing pipe replacement. What is most important in such decisions is the presence of major defects and the number of such defects. For example, a single Grade 5 defect in a pipe or manhole may require immediate action, while five Grade 1 defects would not, even though they both have a PACP overall segment grade score of 5.

For the purposes of evaluating the overall condition rating of a pipeline or manholes resulting from the various structural defects, a scoring system that consolidates the PACP grades was developed by the City of Alameda, California. The scoring system provides a single “total structural grade score (TSGS)” which ranges from 0 to 5 and accounts for multiple defect ratings and the number of defects. Using this approach, all pipes with at least one Grade 5 structural defect are given the maximum TSGS of 5, but lesser grade defects can also contribute to the overall condition rating depending on the number and grade of these defects. Figure 4, Table 4.6.1, and the following equations illustrate the calculation of total structural grade scores (TSGS).

Figure 4 - Calculation of Total Structural Grade Score (TSGS)

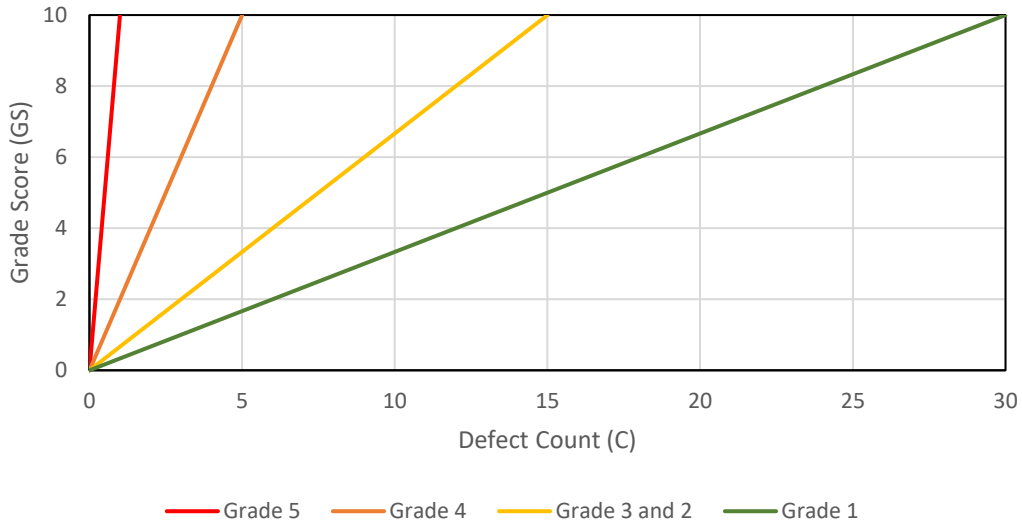


Table 4.6.1 - Grade Score Ratios

Defect Grade	Score Ratio (R)
5	5
4	1
3/2	0.333
1	0.166

Total Structural Grade Score Equations:

$$Grade\ Score\ (GS) = Score\ Ratio\ (R) * Defect\ Count\ (C)$$

$$Total\ Structural\ Grade\ Score\ (TSGS) = \sum GS_i$$

$$Maximum\ Score = 5$$

Total Structural Grade Score Example:

Defect Grade	Defect Count (DC)	Grade Score (GS)
5	0	5 * 0 = 0
4	3	1 * 3 = 3
3	5	0.333 * 5 = 1.66
2	2	0.333 * 2 = 0.66
1	6	0.166 * 6 = 1
Total Structural Grade Score (TSGS)		= 6.16 => 5.0

4.7 Guiderails

Reference: American Association of State Highway and Transportation Officials (AASHTO): Manual for Bridge Inspection

The overall condition rating of guiderails can be determined by evaluating each of the guiderail components individually and then averaging the total score. Three (3) guiderail components are identified:

1. Rail
2. Post
3. End Section

Definitions for the condition ratings of each component are summarized in Table 4.7.1.

Table 4.7.1 - Guiderail Condition Rating Descriptions

Condition	Description
1 – Very Good	The element has no deterioration and no preventative maintenance needs or repairs are required.
2 – Good	Element deterioration is insignificant to the management of the element and no preventative maintenance needs or repairs are required.
3 – Fair	The element has minor deficiencies that signify a progression of the deterioration process. Element may need preventative maintenance. Areas of the element that have received repairs, but the repair is considered equal to the original member.
4 – Poor	The element has advanced deterioration. This portion of the element may need condition based preventive maintenance or other remedial action.
5 – Very Poor	The element is no longer effective for its intended purpose.

As guiderail is a linear feature with potential varying condition along its length, the rail and post condition scores are given a corresponding percent of the total rail for each condition. For example, a relatively new rail installation that had minor impact damage affecting 20% of the length would receive a score of “3” for 20% and “1” for 80% of the rail, with a corresponding weighted condition rating of 1.4 => 1.0. Rail, post and end section condition formulas and the overall condition rating formula is presented in the tables below along with an example.

Table 4.7.2 - Rail Condition Ratings

Condition	Percentage of Rail	Rail Condition Rating
1	$\%_1$ = 0 to 100	$C_R = (1*\%_1 + 2*\%_2 + 3*\%_3 + 4*\%_4 + 5*\%_5)$
2	$\%_2$ = 0 to 100	
3	$\%_3$ = 0 to 100	
4	$\%_4$ = 0 to 100	
5	$\%_5$ = 0 to 100	

Table 4.7.3 - Rail Condition Ratings

Condition	Percentage of Posts	Post Condition Rating
1	$\%_1$ = 0 to 100	$C_P = (1*\%_1 + 2*\%_2 + 3*\%_3 + 4*\%_4 + 5*\%_5)$
2	$\%_2$ = 0 to 100	
3	$\%_3$ = 0 to 100	
4	$\%_4$ = 0 to 100	
5	$\%_5$ = 0 to 100	

Table 4.7.4 – End Section Condition Ratings

Condition	Number of End Sections	End Section Condition Rating
1	N_1 = 0 to 2	$C_{ES} = (1*N_1 + 2*N_2 + 3*N_3 + 4*N_4 + 5*N_5) / N_{total}$
2	N_2 = 0 to 2	
3	N_3 = 0 to 2	
4	N_4 = 0 to 2	
5	N_5 = 0 to 2	

Overall Guiderail Condition Rating Formula:

$C_{overall}$ = Average(C_R, C_P, C_{ES})

Example:

Condition	Rail	Post	End Section
1	0%	0%	0
2	60%	40%	1
3	20%	60%	1
4	20%	0%	0
5	0%	0%	0

C_R = (1*0% + 2*60% + 3*20% + 4*20% + 5*0%) = 2.6

C_P = (1*0% + 2*40% + 3*60% + 4*0% + 5*0%) = 2.6

C_{ES} = (1*0 + 2*1 + 3*1 + 4* + 5*0) / 2 = 3.0

$C_{overall}$ = Average(2.6, 2.6, 3.0) = 2.7 => **3.0 (Fair)**

4.8 Facilities

Reference: ASTM E1557 – 09: Standard Classification for Building Elements and Related Sitework—UNIFORMAT II

Facility condition assessments can be done in a variety of ways. The standard and most common methodology used is the Facility Condition Index (FCI). FCI provides a measure of the "catch-up" costs of a facility and is calculated with the following formula:

$$FCI = \frac{Total\ cost\ of\ existing\ repair\ or\ deferred\ maintenance\ (DM)}{Current\ replacement\ value\ (CRV)}$$

Table 4.8.1 - FCI Condition Ratings

Condition	FCI
Good	0 – 5%
Fair	5 – 10%
Poor	10 – 30%
Critical	30% +

However, this methodology is not suitable for the purposes of asset management. All components not requiring repair or having deferred maintenance will be "missed" in the assessment. As a result, a "bottom-up" approach is recommended to ensure all facility components are included. For this methodology, a simple visual assessment and discussion with facility operators will appropriately score each asset.

A facility component condition rating guide has been prepared to subjectively evaluate all components (Table 4.8.2). This guide provides descriptions for the various criteria which can be considered when determining a condition rating. When evaluating components, the highest score of the various criteria is used to determine the overall asset condition rating (i.e. a physical working condition score of 2 and an expected service life of 5, will result in an overall condition rating for the asset of 5).

Additional guidance has been provided to assist with the identification and classification of facility components (see Table 4.8.3). This list was prepared from the UNIFORMAT II building classification system (the activity-based categories reserved for construction planning were deleted) and was modified to accommodate the water and wastewater facilities in the City and adjusted some of.

Table 4.8.2 - Facility Component Condition Rating Guide

Condition Rating	Physical Condition	Expected Service Life
1 - Very Good	Excellent working condition. No signs of deterioration.	Like new. *(>65% life left)*
2 - Good	Minor signs of deterioration.	Approaching or at mid-stage of life. *(65% - 40% life left)*
3 - Fair	Some elements exhibiting major deficiencies.	Beyond mid-stage of life. *(40% - 20% life left)*
4 - Poor	Significant deterioration with localized areas of failure.	Needs to be replaced in the short-term. *(20% - 5% life left)*
5 - Very Poor	Asset is beyond repair and, generally, has completed failed.	Needs to be replaced almost immediately. *(<5% life left)*

Table 4.8.3 - Facility Component Classification Standard

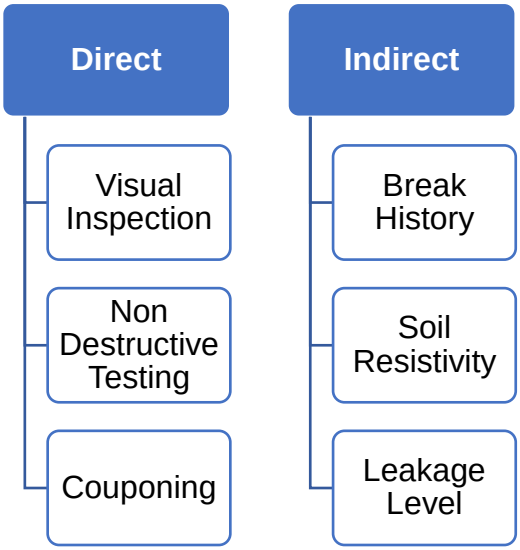
Component Category		
1	**2**	**3**
Substructure	Foundations	Standard Foundations
		Special Foundations
		Slab on Grade
	Basement Construction	Basement Walls
Shell	Superstructure	Floor Construction
		Roof Construction
	Exterior Enclosure	Exterior Walls
		Exterior Windows
		Exterior Doors
	Roofing	Roof Coverings
		Roof Openings
Interiors	Interior Construction	Partitions
		Interior Doors
		Fittings
	Stairs	Stair Construction
		Stair Finishes
	Interior Finishes	Wall Finishes
		Floor Finishes
		Ceiling Finishes
Services	Conveying	Elevators and Lifts
		Escalators and Moving Walks
		Other Conveying Systems
	Plumbing	Plumbing Fixtures
		Domestic Water Distribution
		Sanitary Waste
		Rain Water Drainage
		Other Plumbing Systems
	HVAC	Energy Supply
		Heat Generating Systems
		Cooling Generating Systems
		Distribution Systems
		Terminal and Package Units
		Controls and Instrumentation
		Other HVAC Systems and Equipment
	Fire Protection	Sprinklers
		Standpipes
		Fire Protection Specialties
		Other Fire Protection Systems
	Electrical	Electrical Services and Distribution
		Lighting and Branch Wiring
		Communications and Security
		Other Electrical Systems
Equipment and Furnishings	Equipment	Commercial Equipment
		Institutional Equipment
		Vehicular Equipment
		Other Equipment
	Furnishings	Fixed Furnishings
		Movable Furnishings
Building Sitework	Site Improvements	Roadways
		Parking Lots
		Pedestrian Paving
		Site Development
		Landscaping
	Site Mechanical Utilities	Water Supply
		Sanitary Sewer
		Storm Sewer
		Heating Distribution
		Cooling Distribution
		Fuel Distribution
		Other Site Mechanical Utilities
Process	Process Piping and Equipment	
	Process Structural	
	Process Instrumentation and Control	
	Process Electrical	

4.9 Water/Sanitary Pressure Pipes

Reference: US EPA: Primer on Condition Curves for Water Mains, Contract No. EP-C-05-057

Pressure pipes pose a unique problem to assess condition as they are typically buried underground and are continuously under pressure. However, direct and indirect methods are available to estimate current pipe condition. Available inspection methods are summarized in Figure 5.

Figure 5 - Pressure Pipe Condition Assessment Methods



For the City of Saint John, it is recommended that a break history analysis is done to estimate current pipe condition. The other methods were reviewed however it was determined they were not cost-effective. This method was selected as the City currently has the necessary data available and the cost to complete the assessments are minimal while still providing significant insight into the current condition of the pressure pipe network.

The most widely used approach to determining condition in pipes is with a pipe frequency curve. Most public utilities, like Saint John Water, keep a detailed record of pipe breaks. A pipe break frequency curve estimates the annual rate of pipe failures over time and can be classified for various pipe cohorts and groups. A generalized correlation between condition rating and pipe break frequencies has been established for the City of Saint John based on reviewed literature and is shown in Table 4.9.1 and Figure 6.

Table 4.9.1 - Pressure Pipe Condition Rating Guide

Condition	Break History (#/100km/yr)
1 – Very Good	< 5.0
2 – Good	5.0 – 12.5
3 – Fair	12.5 – 25.0
4 – Poor	25.0 – 60.0
5 – Very Poor	> 60.0

Figure 6 - Condition Rating and Pipe Break Frequency Conversion