

DRAFT
GROUT-IN-PLACE CULVERT LINING INVESTIGATION REPORT

4018-E-0001 ASSIGNMENT #5

GEOCRES NO:

Report to:

Ministry of Transportation Ontario
c/o WSP Canada Group Limited

October 2020
Thurber File No.: 28182



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1 INTRODUCTION

This report presents the results of an investigation into the quality of grouting operations at recent culvert lining sites across Eastern, Central and Northeastern Regions of Ontario. The purpose of the work was to investigate potential voids in the grout backfill between the host pipe and the liner pipe.

The Ministry provided an initial list of 99 culvert lining sites from contracts within the past five years. A preliminary screening of these 99 sites ruled out sites where entry was not possible due to the small liner diameter (<900 mm), sites with relatively deep open water at the inlet/outlet, and sites where it was known that the planned lining had been changed to a full replacement. Following the preliminary screening, twenty-three (23) culverts with work completed under 15 separate contracts in three separate regions (East, Central and Northeast) were carried forward for detailed investigation.

Details regarding the 23 culvert lining sites, including Highway number, MTO Region, GWP/WP numbers, contract number and general details such as the diameter of the host pipe and liner pipe are provided in Table 1 of Appendix A. The Culvert ID # (1 through 23) is provided in the first column. The original Culvert ID# from the original screening list of 99 culverts is included in the second column. Throughout the remainder of the body of this report, the current culvert numbering system (1 through 23) has been used.

This work was carried out under Work Order #5 of Engineering Retainer Assignment No. 4018-E-0001.

2 INVESTIGATION METHODOLOGY

The investigation was carried out in two phases as described below:

Phase 1 consisted of a start-up meeting with MTO Foundations and the Region, and a desktop study that included a review of available documentation including contract drawings and specifications, contractor submissions and construction documentation such as inspection notes from the Contract Administrator.

Phase 2 consisted of a detailed investigation including the following:

- Visual assessment of the portions of the culverts accessible and visible at the time of the inspection and without the use of cofferdams or dewatering measures. The visual assessment was documented with photographs of the inlet, outlet and general conditions of the culvert and liner.

- Void screening for potential voids between the liner pipe and host pipe using a single sided radiation probe (InSight™ Lite).
- Four (4) probeholes (approximately 10mm dia.) were completed above the liner at the 12 o'clock position at both ends of the culvert and at two other locations between the ends at suspected void locations selected based on the void screening. Commonly, an additional control point probehole (approximately 10mm dia.) was completed to show no void for quality control.
- Endoscopy performed and documented at each probehole location to capture pictures and video recordings. The probeholes were patched using caulking upon completion.

The intent had been to complete the above scope of work on all 23 culvert sites listed in Table 1 (attached), however, during the course of the desktop review and field investigation planning, the number of culvert sites subjected to the full field investigation was reduced due to the following conditions and/or constraints:

- One culvert (#3) had been lined with a fold & form liner and therefore had no grout;
- Three (3) culverts (#10, 14 and 22) had not been lined;
- At three (3) culverts (#4, 13 and 17), the diameter of the liner had been reduced to <900mm, precluding person entry and detailed testing;
- Five (5) culverts (#5, 6, 7, 8 and 9) were previously inspected and tested in summer 2019. The 2019 test results have been incorporated into the current investigation;
- One (1) culvert (#1) had excessive sediment build-up preventing access for testing;
- One (1) culvert (#11) was within an active construction zone and the Contractor would not grant permission to complete the inspection/testing during the available work window.

A full field investigation of the remaining nine (9) culverts was performed.

The InSight™ Lite screening, probeholes, and endoscopy were carried out by Inversa Systems Inc. (Inversa) under the supervision of Thurber Engineering Ltd. (Thurber).

3 INVESTIGATION RESULTS

3.1 Phase 1 – Desktop Study

A detailed summary of the document review findings, along with general site observations and site photos for each culvert is provided in Appendix B. Key observations include the following:

- Culvert 3 was specified to be lined with a fold & form liner which does not require grouting.
- The 22 grout-in-place culvert lining sites (excluding Culvert 3) were part of 14 separate contracts spanning 4 contract years (2016 through 2019).

- Of the 22 grout-in-place culvert lining sites, the specified liner types were as follows:
 - 16 sites with HDPE liners
 - 4 sites with CSP liners
 - 1 site with a structural plate corrugated steel pipe (SPCSP)
 - 1 site with a Structural Tunnel Liner.
- MTO staff indicated that the grout-in-place liners were not installed at Culverts 10 and 14.
- Contract documents were not received for Culvert 13.
- The culvert lining work at all culvert sites where contractual documents were provided, was specified to be in accordance with SP 9999-0440. Section 5.0 *Materials* of the SP for nine (9) of the sites indicated that “Grout shall conform to the pipe manufacturer’s recommendations and specifications.”. For the remainder of the sites, the SP indicated that “Grout shall consist of a mixture of one part Portland cement conforming to CAN/CSA-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic”.
- Construction documentation (e.g. grout mix and general methodology) was available for 17 of 23 culverts. Construction details were not provided for Culverts 3, 10, 14, 15, 22, and 23. In general, details regarding the construction methodology were fairly generic and did not provide details on the number and location of grout and vent tubes, or an assessment of actual versus theoretical grout volumes.
- The construction documents for Culvert 13 indicate that the host pipe was ovalized and would not accommodate the specified liner pipe (1022 mm dia.). The contractor requested to reduce the liner diameter to 865 mm, and this was accepted by the Ministry. The reduced size meant that the liner was too small to allow for the planned void screening.
- The construction documents for Culvert 17 indicate that the host pipe was in very poor condition with many broken joints and ovalized sections in four different locations. The host pipe would not accommodate the specified liner pipe (1220 mm dia.). The contractor requested to reduce the liner outer diameter to 861 mm. During the Phase 2 site inspection, it was confirmed that the liner that was installed has an internal diameter of approximately 762mm. The reduced size meant that the liner was too small to allow for the planned void screening.
- The construction documents for Culvert 18 (75) indicate that the specified liner pipe (1000 mm dia.) does not provide sufficient grout area between the host and the liner. The contractor requested to reduce the liner diameter to 900 mm, and this was accepted by the Ministry.
- The construction records indicate that the grout mix for fifteen (15) of the culverts included a foaming agent.



- Of the 19 culvert sites at which the grouting work had been completed, the same grouting contractor (Provincial Underground Services Ltd.) worked on 16 of the 19 culverts, Marathon Underground Ltd. was the grouting contractor for one site and the grouting contractor for the other two sites was not known.

3.2 Phase 2 - Detailed Investigation

The Phase 2 field investigations were completed between July 13 and 27, 2020. The InSight™ Lite void screening, probeholes, and endoscopy were carried out by Inversa Systems Inc. (Inversa) under the supervision of Thurber Engineering Ltd. (Thurber). A detailed condition assessment report was prepared by Inversa for each culvert; these reports are provided in Appendix C along with the detailed condition assessment reports for the five (5) culvert sites completed in 2019.

Observations and findings of the detailed investigations include the following:

- The grout-in-place liner work for Culvert 22 was on-going in Summer 2020 and the grouting had not been completed at the time of the detailed field investigation.
- At Culvert 4, the liner pipe was only visible at the outlet end and was measured to be approximately 530 mm, significantly less than the specified diameter of 1020 mm. The liner diameter was too small to allow for void screening. It was also noted that the host CSP at the inlet was broken and plugged with soil including cobbles and boulders. Grout pipes were noted at the inlet extending through a spray foam bulkhead.
- The In-Sight™ Lite screening tool identified frequent potential voids along the majority of the culvert length of Culverts 2, 5, 6, 7, 8, 9, 16, 18 and 19. Testing at Culverts 15, 20 and 21 indicated voids were more localized. The extent of voids is shown on the SoilSight™ Pipe Map in the Inversa reports in Appendix C.
- The probeholes and endoscopic photography provided a clear confirmation of the presence of grout/concrete versus voids after voids were observed using In-Sight™ technology but is only representative of a very small drill location with an approximate diameter of 10mm.
- At some locations (e.g. Culvert 4 and 16), the host pipe and end of the grout were not visible and may have been buried within embankment fill.
- The annular space between the host pipe and liner at the outlet end of Culvert 17 was filled with spray-foam and sand that was painted grey. Based on the available construction documents, it appears that spray foam was used to construct the bulkheads.
- There is insufficient data to draw any conclusions regarding the extent of voids in relation to pipe diameter, liner pipe material, or width of annular space. In addition, since Thurber did not witness the liner installation and grouting procedures, it is difficult to draw conclusions regarding specific construction activities that may have impacted the results.

- A general summary of the extent of voids detected by the In-Sight™ Lite screening is provided in Table 3-1. The maximum void length is the estimate of the longest continuous void.

Table 3-1. Phase 2 Testing Program

Culvert ID # (original No)	Culvert Length (m)	Maximum Void Length⁽¹⁾ (m)	Approximate Percent Void⁽¹⁾ (%)	Comments
2 (6)	35.0	12	24	Full annular void present along the northern two thirds of the culvert length; most prevalent near the springline.
5 (22) #6 in 2019	22.9	15	20	Full annular void present intermittently along full length of pipe
6 (24) #14 in 2019	22.2	22	67	Full annular voids detected along the majority of the culvert length within the upper 2/3 of the pipe.
7 (42) #4 in 2019	41.6	40	35	Full annular void present along the majority of the culvert length within the upper 2/3 of the pipe on the west wall; less voiding on east side
8 (46) #2 in 2019	31.0	6	50	Full annular void present along the majority of the culvert length within the upper 2/3 of the pipe on the north wall; less voiding on south side
9 (47) #1 in 2019	30.0	21	25	Full annular void present along the majority of the culvert length; most prevalent near the springline and near inlet.
12 (58)	41.9	1	<1	Localized small void near inlet
15 (69)	41.0	5	3	Localized void encountered above springline on north wall approximately 5m from inlet.
16 (71)	31.6	29	40	Full annular void present along springline along full length of pipe
18 (75)	41.4	37	50	Full annular void present along springline along almost full length.



Culvert ID # (original No)	Culvert Length (m)	Maximum Void Length ⁽¹⁾ (m)	Approximate Percent Void ⁽¹⁾ (%)	Comments
19 (76)	24.8	24	50	Full annular void present along full culvert length.
20 (77)	27.1	14	<10	Localized void(s) near crown of liner.
21 (78)	27.1	8	<10	Localized void(s) near crown of liner.
23 (80)	97.1	0	0	No Voids detected.

Notes: 1) Based on InSight™ Lite scans showing high probability of voids or other low density material.

4 DISCUSSIONS AND RECOMMENDATIONS

The results of the detailed investigation indicate that the majority of the 14 culvert sites had extensive voids in the annular void between the host pipe and liner pipe. As per the contract specifications, the annular void was to have been completely filled with grout. The sections below provide a discussion or remedial options for culverts with deficient grouting as well as a discussion of policy and standard considerations that might improve the quality of grouting on culvert lining projects in the future.

4.1 Assessment of Remedial Options

Remedial options for the culverts where extensive voids in the grouting between the host pipe and liner pipe include:

- 1) Do nothing and accept that the lined culvert may have a reduced service life and a risk of loss of soil from around the host pipe into the voids which could lead to settlement of the overlying pavement structure or even sinkholes.
- 2) Do nothing in terms of repairs but implement a monitoring program in the hopes of identifying the start of performance problems so that remedial measures (e.g. grouting or culvert replacement) can be completed before the performance issues become severe.
- 3) Supplemental grouting. Carry out supplemental grouting to fill the voids between the host pipe and liner pipe so that the condition is similar to the original design intent.

These remedial options are compared in terms of advantages, disadvantages, relative cost, risks/consequences in the table provided in Appendix D.



From a foundation engineering perspective, supplemental grouting is the preferred option as it will provide the best long term performance, the least risk and provides an end result similar to the design intent of the contracts that recommended grout-in-place liners.

4.2 Site Specific

No voids were detected in the grout between the liner and host pipe at Culvert 23. No remedial actions are required at this site.

One localized small void was detected near the inlet of Culvert 12. Based on the endoscopy images, the liner was in contact with the host pipe near this location. This anomaly is located outside of the highway platform and the remainder of the annular void appeared to be well grouted. No remedial actions are required at this site. Some erosion of the embankment sideslopes was noted and should be monitored and maintained by the local Area Maintenance Contractor.

The overall extent of voids at Culverts #20 and 21 (twin CSP's) was less than 10%, with the majority of the annular space appearing to be well grouted, however, the voids are concentrated above the crown of the liners beneath the highway platform. It is recommended that supplemental grouting be completed to fill the voids.

Grouting at Culvert #15 was generally assessed to be good with the exception of one large void (approx. 5 m in length) along the north face of the pipe. It is recommended that supplemental grouting be completed to fill the void. Some erosion of the embankment sideslopes was noted and should be monitored and maintained by the local Area Maintenance Contractor.

The other nine (9) culverts (#2, 5, 6, 7, 8, 9, 16, 18 and 19) exhibited significant voids, often throughout much of the length of the pipe. It is recommended that supplemental grouting be completed to fill the void(s) at these culvert sites.

It is noted that many of the original grouting pipes have been cut off and in some cases sealed. Supplemental grouting may require grouting from new grouting ports installed from the inside of the liner. The contractor should review the SoilSight™ Pipe Maps to assess the location and distribution of voids during the planning of the remedial grouting work. In addition, the properties of the grout should be carefully considered to ensure complete grouting of the voids and annular void.

4.3 Policy and Standard

Based on the widespread grouting deficiencies observed during this investigation, it is recommended that changes be considered with respect to how grout-in-place liner work is designed, constructed and administered. Consideration should be given to the following:

- The Gravity Pipe Design Guidelines (April 2014) include a brief discussion on pipe rehabilitation/replacement construction techniques (pages 62 to 64) but does not address detailed requirements for design, construction or quality control of culvert lining projects. Given how common culvert lining work has become and the

frequency of deficiencies identified, the Gravity Pipe Design Guideline should be reviewed and consideration should be given to updating the manual to include more details for culvert lining work and/or development of a policy document for design, quality control/assurance and asset management.

- The Special Provision (SP) currently in use leaves the details of the liner installation and grouting procedure up to the Contractor and includes language (Section 6.0) such as “Installation methods and procedures shall conform to the pipe Manufacturer’s Installation Guide”, however, for eleven of the sites it is explicit with respect to the grout (Section 5.3), by specifying that “Grout shall consist of a mixture of one part Portland cement conforming to CAN/CSA-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.”. For nine of the sites, the specification for the grout indicated that “Grout shall conform to the pipe manufacturer’s recommendations and specifications.” It is also noted that the current SP does not include a Quality Assurance section. Consideration could be given to mandating two-stage grouting operations or to implementing post-grouting inspection such as single-sided radiation scanning (e.g. InSight™ Lite) or backscatter computed tomography (BCT) scanning as part of the quality assurance and acceptance. It is recommended that the current Special Provision be reviewed and updated. Review of the grout mix to be used for these projects is recommended.
- Construction Administration plays a role in ensuring the quality of construction. Currently, the Construction Administration Inspection Task Manual (CAITM) does not include inspection tasks for culvert lining work. It is recommended that consideration be given to developing inspection tasks to help the Contract Administrator and associated inspection staff in the administration of this type of construction activity.

If significant changes to the specifications and/or policy are implemented, consideration could be given to hosting a technical workshop for design consultants, contractors and contract administrators to ensure that all parties are aware of the changes and the Ministry’s expectations.

5 CONCLUSIONS

Based on the detailed assessment of nine culverts from eight different construction contracts completed in Eastern, Central and Northeastern Regions over the past three years, the current construction specifications and construction methods are not typically achieving a “fully grouted” condition between the host pipe and liner pipe. Recommendations have been provided for remedial measures for the existing culverts and for policy and standard changes intended to improve the quality of work being achieved.



6 CLOSURE

The report was prepared by Katya Edney, P.Eng. and Paul Carnaffan, P.Eng. and reviewed by Dr. P.K. Chatterji, P.Eng. the Designated Principal Contact for MTO Foundation Projects.

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Appendix A.

Grout-in-Place Culvert Lining Site Summary

Table 1

Grout-In-Place Culvert Lining Site Summary

Culvert ID #	Original ID #	Contract #	Region	GWP	WP	Highway	Item # in Contract	Approximate Station	Longitude ¹	Latitude ¹	Original Culvert Diameter ²	Liner Diameter (mm) ²	Pipe Liner Length (m) ²	Type ²	Comments	Assessment of Voids in Grout			Recommendation
																Presence of Voids	Maximum Void Length (m) ⁽³⁾	Approximate Percent Voids ⁽³⁾	
1	4	2017-4014	ER	4022-16-00	4195-15-01	7	17	STA 11+190; Township of Elzevir	-77.3755	44.53817	1200 mm SPCSP	910	32	HDPE	Not tested in 2020 excessive sediment build-up				
2	6	2017-4014	ER	4022-16-00	4195-15-01	7	17	STA 14+260; Township of Elzevir	-77.33863	44.54557	1372 mm SPCSP	1070	35	HDPE		Yes - confirmed with probe holes Inlet end worse than outlet end	12	24	Supplemental grouting to fill voids
3	20	2017-4029	ER	4019-13-00	4298-13-01	115 WBL Centerline	53	STA 13+998; Township of North Monaghan	-78.359216	44.248477	900/1050 mm	885/1025	43	PVC Fold & Form Liner	Not tested in 2020 no grout - fold & form liner				
4	21	2018-4006	ER	4072-16-00	4249-15-00	118	7	STA 21+088; Township of Cardiff	-78.052403	45.00048	1200 mm CSP	1020	35	HDPE	Not tested in 2020 - actual liner diameter <900mm				
5	22	2018-4006	ER	4072-16-00	4249-15-00	118	7	STA 10 +355; Township of Monmouth	-78.349245	45.016913	1350 mm CSP	1070	21	HDPE	Tested in 2019 - Culvert #6	Yes - confirmed with probe holes Voids along majority of pipe length	15	20	Supplemental grouting to fill voids
6	24	2018-4006	ER	4072-16-00	4249-15-00	118	7	STA 15+520; Township of Monmouth	-78.299763	44.995419	1219 mm CSP	910	21	HDPE	Tested in 2019 - Culvert #14	Yes - confirmed with probe holes Voids along full length of pipe	22	67	Supplemental grouting to fill voids
7	42	2017-4023	ER	4121-12-00	-	401 W-N/S Ramp	31	STA 21+855; Township of Sidney	-77.450448	44.178414	1500 mm CSP	1220	43	HDPE	Tested in 2019 - Culvert #4	Yes - confirmed with probe holes Voids along full length of pipe	40	35	Supplemental grouting to fill voids
8	46	2017-4052	ER	4066-16-00	4066-16-00	17	93	STA 14+589; Township of Westmeath	-76.997533	45.730328	1800 mm CSP	1372	29	HDPE	Tested in 2019 - Culvert #2	Yes - confirmed with probe holes Voids along full length of pipe	6	50	Supplemental grouting to fill voids
9	47	2017-4052	ER	4066-16-00	4066-16-00	17	93	STA 15+000; Township of Westmeath	-76.996517	45.726764	1800 mm CSP	1600	29	CSP	Tested in 2019 - Culvert #1	Yes - confirmed with probe holes Voids along majority of pipe length	21	25	Supplemental grouting to fill voids
10	50	2017-4052	ER	4066-16-00	4066-16-00	17	93	STA 12+743; Township of Horton	-76.703814	45.535933	1500 mm SPCSP	1200	38	CSP	Not tested in 2020 no liner installed				
11	51	2016-4005	ER	4069-11-00	4035-14-01	401	18	STA. 18+203;	-76.00523	44.377719	1200 mm SPCSP	910	105	HDPE	Not tested in 2020 - active work zone - no access				
12	58	2017-5000	NER	5005-05-00	-	60	26	STA 17+176; Township of Chaffey	-79.149684	45.34972	1760 mm CSP	1370	41	HDPE		One localized small void detected near inlet end	<1	<1	No further action required
13	60	2017-5008	NER	5140-13-00	5140-13-01	118	28	STA 22+949; Township of Hidon	-78.81266	45.043361	1200 mm CSP	910	33	HDPE	Not tested in 2020 - actual liner diameter <900mm				
14	66	2017-5126	NER	5264-13-00	5264-13-01	60	35	STA 25+107; Township of Sproule	-78.287934	45.572599	2500 mm CSP	1980	39	HDPE	Not tested in 2020 no liner installed				
15	69	2018-5008	NER	5205-10-00	5205-10-01	11	60	STA 20+100; Township of Clergue	-80.774342	48.690011	2100 mm CSP	1676	27	HDPE		One large void detected; localized within west third of pipe length	5	3	Supplemental grouting to fill voids
16	71	2016-5132	NER	545-00-00	-	17	34	STA 11+215.5; Township of Fenwick	-84.370466	46.778265	1220 mm CSP	900	31	HDPE		Yes - confirmed with probe holes Voids along full length of pipe	29	40	Supplemental grouting to fill voids
17	72	2016-5132	NER	545-00-00	-	17	34	STA 12+739.1; Township of Fenwick	-84.360574	46.76738	1220 mm CSP	900	106	HDPE	Not tested in 2020 - actual liner diameter <900mm				
18	75	2018-5108	NER	5374-11-00	5374-11-01	17	65	STA 16+747; Township of Dryden	-80.73741	46.501578	1220 mm CSP	900	39	HDPE		Yes - confirmed with probe holes Voids along majority of pipe length	37	50	Supplemental grouting to fill voids
19	76	2019-5013	NER	5376-15-00	5376-15-01	7300	20	STA 10+111; Township of Salter	-82.075151	46.203377	1200 mm CSP	900	25	HDPE		Yes - confirmed with probe holes Voids along full length of pipe	24	50	Supplemental grouting to fill voids
20	77	2018-5129	NER	5272-14-00	5307-14-02	556	29	STA 12+452.055; Township of Hughes	-83.738615	46.81503	3050 mm CSP	2700	27	CSP		Yes - confirmed with probe holes Localized along crown	14	<10	Supplemental grouting to fill voids
21	78	2018-5129	NER	5272-14-00	5307-14-02	556	29	STA 12+456.630; Township of Hughes	-83.73844	46.815095	3050 mm CSP	2700	27	CSP		Yes - confirmed with probe holes Localized along crown	8	<10	Supplemental grouting to fill voids
22	79	2017-2013	Central	2286-15-00	-	401	24	Site 21-489/C Darlington Creek Culvert	-78.709975	43.885641	-	3251 x 2108	86	SPCSP	Not tested in 2020 - liner work scheduled for later in 2020				
23	80	2017-2013	Central	2286-15-00	-	401	41	Site 22-374/C Miller Creek Culvert	-79.04499	43.848271	4300 mm SPCSP	3080	97	Structural Tunnel Liner Plate Pipe		None Detected	0	0	No further action required

Notes:

(1) Approximate longitude and latitude provided by MTO.

(2) Values provided are the specified culvert diameter, liner diameter and liner length

(3) Based on InSight™ Lite scans showing high probability of voids or other low density material



Appendix B.

Document Review Summaries and Site Photos

Culvert ID # 1 of 23 (4 of 99)**Location and General Details**

Highway	7		Culvert Dia. (mm)	1200	
Station	11+190		Liner Dia. (mm)	910	
Latitude	44.53817		Liner Material	HDPE	
Longitude	-77.3755		Liner Length (m)	32	
			Cover (mm)	3200	

Contract & Specifications

Region	Eastern	Reference Documents		Grout Spec: 5.3
Contract #	2017-4014	Q-Sheets	Sheet 8	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.
GWP	4022-16-00	Drawing	Sheets 1 and 15	
WP	4195-15-01	Tender	Page 134 to 139	
Item No.	17	SP	9999-0440	
Contract Culvert ID 13				Liner Pipe Material Spec: 5.1

Construction Details

General Contractor	AECON	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Dave Pearson	
CSA	Quinn Meske	

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections that are threaded connections to achieve sealed and flush finish. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

No record of RFC having been issued.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	Not Provided
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	Not Provided
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	10.1
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Not Provided

Culvert ID # 1 of 23 (4 of 99)

Site Inspection

Inspection Date:	25-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.

Culvert Access	Highway 7 Eastbound Lane #2 closure for wide shoulder at end of passing lane
Pavement Condition	good - no visible cracks in pavement

Observations at North End of Culvert

Water Depth (m)	0.24
Grout Condition	grout pipe had been cut off and left in place; no grout visible
General Comments	Presence of excessive basal sediment precluded person entry for testing; 1.7m liner overhang from embankment

Observations at South End of Culvert

Water Depth (m)	0.30 (water with sediment/muck)
Grout Condition	Rocks and gravelly material observed; grout tube had been cut off and left in place.
General Comments	0.5m liner overhang from embankment; Measured diameter approximately 910mm but headspace above streambed material and sediments/muck limited to only approximately 0.6m. Void detection testing cannot be completed in diameters less than 900mm.

Culvert ID # 1 of 23 (4 of 99)



Photo 1: No flow at north end of culvert – looking south



Photo 2: Marshy area with bulrushes located north of culvert – looking north

Culvert ID # 1 of 23 (4 of 99)



Photo 3: Excessive sediment at south end of culvert – looking north



Photo 4: Marshy area with bulrushes and significant basal sediment at south end of culvert. – looking east

Culvert ID # 2 of 23 (6 of 99)

Location and General Details					
Highway	7		Culvert Dia. (mm)	1372	
Station	14+260		Liner Dia. (mm)	1070	
Latitude	44.54557		Liner Material	HDPE	
Longitude	-77.33863		Liner Length (m)	35	
			Cover (mm)	1400	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2017-4014	Q-Sheets	Sheet 8		Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.
GWP	4022-16-00	Drawing	Sheets 1 and 15		
WP	4195-15-01	Tender	Page 134 to 139		
Item No.	17	SP	9999-0440		
Contract Culvert ID 18				Liner Pipe Material Spec: 5.1	

Construction Details		
General Contractor	AECON	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Dave Pearson	
CSA	Quinn Meske	
Contractor Submission:		
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections that are threaded connections to achieve sealed and flush finish. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes in considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3	
Theoretical Wet Cast Density (kg/m3)	Not Provided	
Measured Wet Cast Density (kg/m3)	Not Provided	
Theoretical 28 Day UCS (MPa)	Not Provided	
Measured 28 Day UCS (MPa)	Not Provided	
Theoretical Volume (m3)	9.9	
Actual Volume (m3)	Not Provided	
Grouting Records Available (Y/N)	N	
CA/Inspector Notes:		
Not Provided		

Culvert ID # 2 of 23 (6 of 99)

Site Inspection

Inspection Date:	25-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 7 EB shoulder closure TL-6
Pavement Condition	good - no visible cracks in pavement; new guidewire on South side

Observations at North End of Culvert (Inlet)

Water Depth (m)	dry
Grout Condition	good - grout noted all around host pipe and invert spillage; minimum hairline fractures observed; grout pipe has been cut off and left in place
General Comments	Original CSP overhangs approximately 0.2m; no basal sediments and/or water observed until approximately 3.4m along liner; diameter measured at inlet to be 1070mm; crack between HDPE liner and grout observed at invert; Grout thickness at crown approximately 0.11m

Observations at South End of Culvert (Outlet)

Water Depth (m)	0.3 (mixture of water, basal sediment/muck)
Grout Condition	good - grout pipe had been cut off and left in place; minimal hairline fractures observed
General Comments	Basal sediment/muck and water observed from approximately 3.4m along liner to the outlet; Grout thickness at crown approximately 0.14m.

Culvert ID # 2 of 23 (6 of 99)



Photo 1: Dry conditions at north end inlet with bulrushes– looking southwest



Photo 2: Standing water at south end outlet – looking northeast

Culvert ID # 2 of 23 (6 of 99)



Photo 3: Basal sediment/muck observed from approx. 3.4m from inlet to outlet – looking south towards outlet

Culvert ID # 3 of 23 (20 of 99)

Location and General Details					
Highway	115		Culvert Dia. (mm)	900/1050	Fold & Form Liner No Grouting
Station	13+998 WBL C/L		Liner Dia. (mm)	885/1025	
Latitude	44.248477		Liner Material	PVC Fold & Form	
Longitude	-78.359216		Liner Length (m)	43	
			Cover (mm)	700	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec:	
Contract #	2017-4029	Q-Sheets	-	Not Applicable	
GWP	4019-13-00	Drawing	Sheets 43 and 58		
WP	4298-13-01	Tender	Pages 160 to 163		
Item No.	53	SP	9999-4104		
Contract Culvert ID 74				Liner Pipe Material Spec: 5.0	
				-	

Construction Details		
General Contractor	Not Provided	
Grouting Contractor	Not Provided	
ACE	Not Provided	
CSA	Not Provided	
Contractor Submission:		
Not Provided		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix	Not Applicable	
Theoretical Wet Cast Density (kg/m3)	Not Applicable	
Measured Wet Cast Density (kg/m3)	Not Applicable	
Theoretical 28 Day UCS (MPa)	Not Applicable	
Measured 28 Day UCS (MPa)	Not Applicable	
Theoretical Volume (m3)	Not Applicable	
Actual Volume (m3)	Not Applicable	
Grouting Records Available (Y/N)	Not Applicable	
CA/Inspector Notes:		
Not Provided		

Culvert ID # 3 of 23 (20 of 99)

Site Inspection

Inspection Date:	Not inspected
Inspector:	

Culvert Access	
Pavement Condition	

Observations at North End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Observations at South End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Culvert ID # 4 of 23 (21 of 99)

Location and General Details					
Highway	118		Culvert Dia. (mm)	1200	Specified Liner Dia. Was 1020 mm Installed Liner Dia. was <900 mm Not Tested
Station	21+088		Liner Dia. (mm)	1020	
Latitude	45.00048		Liner Material	HDPE	
Longitude	-78.052403		Liner Length (m)	35	
			Cover (mm)	6000	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2018-4006	Q-Sheets	Sheet 4	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	4072-16-00	Drawing	Sheet 1		
WP	4249-15-00	Tender	Pages 122 to 127		
Item No.	7	SP	9999-0440		
Contract Culvert ID 1				Liner Pipe Material Spec: 5.1	
				HDPE	

Construction Details		
General Contractor	Miller Group Inc	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Kevin Vanasseldonk	
CSA	Charlie Trueman	

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

Smith's Construction (A Division of Miller) sent MTO a Request for Clarification to see if cellular concrete could be used.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	3.6
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Not Provided

Culvert ID # 4 of 23 (21 of 99)

Site Inspection

Inspection Date:	25-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Park at Boat Launch East of site and walk to culvert
Pavement Condition	good - no visible cracks in pavement

Observations at South End of Culvert (Inlet)

Water Depth (m)	N/A (No flow is observed and debris is noted)
Grout Condition	Grout and grout pipe is not visible; Spray foam insulation is observed.
General Comments	The existing SPCSP is severely damaged - ruptured; Two grout pipes are noted to be cut off and left in place, however, no grout is noted; Spray foam insulation used to fill in gaps in SPCSP; Debris at inlet observed.

Observations at North End of Culvert (Outlet)

Water Depth (m)	<0.01 (No flow is observed)
Grout Condition	Grout and grout pipe is not visible.
General Comments	Diameter of Liner at Outlet was measured approximately 533mm; No grout is visible; the liner extends from embankment approximately 1.9m.

Culvert ID # 4 of 23 (21 of 99)



Photo 1: Outlet liner (Host pipe buried in embankment)– looking northeast



Photo 2: Liner observed in severely damaged inlet (no flow)– looking northwest

Culvert ID # 4 of 23 (21 of 99)



Photo 3: Damaged host pipe filled with spray foam insulation at inlet

Culvert ID # 5 of 23 (22 of 99)

Location and General Details					
Highway	118		Culvert Dia. (mm)	1350	Tested in 2019 as Culvert #6
Station	10+355		Liner Dia. (mm)	1070	
Latitude	45.016913		Liner Material	HDPE	
Longitude	-78.349245		Liner Length (m)	21	
			Cover (mm)	1000	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2018-4006	Q-Sheets	Sheet 4	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	4072-16-00	Drawing	Sheet 3		
WP	4249-15-00	Tender	Pages 122 to 127		
Item No.	7	SP	9999-0440		
Contract Culvert ID 2				Liner Pipe Material Spec: 5.1	
				HDPE	

Construction Details	
General Contractor	Miller Group Inc
Grouting Contractor	Provincial Underground Services Ltd.
ACE	Kevin Vanasseldonk
CSA	Charlie Trueman

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

Smith's Construction (A Division of Miller) sent MTO a Request for Clarification to see if cellular concrete could be used.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3				
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1				
Measured Wet Cast Density (kg/m3)	553 to 571				
Theoretical 28 Day UCS (MPa)	1				
Measured 28 Day UCS (MPa)	1.6 to 2.1				
Theoretical Volume (m3)	5.9				
Actual Volume (m3)	8.25				
Grouting Records Available (Y/N)	Y				

CA/Inspector Notes:

Cleaned out the pipe. No cofferdams or straw bales installed to carry out the work. HDPE liner specified in contract documents was used. Culvert was lined and grouted with cellular grout. Grouting occurred from 3:00PM to 4:50PM. QC samples of grout taken.

Culvert ID # 5 of 23 (22 of 99)

Site Inspection

Inspection Date:	27-Jun-19
Inspector:	Deanna Pizycki, P.Eng., Thurber Engineering Ltd.

Culvert Access	Park on Shoulder of Highway
Pavement Condition	Good. No visible cracks in the pavement.

Observations at West End of Culvert (Inlet)

Water Depth (m)	0.02
Grout Condition	Fair. Occasional 1-2mm cracks. Grout protruding 70mm from host pipe on north side and 30mm from host pipe on the south side.
General Comments	Liner is an HDPE pipe ~55mm thick. Grout thickness ranges from 70mm to 165mm.

Observations at East End of Culvert (Outlet)

Water Depth (m)	0.005
Grout Condition	Host pipe and grout buried underneath embankment. Grout pipe is visible 1900mm from the end of the liner.
General Comments	Liner is HDPE pipe ~55mm thick. No grout visible.

Culvert ID # 5 of 23 (22 of 99) [Culvert 6 in 2019]



Photo 1 – Inlet looking north east



Photo 2 – Outlet looking south west

Culvert ID # 5 of 23 (22 of 99) [Culvert 6 in 2019]



Photo 3 – Inlet looking down at grout protruding ~30 to 70mm

Culvert ID # 6 of 23 (24 of 99)

Location and General Details					
Highway	118		Culvert Dia. (mm)	1219	Tested in 2019 as Culvert 14
Station	15+520		Liner Dia. (mm)	910	
Latitude	44.995419		Liner Material	HDPE	
Longitude	-78.299763		Liner Length (m)	21.0	
			Cover (mm)	1000	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2018-4006	Q-Sheets	Sheet 4	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	4072-16-00	Drawing	Sheet 4		
WP	4249-15-00	Tender	Pages 122 to 127		
Item No.	7	SP	9999-0440		
Contract Culvert ID 4				Liner Pipe Material Spec: 5.1	
				HDPE	

Construction Details	
General Contractor	Miller Group Inc
Grouting Contractor	Provincial Underground Services Ltd.
ACE	Kevin Vanasseldonk
CSA	Charlie Trueman

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

Smith's Construction (A Division of Miller) sent MTO a Request for Clarification to see if cellular concrete could be used.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3				
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1				
Measured Wet Cast Density (kg/m3)	637 to 662				
Theoretical 28 Day UCS (MPa)	1				
Measured 28 Day UCS (MPa)	3.3 to 4.1				
Theoretical Volume (m3)	6.5				
Actual Volume (m3)	7.75				
Grouting Records Available (Y/N)	Y				

CA/Inspector Notes:

HDPE liner specified in contract document was used. No cofferdams or straw bales installed to carry out the work. Minor leakage at north end of culvert during grouting but was properly managed and grouted by the subcontractor. Culvert was lined and grouted with cellular grout. Grouting occurred from 9:30AM to 12:00PM. QC samples of grout taken.

Culvert ID # 6 of 23 (24 of 99)

Site Inspection

Inspection Date:	27-Jun-19
Inspector:	Deanna Pizycki, P.Eng., Thurber Engineering Ltd.

Culvert Access	Park on Shoulder of Highway
Pavement Condition	Good. No visible cracks in the pavement.

Observations at East End of Culvert (Inlet)

Water Depth (m)	0.04
Grout Condition	Good. One 2mm crack. Grout protruding 30mm from host pipe on north side.
General Comments	Liner is an HDPE pipe ~50mm thick. Grout thickness ranges from 80mm to 110mm.

Observations at West End of Culvert (Outlet)

Water Depth (m)	0.04
Grout Condition	Good. One 1mm crack. Grout set back approximately 30mm from host pipe at along the top. Slight delamination from liner observed.
General Comments	Liner is an HDPE pipe. Grout thickness ranges from 110mm to 160mm.

Culvert ID # 6 of 23 (24 of 99) [Culvert 14 in 2019]



Photo 1 – Inlet looking west



Photo 2 – Outlet looking north east

Culvert ID # 6 of 23 (24 of 99) [Culvert 14 in 2019]



Photo 3 – Inlet looking down at grout protruding ~30 mm

Culvert ID # 7 of 23 (42 of 99)

Location and General Details

Highway	401		Culvert Dia. (mm)	1500	Tested in 2019 as Culvert 4
Station	21+855 W-N/S		Liner Dia. (mm)	1220	
Latitude	44.178414		Liner Material	HDPE	
Longitude	-77.450448		Liner Length (m)	43	
			Cover (mm)	2000	

Contract & Specifications

Region	Eastern	Reference Documents		Grout Spec: 5.3
Contract #	2017-4023	Q-Sheets	Sheet 25	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.
GWP	4121-12-00	Drawing	Sheet 9	
WP	4121-12-01	Tender	Pages 129 to 134	
Item No.	31	SP	9999-0440	
Contract Culvert ID 28				Liner Pipe Material Spec: 5.1
				HDPE

Construction Details

General Contractor	Coco Paving Inc.	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	David Pearson	
CSA	Shane Cassidy	

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

No record of RFC having been issued.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	12.9
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Not Provided

Culvert ID # 7 of 23 (42 of 99)

Site Inspection

Inspection Date:	27-Jun-19
Inspector:	Deanna Pizycki, P.Eng., Thurber Engineering Ltd.
Culvert Access	Park on Shoulder of Highway
Pavement Condition	Good. No visible cracks in the pavement.

Observations at North End of Culvert (Inlet)

Water Depth (m)	0.09
Grout Condition	Fair. Occasional to frequent 1-4mm cracks. Grout protruding approximately 120mm from host pipe around liner. Slight delamination from liner observed.
General Comments	Liner is an HDPE pipe ~40mm thick. Grout thickness ranges from 100mm to 190mm.

Observations at South End of Culvert (Outlet)

Water Depth (m)	0.1
Grout Condition	Fair. Occasional 1-2mm cracks. Grout set back approximately 90mm from host pipe along the top of the host pipe. Slight delamination from liner observed.
General Comments	Liner is HDPE pipe ~50mm thick. Grout thickness ranges from 100mm to 190mm.

Culvert ID # 7 of 23 (42 of 99) [Culvert 4 in 2019]



Photo 1 – Inlet looking south west



Photo 2 – Outlet looking north east

Culvert ID # 7 of 23 (42 of 99) [Culvert 4 in 2019]



Photo 3 – Inlet looking down at grout protruding ~120mm

Culvert ID # 8 of 23 (46 of 99)

Location and General Details					
Highway	17		Culvert Dia. (mm)	1800	Tested in 2019 as Culvert 2
Station	14+589		Liner Dia. (mm)	1372	
Latitude	45.730356		Liner Material	HDPE	
Longitude	-76.997516		Liner Length (m)	29	
			Cover (mm)	900	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2017-4052	Q-Sheets	Sheet 55	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	4066-16-00	Drawing	Sheets 20 and 41		
WP	4220-15-01	Tender	Pages 145 to 150		
Item No.	93	SP	9999-0440		
Contract Culvert ID 27				Liner Pipe Material Spec: 5.1	
Additional Ref. Docs:				HDPE	
2017-4052 Culvert Locations					
2017-4052 Hwy 17 Culvert Photo Log (1)					

Construction Details		
General Contractor	Bonnechere Excavating Inc.	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	David Glass	
CSA	Tim Lynch	

Contractor Submission:
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details
No record of RFC having been issued.

Grouting Details	
Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	21
Grouting Records Available (Y/N)	Y

CA/Inspector Notes:
Not Provided

Culvert ID # 8 of 23 (46 of 99)

Site Inspection

Inspection Date:	28-Jun-19
Inspector:	Deanna Pizycki, P.Eng., Thurber Engineering Ltd.
Culvert Access	Park on Shoulder of Highway
Pavement Condition	Good. No visible cracks in the pavement.

Observations at East End of Culvert (Inlet)

Water Depth (m)	0.02
Grout Condition	Fair. Occasional 1-5mm cracks. Grout set back approximately 25mm from host pipe on south east side.
General Comments	Liner is HDPE pipe ~60mm thick. Grout thickness ranges from 50mm to 240mm.

Observations at West End of Culvert (Outlet)

Water Depth (m)	0.02
Grout Condition	Fair. Occasional 1-3mm cracks. Grout at top protruding approximately 70mm from host pipe.
General Comments	Liner is HDPE pipe ~60mm thick. Grout thickness ranges from 160mm to 200mm.

Culvert ID # 8 of 23 (46 of 99) [Culvert 2 in 2019]



Photo 1 – Inlet looking north west



Photo 2 – Outlet looking north east

Culvert ID # 8 of 23 (46 of 99) [Culvert 2 in 2019]



Photo 3 – Outlet looking down at grout protruding ~70mm

Culvert ID # 9 of 23 (47 of 99)

Location and General Details					
Highway	17		Culvert Dia. (mm)	1800	Tested in 2019 as Culvert 1
Station	15+000		Liner Dia. (mm)	1600	
Latitude	45.726764		Liner Material	CSP	
Longitude	-76.996517		Liner Length (m)	29	
			Cover (mm)	1000	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2017-4052	Q-Sheets	Sheet 55	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	4066-16-00	Drawing	Sheets 20 and 41		
WP	4220-15-01	Tender	Pages 145 to 150		
Item No.	93	SP	9999-0440		
Contract Culvert ID 28				Liner Pipe Material Spec: 5.1	
Additional Ref. Docs:				CSP	
2017-4052 Culvert Locations					
2017-4052 Hwy 17 Culvert Photo Log (1)					

Construction Details		
General Contractor	Bonnechere Excavating Inc.	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	David Glass	
CSA	Tim Lynch	

Contractor Submission:
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details
No record of RFC having been issued.

Grouting Details	
Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	17.25
Grouting Records Available (Y/N)	Y

CA/Inspector Notes:
Not Provided

Culvert ID # 9 of 23 (47 of 99)

Site Inspection

Inspection Date:	28-Jun-19
Inspector:	Deanna Pizycki, P.Eng., Thurber Engineering Ltd.
Culvert Access	Park on Shoulder of Highway
Pavement Condition	Good. No visible cracks in the pavement.

Observations at East End of Culvert (Inlet)

Water Depth (m)	0.02
Grout Condition	Fair. Occasional 1mm cracks. Generally flush with host pipe.
General Comments	Liner is steel/metal pipe. Grout thickness ranges from 50mm to 80mm.

Observations at West End of Culvert (Outlet)

Water Depth (m)	0.15
Grout Condition	Fair. Occasional 1mm cracks. Slight delamination from liner observed.
General Comments	Liner is steel/metal pipe. Grout thickness ranges from 10mm to 180mm.

Culvert ID # 9 of 23 (47 of 99) [Culvert 1 in 2019]



Photo 1 – Inlet looking north west



Photo 2 – Outlet looking south east

Culvert ID # 9 of 23 (47 of 99) [Culvert 1 in 2019]



Photo 3 – Rust on steel/metal liner pipe at outlet

Culvert ID # 10 of 23 (50 of 99)

Location and General Details					
Highway	17		Culvert Dia. (mm)	1500	No liner installed
Station	12+743		Liner Dia. (mm)	1200	
Latitude	45.535933		Liner Material	CSP	
Longitude	-76.703814		Liner Length (m)	38	
			Cover (mm)	4100	

Contract & Specifications				
Region	Eastern	Reference Documents		Grout Spec: 5.3
Contract #	2017-4052	Q-Sheets	Sheet 55	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.
GWP	4066-16-00	Drawing	Sheets 20 and 41	
WP	4066-16-00	Tender	Pages 145 to 150	
Item No.	93	SP	9999-0440	
Contract Culvert ID 57				Liner Pipe Material Spec: 5.1
Additional Ref. Docs:				CSP
2017-4052 Culvert Locations				
2017-4052 Hwy 17 Culvert Photo Log (1)				

Construction Details		
General Contractor	Not Provided	
Grouting Contractor	Not Provided	
ACE	Not Provided	
CSA	Not Provided	

Contractor Submission:
Not Provided

RFC Issued/Details
No record of RFC having been issued.

Grouting Details	
Grout Mix	Not Provided
Theoretical Wet Cast Density (kg/m3)	Not Provided
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	Not Provided
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:
Not Provided

Culvert ID # 10 of 23 (50 of 99)

Site Inspection

Inspection Date:	Not inspected
Inspector:	

Culvert Access	
Pavement Condition	

Observations at Northeast End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Observations at Southwest End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Culvert ID # 11 of 23 (51 of 99)

Location and General Details					
Highway	401		Culvert Dia. (mm)	1200	Active Work Zone No Access Not Tested in 2020
Station	18+203		Liner Dia. (mm)	910	
Latitude	44.377719		Liner Material	HDPE	
Longitude	-76.005230		Liner Length (m)	105	
			Cover (mm)	4500	

Contract & Specifications					
Region	Eastern	Reference Documents		Grout Spec: 5.3	
Contract #	2016-4005	Q-Sheets	-	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	4069-11-00	Drawing	Sheets 1 and 10		
WP	4035-14-01	Tender	Pages 137 to 142		
Item No.	18	SP	9999-0440		
Contract Culvert ID 10				Liner Pipe Material Spec: 5.1	
				HDPE	

Construction Details		
General Contractor	Coco Paving Inc.	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Frank Pinder	
CSA	Shawn Hall	
Contractor Submission:		
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3	
Theoretical Wet Cast Density (kg/m3)	535.7 to 857.1	
Measured Wet Cast Density (kg/m3)	Not Available	
Theoretical 28 Day UCS (MPa)	1	
Measured 28 Day UCS (MPa)	Not Available	
Theoretical Volume (m3)	32.6	
Actual Volume (m3)	Not Available	
Grouting Records Available (Y/N)	N	
CA/Inspector Notes:		
Not Available		

Culvert ID # 11 of 23 (51 of 99)

Site Inspection

Inspection Date:	Not inspected
Inspector:	

Culvert Access	
Pavement Condition	

Observations at North End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Observations at South End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Culvert ID # 12 of 23 (58 of 99)

Location and General Details					
Highway	60		Culvert Dia. (mm)	1760	
Station	17+176		Liner Dia. (mm)	1370	
Latitude	45.34972		Liner Material	HDPE	
Longitude	-79.149684		Liner Length (m)	41	
			Cover (mm)	1750	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec: 5.0	
Contract #	2017-5000	Q-Sheets	Sheet 19	Grout shall conform to the pipe manufacturer's recommendations and specifications.	
GWP	5005-05-00	Drawing	Sheet 23		
WP	-	Tender	Pages 80 to 83		
Item No.	26	SP	9999-0440		
Contract Culvert ID 16				Liner Pipe Material Spec: 5.0	
				HDPE	

Construction Details		
General Contractor	Miller	
Grouting Contractor	Marathon Drilling Company Ltd.	
ACE	Fuluso Soroye, Darren Stephenson	
CSA	Terry Ferrante	
Contractor Submission:		
Weholite PE Pipe by uponor to be used		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix	Mix Design No: 2017-5000-01-01; Target Air 25%, Slump 250mm	
Theoretical Wet Cast Density (kg/m3)	Not Provided	
Measured Wet Cast Density (kg/m3)	Not Provided	
Theoretical 28 Day UCS (MPa)	Not Provided	
Measured 28 Day UCS (MPa)	Not Provided	
Theoretical Volume (m3)	Not Provided	
Actual Volume (m3)	Not Provided	
Grouting Records Available (Y/N)	N	
CA/Inspector Notes:		
Existing CSP Culvert at Station 17+176 flushed out (17:27); Silt fencing was used during flushing operations (10:02); A 41m 1370 poly pipe installed(22:08); grouting operations were noted to go well (21:14)		

Culvert ID # 12 of 23 (58 of 99)

Site Inspection

Inspection Date:	27-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 60 utilizing TL-6 shoulder closure
Pavement Condition	good - no visible cracks in pavement

Observations at West End of Culvert (Inlet)

Water Depth (m)	0.19
Grout Condition	grout is irregular and finished with spray foam insulation; rocks and cobbles are noted in grout mix; grout pipe cut off, filled and left in place
General Comments	Diameter measured with 1390mm span and 1360mm rise; sediment at inlet up to approximately 5.0m length into liner; Liner overhang from original CSP approximately 0.37m; Grout infill thickness at crown approximately 0.27m.

Observations at East End of Culvert (Outlet)

Water Depth (m)	0.02
Grout Condition	Three grout pipes noted to be cut off and left in place; spray foam insulation applied; grout extruding from original CSP approximately 0.13m at obvert.
General Comments	Measured size: 1400mm span and 1360mm rise; minimal flow at outlet; Liner overhang from original CSP approximately 0.64m; Grout thickness at crown approximately 0.25m.

Culvert ID # 12 of 23 (58 of 99)



Photo 1: Inlet liner with irregular grouting between host pipe – looking east



Photo 2: Outlet with minimal flow showing three (3) cut off grout pipes– looking west

Culvert ID # 12 of 23 (58 of 99)



Photo 3: Cobbles paired with spray foam insulation utilized to fill voids at inlet in irregular grout finish

Culvert ID # 13 of 23 (60 of 99)

Location and General Details					
Highway	118		Culvert Dia. (mm)	1200	Installed liner dia. <900 mm Not Tested
Station	17+176		Liner Dia. (mm)	910	
Latitude	45.043361		Liner Material	HDPE	
Longitude	-78.81266		Liner Length (m)	-	
			Cover (mm)	5270	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec:	
Contract #	2017-5008	Q-Sheets	-		
GWP	5140-13-00	Drawing	-		
WP	5140-13-01	Tender	-		
Item No.		SP	-		
Contract documents not received				Liner Pipe Material Spec:	
				-	

Construction Details		
General Contractor	Aecon Construction and Materials Ltd.	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Darren Stephenson	
CSA	Jeremy O'Brien	
Contractor Submission:		
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections that are threaded connections to achieve sealed and flush finish. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes in considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.		
RFC Issued/Details		
2017-5008-RFC-10: The floor of the existing CSP has pushed up at about 7m from the south end of the culvert, causing host pipe to ovalize to 977mm affecting a length of 8m. The spec'd pipe will not fit, as the spec'd pipe OD is 1022mm. Recommendation to switch to ID 762mm (OD 865mm) with a loss of flow of 31% Accepted on June 15, 2018		
Grouting Details		
Grout Mix	Cement Powder: 320 kg, Water: 152.2 L, Foaming Agent: 0.6 m3	
Theoretical Wet Cast Density (kg/m3)	Not Provided	
Measured Wet Cast Density (kg/m3)		
Theoretical 28 Day UCS (MPa)	1.00	
Measured 28 Day UCS (MPa)	Not Provided	
Theoretical Volume (m3)	Not Provided	
Actual Volume (m3)	Not Provided	
Grouting Records Available (Y/N)	N	
CA/Inspector Notes:		
June 25, 2018 at 18:42 - 750mm diameter pipe liner spanning 33m installed rather than original spec'd 910mm diameter as per pg127 since part of existing culvert was deviated a smaller size liner was installed June 26, 2018 at 15:32 - grouting. QA samples of grout collected for testing.		

Culvert ID # 13 of 23 (60 of 99)

Site Inspection

Inspection Date:	24-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 118 park off road west of culvert Site
Pavement Condition	good - no visible cracks in pavement

Observations at South End of Culvert

Water Depth (m)	0.15
Grout Condition	good - minimal hairline fractures observed; grout pipe cut off and left in place;
General Comments	Diameter measured at inlet to be approximately 787mm; no flow is observed so determination of inlet and outlet is unclear; grout infill at crown approx. 0.28m; grout infill terminated approx. 0.15m short of original host pipe end; HDPE liner extends approxiamtely 1.73m from host pipe.

Observations at North End of Culvert

Water Depth (m)	0.18
Grout Condition	poor - spray foam insulation utilized to finalize fill; rocks and cobbles noted within fill mixture; grout pipe cut off and left in place.
General Comments	Grout infill (Spray Foam with cobbles and boulders) at crown approx. 0.30m; HDPE liner extends approx. 2.16m from host pipe.

Culvert ID # 13 of 23 (60 of 99)



Photo 1: North end of culvert – looking southeast



Photo 2: Voids at north end of culvert filled with cobbles and spray foam insulation – looking south

Culvert ID # 13 of 23 (60 of 99)



Photo 3: South end of culvert with one cut off grout pipe exposed– looking west



Photo 4: Approximately 150mm host pipe left unfilled with grout at south end of culvert.

Culvert ID #14 of 23 (66 of 99)

Location and General Details					
Highway	60		Culvert Dia. (mm)	2500	No liner installed
Station	25+107		Liner Dia. (mm)	1980	
Latitude	45.572599		Liner Material	HDPE	
Longitude	-78.287934		Liner Length (m)	29	
			Cover (mm)	6550	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec: 5.0	
Contract #	2017-5126	Q-Sheets	-		
GWP	5264-13-00	Drawing	Sheets 17, 18, 45		
WP	5264-13-01	Tender	Pages 126 to 128		
Item No.	35	SP	9999-0440		
Contract Culvert ID 26				Liner Pipe Material Spec: 5.0 HDPE	
Additional Ref. Docs:					
2017-5126 Final FIR_Culvert 25+108 - Sproule Twp.pdf					

Construction Details		
General Contractor	Not Provided	
Grouting Contractor	Not Provided	
ACE	Not Provided	
CSA	Not Provided	
Contractor Submission:		
Not Provided		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix		Not Provided
Theoretical Wet Cast Density (kg/m3)		Not Provided
Measured Wet Cast Density (kg/m3)		Not Provided
Theoretical 28 Day UCS (MPa)		Not Provided
Measured 28 Day UCS (MPa)		Not Provided
Theoretical Volume (m3)		Not Provided
Actual Volume (m3)		Not Provided
Grouting Records Available (Y/N)		N
CA/Inspector Notes:		
Not Provided		

Culvert ID #14 of 23 (66 of 99)

Site Inspection

Inspection Date:	Not inspected
Inspector:	

Culvert Access	
Pavement Condition	

Observations at North End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Observations at South End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Culvert ID #15 of 23 (69 of 99)**Location and General Details**

Highway	11		Culvert Dia. (mm)	2100	
Station	20+100		Liner Dia. (mm)	1676	
Latitude	48.64868		Liner Material	HDPE	
Longitude	-80.701728		Liner Length (m)	41	
			Cover (mm)	4200	

Contract & Specifications

Region	Northeastern	Reference Documents		Grout Spec: 5.0
Contract #	2018-5008	Q-Sheets	Sheet 29	Grout shall conform to the pipe manufacturer's recommendations and specifications.
GWP	5205-10-00	Drawing	Sheet 16	
WP	5205-10-01	Tender	Pages 158 to 160	
Item No.	60	SP	9999-0440	
Contract Culvert ID 51				Liner Pipe Material Spec: 5.0
				HDPE

Construction Details

General Contractor	Not Provided	
Grouting Contractor	Not Provided	
ACE	Not Provided	
CSA	Not Provided	

Contractor Submission:

Not Provided

RFC Issued/Details

No record of RFC having been issued.

Grouting Details

Grout Mix	Not Provided
Theoretical Wet Cast Density (kg/m3)	Not Provided
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	Not Provided
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Not Provided

Culvert ID #15 of 23 (69 of 99)

Site Inspection

Inspection Date:	17-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 11 - park off road north of culvert site
Pavement Condition	New - paved the week of inspection - no cracks visible in pavement

Observations at West End of Culvert (Inlet)

Water Depth (m)	0.03 (No Flow)
Grout Condition	good - grout finish is smooth; no grout pipe is noted; grout spillage is noted on sides of host pipe
General Comments	Diameter deviates throughout liner length as noted by INVERSA; rockfill (riprap) surrounding original CSP host pipe; minimal water flow is observed; HDPE wall thickness is approx. 0.06m; Liner overhang from host pipe is approx. 0.15m

Observations at East End of Culvert (Outlet)

Water Depth (m)	0.13
Grout Condition	good, grout finish is smooth, however, debris/plastic is noted within grout finish; no grout pipe is noted - perhaps grouted over.
General Comments	Diameter measured to be approx. 1210mm, but deviations throughout pipe length noted by INVERSA; original CSP covered in silt fence; Liner overhang from host pipe approx. 0.19m; erosion channels in embankment observed above host pipe

Culvert ID # 15 of 23 (69 of 99)



Photo 1: East end of culvert (outlet) surrounded by rip rap embankment exhibiting low flow and no visual grout pipes. – looking west



Photo 2: West end of culvert (inlet) not well centred in host pipe, surrounded by rip rap embankment – looking east

Culvert ID # 15 of 23 (69 of 99)



Photo 3: Liner overhang of approx. 0.19m at culvert outlet exhibiting smooth grout finish- looking south

Culvert ID # 16 of 23 (71 of 99)

Location and General Details					
Highway	17		Culvert Dia. (mm)	1220	
Station	11+215.5		Liner Dia. (mm)	900	
Latitude	46.778265		Liner Material	HDPE	
Longitude	-84.370466		Liner Length (m)	31	
			Cover (mm)	2800	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec: 5.0	
Contract #	2016-5132	Q-Sheets	Sheet 35	Grout shall conform to the pipe manufacturer's recommendations and specifications.	
GWP	545-00-00	Drawing	Sheet 18		
WP	-	Tender	Pages 110 to 112		
Item No.	34	SP	9999-0440		
Contract Culvert ID 41				Liner Pipe Material Spec: 5.0	
				HDPE	

Construction Details		
General Contractor	Pioneer Construction	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Bruce Sedgwick, Sean Lalonde	
CSA	Dan Parise, Craig Seabrook	
Contractor Submission:		
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix	Cement Powder: 320 kg, Water: 152.5 L, Foaming Agent: 0.6 m3	
Theoretical Wet Cast Density (kg/m3)	15kg/0.028m3 to 24kg/0.028m3	
Measured Wet Cast Density (kg/m3)	Not Provided	
Theoretical 28 Day UCS (MPa)	1	
Measured 28 Day UCS (MPa)	Not Provided	
Theoretical Volume (m3)	Not Provided	
Actual Volume (m3)	Not Provided	
Grouting Records Available (Y/N)	N	
CA/Inspector Notes:		
Streamliner CR pipe manufacture by ADS Canada used. Specified pipe diameter outlined in tender documents used.		

Culvert ID # 16 of 23 (71 of 99)

Site Inspection

Inspection Date:	16-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.

Culvert Access	Highway 17 - park vehicles on Karalash Road and walk to culvert site
Pavement Condition	good - no cracks visible in pavement; paved shoulders (very minimal to no rutting)

Observations at East End of Culvert (Inlet)

Water Depth (m)	dry
Grout Condition	N/A - grout is not visible
General Comments	Liner diameter measured approx. 910mm with a wall thickness of approx. 0.06m; rockfill (riprap) noted at inlet surrounding host pipe; silt fence left in place over slipliner resulting in no grout being visible.

Observations at West End of Culvert (Outlet)

Water Depth (m)	0.02 above basal sediment
Grout Condition	N/A - grout is not visible.
General Comments	Pooling of standing water noted from 24.0 to 31.6m liner length and basal sediments for last 5.0m of liner; silt fence left in place over slipliner resulting in no grout being visible.

Culvert ID # 16 of 23 (71 or 99)



Photo 1: East end of culvert (inlet) covered with silt fence and surrounded by rip rap embankment. Grout is not visible. – looking west



Photo 2: West end of culvert (outlet) liner, surrounded by rip rap embankment. Host pipe is not visible – looking east

Culvert ID # 16 of 23 (71 or 99)



Photo 3: Standing water and basal sediments observed at outlet - looking east

Culvert ID #17 of 23 (72 of 99)

Location and General Details					
Highway	17		Culvert Dia. (mm)	1220	Installed liner dia. <900 mm Not Tested
Station	12+739.1		Liner Dia. (mm)	900	
Latitude	46.76738		Liner Material	HDPE	
Longitude	-84.360574		Liner Length (m)	106	
			Cover (mm)	9000	

Contract & Specifications				
Region	Northeastern	Reference Documents		Grout Spec: 5.0 Grout shall conform to the pipe manufacturer's recommendations and specifications.
Contract #	2016-5132	Q-Sheets	Sheet 35	
GWP	545-00-00	Drawing	Sheet 18	
WP	-	Tender	Pages 110 to 112	
Item No.	34	SP	9999-0440	
Contract Culvert ID 44				Liner Pipe Material Spec: 5.0 HDPE
Additional Ref. Docs:				
2016-5132 FIR 12+739 Fenwick.pdf				

Construction Details		
General Contractor	Pioneer Construction	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Bruce Sedgwick, Sean Lalonde	
CSA	Dan Parise, Craig Seabrook	

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

Culvert 44 (72) is in very poor condition. It has broken joints and ovalized sections in four different locations. The worst area brings the culvert down to 890mm for 11m in one section. Bottom is completely gone, and jacking is not an option. We recommend a 762mm ID liner which will give us a 861mm OD and will have a loss of flow of 28%. With the length of the pipe, and being down so deep there should be no issue of spring run off as the condition of the CSP now with all its restrictions due to its structural problems would only be running at 50% at best at high head.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.5 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	15kg/0.028m3 to 24kg/0.028m3
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Streamliner CR pipe manufacture by ADS Canada used.

Culvert ID #17 of 23 (72 of 99)

Site Inspection

Inspection Date:	16-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.

Culvert Access	Highway 17 - park on abandoned driveway south of culvert site and walk
Pavement Condition	good - no ruts nor cracks visible in pavement

Observations at West End of Culvert (Inlet)

Water Depth (m)	<0.01 (minimal to no flow)
Grout Condition	N/A - grout is not visible
General Comments	Host CSP is not visible. A trumpet-shaped adaptor has been added to end of liner (outer diameter approx. 1016mm). Sediment is noted in trumpet adapter entrance. Only minimal flow observed. Curve in liner noted near inlet.

Observations at East End of Culvert (Outlet)

Water Depth (m)	<0.01 (Flow observed)
Grout Condition	Poor: grout consistency is sand-like and seems to be deteriorating; spray foam utilized; two grout pipes cut off and left in place
General Comments	Sandbags left on site at outlet; Liner overhangs original CSP approximately 0.36m; Grout thickness (with spray foam and sand-like material) at crown approx. 0.32m. Grout terminated approx. 0.28 to 0.36m short of original CSP end.

Culvert ID # 17 of 23 (72 of 99)



Photo 1: East end of culvert (outlet) in poor condition. Spray foam and sandy material utilized to fill voids – looking west



Photo 2: Cut off grout pipes noted, but no grout is visible at culvert outlet. Bulkhead appears to consist solely of spray foam and sandy material – looking west

Culvert ID # 17 of 23 (72 of 99)



Photo 3: West end of culvert (inlet) trumpet entrance telescoping to smaller diameter liner. Host pipe not visible - looking south

Culvert ID #18 of 23 (75 of 99)

Location and General Details					
Highway	17		Culvert Dia. (mm)	1220	<i>Note: Quantity says 900mm diameter and 39m, but Tender says 1000mm diameter and 36m</i>
Station	16+747		Liner Dia. (mm)	900	
Latitude	46.5014703		Liner Material	HDPE	
Longitude	-80.7375037		Liner Length (m)	39	
			Cover (mm)	5000	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec: 5.0	
Contract #	2018-5108	Q-Sheets	Sheet 45	Grout shall conform to the pipe manufacturer's recommendations and specifications.	
GWP	5374-11-00	Drawing	Sheet 1		
WP	5374-11-01	Tender	Pages 163 to 165		
Item No.	65	SP	9999-0440		
Contract Culvert ID 1				Liner Pipe Material Spec: 5.0	
				HDPE	

Construction Details		
General Contractor	Interpaving Limited	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Bruce Sedgwick	
CSA	Don Teddy	

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

RFC#14: A 900mm ID pipe liner is recommended by Provincial Underground Services Ltd. The explanation would be that a 1000mm ID pipe liner will have an OD of 1168mm and the existing pipe has an ID of 1200mm, which gives about 16mm space between the OD of pipe liner and ID of existing pipe. This small spacing will not be sufficient to insert the liner and place grout. Whereas, a pipe liner with 900mm ID will have an OD of 1029mm, which gives approx. 85mm space, giving enough room for work between pipe liner and existing pipe. - Approved by Tulloch.

Grouting Details	
Grout Mix	Cement Powder: 320 kg, Water: 152.5 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	15kg/0.028m3 to 24kg/0.028m3
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	12.5
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Aug 29, 2018 at 16:39 - Cleaned out pipe debris and inserted pipe liner (8 sections of 5m with OD of 1M). Pipes were stamped and were in good conditions. Foreman anticipates grouting sometime tomorrow.

Aug 30, 2018 at 15:25 - worked on bulkhead, grout pumping and restoring the site. They installed small sections of silt fence for added erosion control. Sample cubes were taken after 15% of batch was mixed. Contractor used 12.5m3 of grout to seal the 39M pipe liner.

Culvert ID #18 of 23 (75 of 99)

Site Inspection

Inspection Date:	13-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.

Culvert Access	Highway 17 EB Shoulder Closure utilizing TL-6 East of Culvert Site
Pavement Condition	Poor - Cracks up to 50mm noted. Potholes/Erosion channels observed approx. 0.28m long and up to 0.10m deep

Observations at South End of Culvert (Inlet)

Water Depth (m)	0.13 outside liner and 0.10 inside liner
Grout Condition	Fair to good - material is crumbly and dry at obvert; Crack observed along host pipe and liner; grout pipe cut off and left in place.
General Comments	Large boulder noted above original CSP; Liner overhangs host pipe approxiamtely 0.27m; erosion channels on south embankment; silt fence lines creek; Liner diameter measured to be 910mm and wall thickness of approx. 0.04m; Grout thickness at crown approx 0.18m.

Observations at North End of Culvert (Outlet)

Water Depth (m)	0.20 outside liner and 0.13 inside liner
Grout Condition	N/A - grout is mixed with fill material at outlet
General Comments	Grout material and original CSP is not visiable at outlet; silt fence across outlet liner; boulders were noted at base of liner

Culvert ID # 18 of 23 (75 of 99)



Photo 1: Grout and host pipe not visible at north end of culvert (outlet) – looking south



Photo 2: Rusty host pipe debris observed on northern embankment – looking east

Culvert ID # 18 of 23 (75 of 99)



Photo 3: South end of culvert (inlet) exhibits good grout condition. Cut off grout pipe observed in grout fill. - looking north

Culvert ID # 19 of 23 (76 of 99)

Location and General Details					
Highway	7300		Culvert Dia. (mm)	1200	<i>Note: Quantity says 25m, but Tender says 24m</i>
Station	10+111		Liner Dia. (mm)	900	
Latitude	46.2032264		Liner Material	HDPE	
Longitude	-82.0751857		Liner Length (m)	25	
			Cover (mm)	3000	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec: 5.0	
Contract #	2019-5013	Q-Sheets	Sheet 11	Grout shall conform to the pipe manufacturer's recommendations and specifications.	
GWP	5376-15-00	Drawing	Sheet 1		
WP	5376-15-01	Tender	Pages 114 to 116		
Item No.	20	SP	9999-0440		
Contract Culvert ID 1				Liner Pipe Material Spec: 5.0	
				HDPE	

Construction Details		
General Contractor	Teranorth Construction & Engineering Ltd.	
Grouting Contractor	Provincial Underground Services Ltd.	
ACE	Bruce Sedgwick	
CSA	Jeff Derksen	

Contractor Submission:
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Liner is installed in sections with integral couplings. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details
No record of RFC having been issued.

Grouting Details	
Grout Mix	Cement Powder: 320 kg, Water: 152.5 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	15kg/0.028m3 to 24kg/0.028m3
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	1
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	5.1 to 6.1
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	Y

CA/Inspector Notes:
Infrapipe Solutions Ltd. Weholite Structural Profile Wall HDPE pipe used. Sept 18, 2019 at 21:27 - Provincial onsite at 1055 to put in culvert liner at Cuvlert#1 contractor cleaned out the culvert before starting liner. First piece of pipe in at 1115 second piece of pipe in at 1203 third piece in at 1218 fourth piece of pipe in at 1227 fifth piece of pipe in at 1240. contractor workign on bulk heads at 1242 contractor used spray foam in the joints and silicone on the joints.

Culvert ID # 19 of 23 (76 of 99)

Site Inspection

Inspection Date:	14-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 7300 Lane Closure with TL-20A flagging operation utilized
Pavement Condition	New - no cracks visible in pavement

Observations at South End of Culvert (Inlet)

Water Depth (m)	dry
Grout Condition	good - slightly crumbly and dry at obvert; grout pipe cut off and left in place; grout thickness at crown approx 0.10m.
General Comments	Liner overhangs out of host pipe approx. 0.36m; Liner diameter measured to be approx. 910mm with wall thickness of 0.05m; south embankment consisting of fill material in good condition

Observations at North End of Culvert (Outlet)

Water Depth (m)	dry with minimal basal sediment
Grout Condition	good - one small crack between grout pipe that has been cut off and left in place and the HDPE liner; grout thickness at crown approx 0.17m.
General Comments	North embankment consists of rockfill material and is in good condition; rockfill (riprap) noted at invert of outlet; Liner overhang from host pipe is approx. 0.27m.

Culvert ID # 19 of 23 (76 of 99)



Photo 1: South end of culvert (inlet) exhibiting good grout condition and cut off grout pipe – looking north



Photo 2: North end of culvert (outlet) surrounded by rock fill embankment. Cut off grout pipe noted– looking south

Culvert ID # 19 of 23 (76 of 99)



Photo 3: Minimal basal sediments observed near culvert outlet– looking south

Culvert ID #20 of 23 (77 of 99) West Twin Culvert

Location and General Details

Highway	556		Culvert Dia. (mm)	3050	
Station	12+452.055		Liner Dia. (mm)	2700	
Latitude	46.81503		Liner Material	CSP	
Longitude	-83.738615		Liner Length (m)	26.4	
			Cover (mm)	1399	

Contract & Specifications

Region	Northeastern	Reference Documents		Grout Spec: 5.0
Contract #	2018-5129	Q-Sheets	Sheet 14	Grout shall be 2.5 Mpa and conform to the pipe manufacturer's recommendations and specifications.
GWP	5272-14-00	Drawing	Sheet 2	
WP	5307-14-02	Tender	Pages 115 to 118	
Item No.	29	SP	9999-0440	
Contract Culvert ID Kinahan Creek Culvert				Liner Pipe Material Spec: 5.0
				CSP

Construction Details

General Contractor	Belanger Construction	
Grouting Contractor	Provincial Underground Services Ltd	
ACE	Sean Lalonde	
CSA	Roberto Lauricella	

Contractor Submission:

Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Once existing CSP's cleaned and checked, 100mm rails will be 4x4 wood and mounted to existing CSP self-tapping bolts placed with a pilot hole and will be placed on the bottom of the CSP's to insert liners on grade. Liner is installed in sections with integral couplings. Grad and alignment will be checked after three sections are in place. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Center support jacks will be placed at 12 O'clock to secure CSP liner for any movement during first lift of Grout. Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details

No record of RFC having been issued.

Grouting Details

Grout Mix	Cement Powder: 320 kg, Water: 152.5 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	15kg/0.028m3 to 24kg/0.028m3
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	2.5
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	42.7
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Not Provided

Culvert ID #20 of 23 (77 of 99) West Twin Culvert

Site Inspection

Inspection Date:	15-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 556 - Park on Side Road West of Site
Pavement Condition	Unpaved gravel road

Observations at North End of Culvert (Inlet)

Water Depth (m)	0.61
Grout Condition	good - hairline fracture observed at obvert; grout pipe cut off and left in place; grout thickness at crown is approx. 0.27m
General Comments	Liner overhang from host pipe is approx. 0.13m; rip-rap noted at base of granular embankment in good condition; CSP liner diameter measured to be 2720mm at Inlet

Observations at South End of Culvert (Outlet)

Water Depth (m)	0.84
Grout Condition	good - grout finish is slightly rough on west side and hairline fractures are observed at obvert; grout thickness at crown is approx. 0.13m.
General Comments	Liner overhang from host pipe measured to be 0.52m; Rockfill surrounding culvert base and granular fill material noted between the twin CSP culverts; erosion channel between twin culverts from Road noted on embankment

Culvert ID # 21 of 23 (78 of 99) East Twin Culvert

Location and General Details					
Highway	556		Culvert Dia. (mm)	3050	
Station	12+456.630		Liner Dia. (mm)	2700	
Latitude	46.815095		Liner Material	CSP	
Longitude	-83.73844		Liner Length (m)	26.4	
			Cover (mm)	1399	

Contract & Specifications					
Region	Northeastern	Reference Documents		Grout Spec: 5.0	
Contract #	2018-5129	Q-Sheets	Sheet 14	Grout shall be 2.5 Mpa and conform to the pipe manufacturer's recommendations and specifications.	
GWP	5272-14-00	Drawing	Sheet 2		
WP	5307-14-02	Tender	Pages 115 to 118		
Item No.	29	SP	9999-0440		
Contract Culvert ID Kinahan Creek Culvert				Liner Pipe Material Spec: 5.0	
				CSP	

Construction Details		
General Contractor	Belanger Construction	
Grouting Contractor	Provincial Underground Services Ltd	
ACE	Sean Lalonde	
CSA	Roberto Lauricella	

Contractor Submission:
Existing pipe cleaned out by flushing and digging. Silt fence and dewatering with pumps as required. Any loose metal and bent edges will be repaired as required. The culvert will be measured to determine the maximum liner size that can be used. Once existing CSP's cleaned and checked, 100mm rails will be 4x4 wood and mounted to existing CSP self-tapping bolts placed with a pilot hole and will be placed on the bottom of the CSP's to insert liners on grade. Liner is installed in sections with integral couplings. Grad and alignment will be checked after three sections are in place. Blocks will be used where required to maintain positive flow. Grout and vent tubes are installed at either end (number and location of each not indicated). Bulkheads 450 mm to 900mm thick are constructed at both ends with high early strength concrete and spray foam where required and will be left in place upon completion (no formwork required). Center support jacks will be placed at 12 O'clock to secure CSP liner for any movement during first lift of Grout. Once complete, cellular grout will be pumped starting from the bottom using a Mobile Cellular Grout Plant. Pressure monitoring occurs during the grouting to ensure there is no leakage. The annular space between the two pipes is considered filled when grout starts coming out of the vent/grout tubes. Grout tubes will be cut-off as close to the bulk head as possible.

RFC Issued/Details
No record of RFC having been issued.

Grouting Details	
Grout Mix	Cement Powder: 320 kg, Water: 152.5 L, Foaming Agent: 0.6 m3
Theoretical Wet Cast Density (kg/m3)	15kg/0.028m3 to 24kg/0.028m3
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	2.5
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	42.7
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:
Not Provided

Culvert ID # 21 of 23 (78 of 99) East Twin Culvert

Site Inspection

Inspection Date:	15-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.
Culvert Access	Highway 556 - Park on Side Road West of Site
Pavement Condition	Unpaved gravel road

Observations at North End of Culvert (Inlet)

Water Depth (m)	0.52
Grout Condition	good - smooth finish, however, cracking is noted at obvert and 2 hairline fractures observed at 11:30 and 1:00; grout thickness at crown 0.30m
General Comments	Liner overhangs from host pipe a distance of approx. 0.23m

Observations at South End of Culvert (Outlet)

Water Depth (m)	0.84
Grout Condition	good - smooth finish; however, three hairline fractures observed (12:00, 10:00 and 2:00); grout thickness at crown 0.30m.
General Comments	Liner overhangs from host pipe a distance of approx. 0.33m; Erosion channel in embankment between twin culverts noted

Culvert ID # 20 and 21 of 23 (77 and 78 of 99)



Photo 1: Culvert 20 (77) (left) and Culvert 21 (78) (right) outlets – looking northeast



Photo 2: Culvert 20 (77) (right) and Culvert 21 (78) (left) inlets – looking southeast

Culvert ID # 20 and 21 of 23 (77 and 78 of 99)



Photo 3: Minimal hairline fractures observed in grout at inlet and outlet in both culverts

Culvert ID # 22 of 23 (79 of 99)

Location and General Details					
Highway	401		Culvert Dia. (mm)	Original Box Culvert	Liner Not Yet Installed Not Tested in 2020
Station	Site 21-489/C Darlington Creek		Liner Dia. (mm)	3251 x 2108	
Latitude	43.885641		Liner Material	SPCSP	
Longitude	-78.709975		Liner Length (m)	86	
			Cover (mm)	7900	

Contract & Specifications				
Region	Central	Reference Documents		Grout Spec: 5.4
Contract #	2017-2013	Q-Sheets	Sheet 2	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.
GWP	2286-15-00	Drawing	Sheets 4 to 11	
WP	-	Tender	Pages 96 to 104	
Item No.	24	SP	9999-0440	
Contract Culvert ID 1				Liner Pipe Material Spec: 5.1.2
				SPCSP

Construction Details		
General Contractor	Not Provided	
Grouting Contractor	Not Provided	
ACE	Not Provided	
CSA	Not Provided	
Contractor Submission:		
Not Provided		
RFC Issued/Details		
No record of RFC having been issued.		
Grouting Details		
Grout Mix	Not Provided	
Theoretical Wet Cast Density (kg/m3)	Not Provided	
Measured Wet Cast Density (kg/m3)	Not Provided	
Theoretical 28 Day UCS (MPa)	Not Provided	
Measured 28 Day UCS (MPa)	Not Provided	
Theoretical Volume (m3)	Not Provided	
Actual Volume (m3)	Not Provided	
Grouting Records Available (Y/N)	N	
CA/Inspector Notes:		
Not Provided		

Culvert ID # 22 of 23 (79 of 99)

Site Inspection

Inspection Date:	Not inspected
Inspector:	

Culvert Access	
Pavement Condition	

Observations at North End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	

Observations at South End of Culvert

Water Depth (m)	
Grout Condition	
General Comments	



Photo 1: Liner installed but not yet grouted - active construction site – looking northwest at southern embankment

Culvert ID # 23 of 23 (80 of 99)

Location and General Details					
Highway	401		Culvert Dia. (mm)	4300	
Station	Site 22-374/C Miller Creek		Liner Dia. (mm)	3080	
Latitude	43.848271		Liner Material	Structural Plate Liner	
Longitude	-79.04499		Liner Length (m)	97	
			Cover (mm)	4800	

Contract & Specifications					
Region	Central	Reference Documents		Grout Spec: 5.4	
Contract #	2017-2013	Q-Sheets	-	Shall consist of a mixture of one part Portland cement conforming to CAN/CAS-A5-M88 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.	
GWP	2286-15-00	Drawing	Sheets 19 and 20		
WP	-	Tender	Pages 96 to 104		
Item No.	41	SP	9999-0440		
Contract Culvert ID 22-374/C				Liner Pipe Material Spec: 5.1.1	
				Structural Plate Liner	

Construction Details		
General Contractor	Not Provided	
Grouting Contractor	Not Provided	
ACE	Not Provided	
CSA	Not Provided	

Contractor Submission:

Not Provided

RFC Issued/Details

No record of RFC having been issued.

Grouting Details

Grout Mix	Not Provided
Theoretical Wet Cast Density (kg/m3)	Not Provided
Measured Wet Cast Density (kg/m3)	Not Provided
Theoretical 28 Day UCS (MPa)	Not Provided
Measured 28 Day UCS (MPa)	Not Provided
Theoretical Volume (m3)	Not Provided
Actual Volume (m3)	Not Provided
Grouting Records Available (Y/N)	N

CA/Inspector Notes:

Not Provided

Culvert ID # 23 of 23 (80 of 99)

Site Inspection

Inspection Date:	26-Jul-20
Inspector:	Katya Edney, P.Eng., Thurber Engineering Ltd.

Culvert Access	Jackwin Residential Entrance north of 401
Pavement Condition	N/A - not visible due to noise barrier

Observations at North End of Culvert (Inlet)

Water Depth (m)	0.04
Grout Condition	Excellent condition - no cracks observed; no grout pipes noted; grout thickness is 0.60m at 9:00, 0.53m at 12:00 and 0.56m at 3:00
General Comments	grouting job well done.

Observations at South End of Culvert (Outlet)

Water Depth (m)	0.04
Grout Condition	Excellent condition - no cracks observed; no grout pipes noted
General Comments	Overhang of liner from original grouted concrete culvert is approx. 0.25m. Grout thickness measured to be 0.74m at 9:00.

Culvert ID # 23 of 23 (80 of 99)



Photo 1: North end of culvert (inlet) grouted in original concrete host pipe – looking south



Photo 2: South end of culvert (outlet) beneath Highway 401 grouted in original concrete host pipe – looking north

Culvert ID # 23 of 23 (80 of 99)



Photo 3: Crown grout infill approx. 0.53m at inlet– looking south



Appendix C.

Void Screening Test Results



SoilSight™ Condition Assessment

MTO 2020

6

Highway 7 in Hastings County

General Summary

The asset 6 located on Highway 7 in Hastings County, consists of a Sliplined High Density Polyethylene (HDPE) circular culvert. The asset is located at latitude 44° 32' 44.68" N, longitude 77° 20' 19.46" W. The dimensions of the asset were found to be approximately 1.07 m in diameter and 35.00 m in length. The asset has approximately 2.20 m of cover from the obvert to the road surface and flows generally north to south.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 7 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	6
County Name	Hastings County
GPS	44° 32' 44.68" N, 77° 20' 19.46" W
Inspection Date	July 24, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.
Approved By	Steven Godbout, B.Sc.Eng.

SoilSight™ Condition Assessment

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

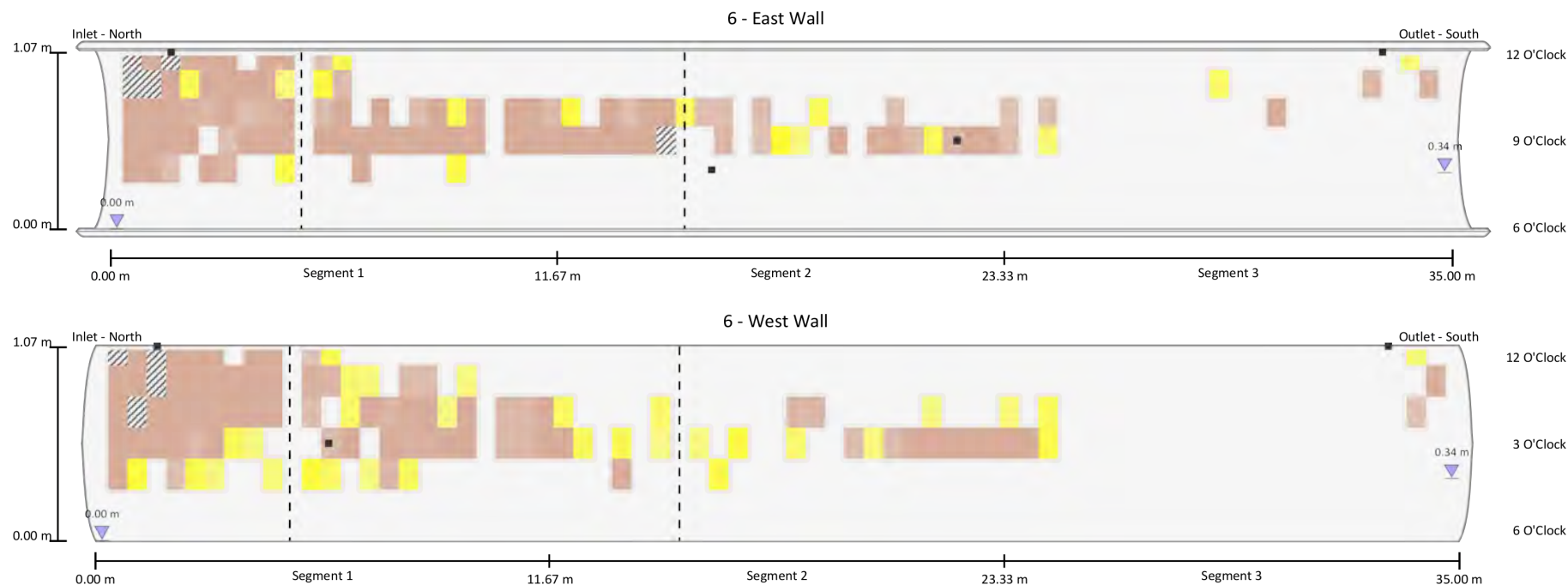
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

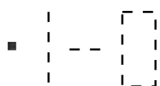
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

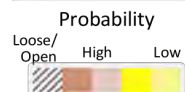
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

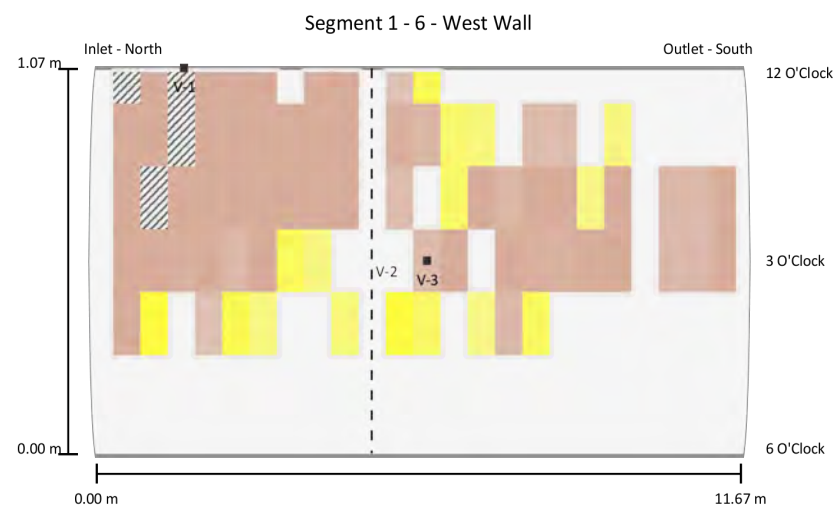
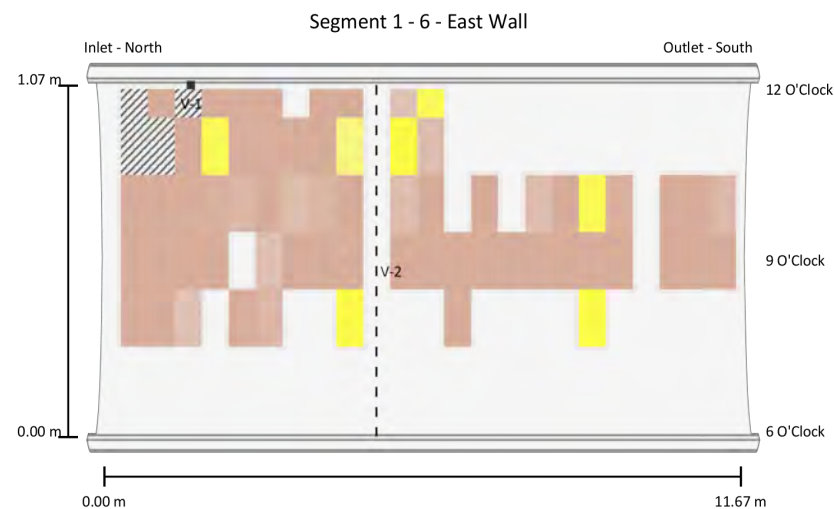


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.60 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-2	5.00 m	5.00 m	-	-	Joint with evident black caulking.
V-3	6.00 m	-	03:00	-	Endoscope camera placed in the probe hole showing void.

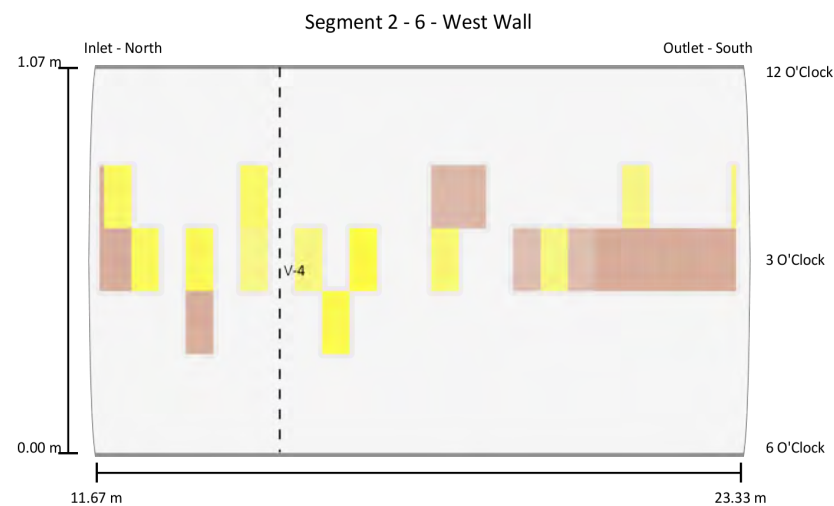
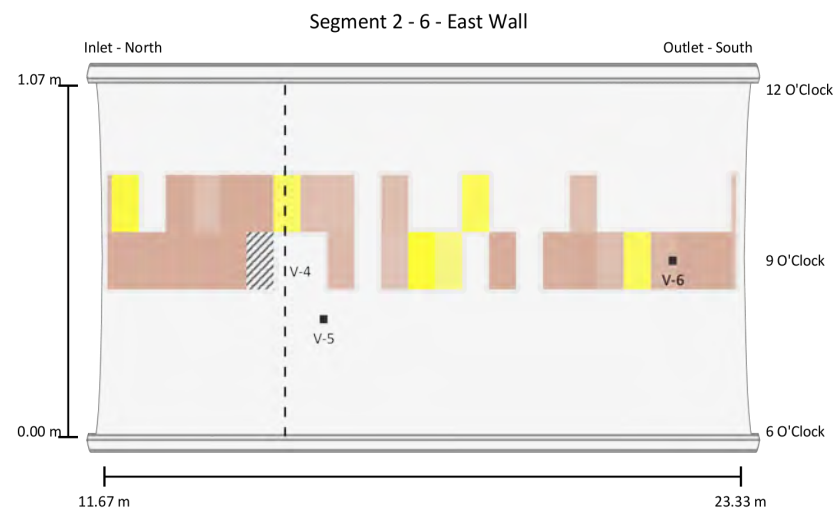
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

X	Clock	Scan ID	Verdict
No BCT images included.			

Segment 2



■ □ Visual Indicators

◆ ◆ InSight™ BCT Images

□ Acoustic Anomalies

■ InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-4	15.00 m	15.00 m	-	-	Separated joint by approximately 40 mm with black caulking evident.
V-5	15.70 m	-	08:00	-	Endoscope camera placed in the probe hole showing no void (control point).
V-6	22.10 m	-	09:00	-	Endoscope camera placed in the probe hole showing void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

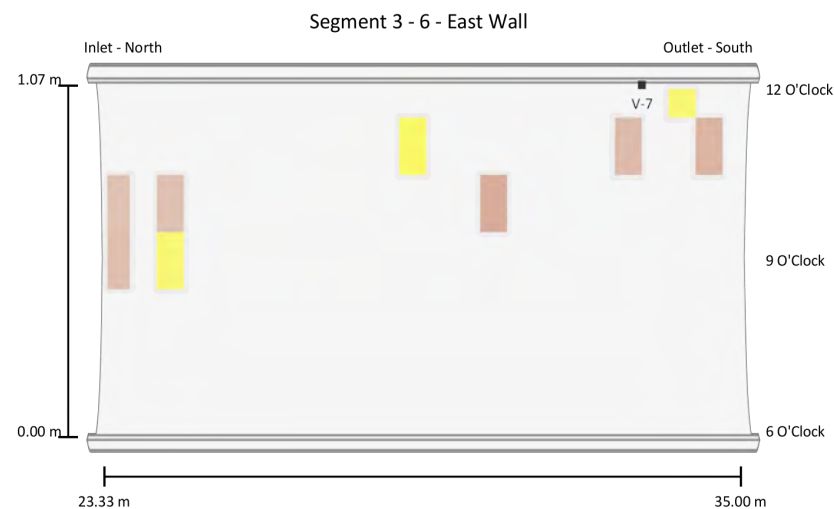
No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

Segment 3



Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-7	33.20 m	-	12:00	-	Endoscope camera placed in the probe hole showing some void since host pipe is resting on Sliplined HDPE.

Acoustic Anomalies

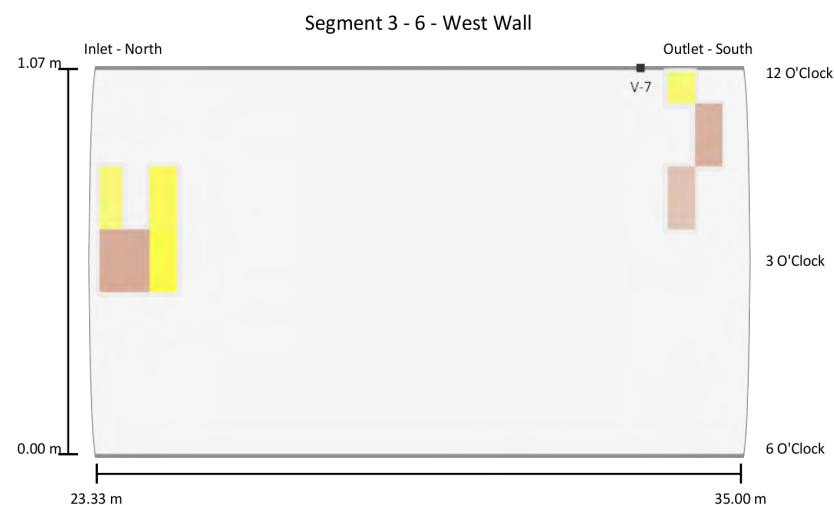
X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement

Rank 2

Pavement in good condition.

Cracks

- Progressive edge cracking: **Severity:** Less than 300 mm (12 in) from road shoulder.
- Transverse cracks present: **Frequency:** Frequent (more than 5 cracks); **Severity:** Light (< 5 mm (0.2 in) Width)



Photo 2 - Light transverse cracks.



Photo 1 - Light progressive edge cracking on outlet side.



Photo 3 - Highway 7 facing east.



Photo 4 - Highway 7 facing west.

Guardrail

Rank 3

Outlet guardrail steel wires has significant slack.

Inlet guardrail.: Inlet guardrail not present.

Outlet guardrail.: Present.

- Corrosion present: **Severity:** Light surface corrosion.

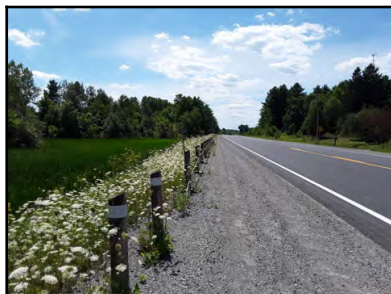


Photo 5 - Outlet guardrail.

Embankment

Rank 1

Embankment stable, no visible ruts or erosion channels. No large vegetation present.

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 6 - Inlet embankment.

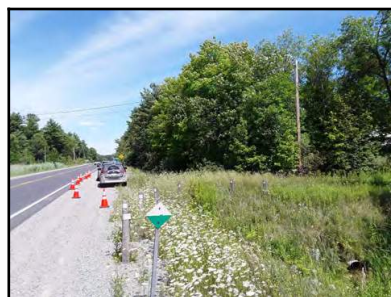


Photo 7 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 8 - Inlet overview.



Photo 9 - Outlet overview.

Waterway Blockage

Rank 2

- Streambed material present: **Location:** Within pipe barrel.; X1: 3.50 m; X2: 35.00 m

Extent of blockage.: Equal to or less than 20%.



Photo 10 - Upstream channel view.



Photo 11 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 2

- Joint separation(s) present: **Severity:** Light (< 100 mm (4 in) Width).

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Maximum shape deviation of approximately -1.9%.

Pipe Alignment

Rank 1

Pipe well aligned.



Photo 12 - Upstream pipe alignment and shape.



Photo 13 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 6 is 1070 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1070 mm	0.0%	1070 mm	0.0%
5.00 m	1060 mm	-0.9%	1060 mm	-0.9%
10.00 m	1050 mm	-1.9%	1050 mm	-1.9%
15.00 m	1060 mm	-0.9%	1050 mm	-1.9%
20.00 m	1060 mm	-0.9%	1050 mm	-1.9%
25.00 m	1050 mm	-1.9%	1050 mm	-1.9%
30.00 m	1060 mm	-0.9%	1050 mm	-1.9%
35.00 m	1050 mm	-1.9%	1050 mm	-1.9%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Light progressive edge cracking on outlet side.



Photo 2 - Light transverse cracks.



Photo 3 - Highway 7 facing east.



Photo 4 - Highway 7 facing west.



Photo 5 - Outlet guardrail.



Photo 6 - Inlet embankment.



Photo 7 - Outlet embankment.



Photo 8 - Inlet overview.



Photo 9 - Outlet overview.



Photo 10 - Upstream channel view.



Photo 11 - Downstream channel view.



Photo 12 - Upstream pipe alignment and shape.



Photo 13 - Downstream pipe alignment and shape.



Photo 14 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 15 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 16 - V-2: Joint with evident black caulking.



Photo 17 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 18 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 19 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 20 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 21 - V-4: Separated joint by approximately 40 mm with black caulking evident.



Photo 22 - V-4: Separated joint by approximately 40 mm with black caulking evident.



Photo 23 - V-5: Endoscope camera placed in the probe hole showing no void (control point).



Photo 24 - V-5: Endoscope camera placed in the probe hole showing no void (control point).



Photo 25 - V-6: Endoscope camera placed in the probe hole showing void.



Photo 26 - V-6: Endoscope camera placed in the probe hole showing void.



Photo 27 - V-6: Endoscope camera placed in the probe hole showing void.

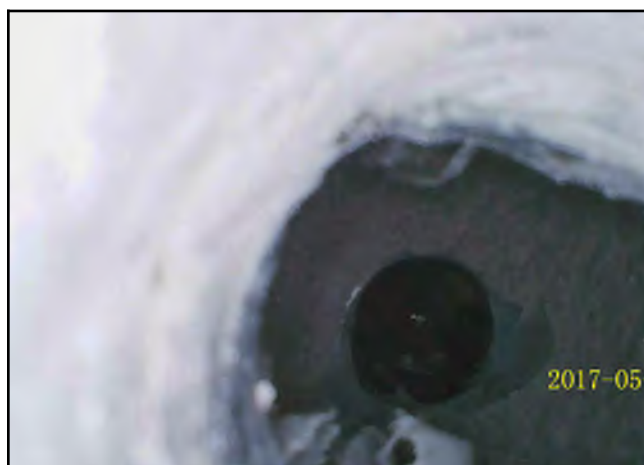


Photo 28 - V-7: Endoscope camera placed in the probe hole showing some void since host pipe is resting on Sliplined HDPE.



Photo 29 - V-7: Endoscope camera placed in the probe hole showing some void since host pipe is resting on Sliplined HDPE.

The asset 6 located on Highway 7 in Hastings County, consists of a previously rehabilitated culvert by means of Sliplined High Density Polyethylene (HDPE) that has an approximate diameter of 1.07 m and length of 35.00 m. A visual inspection and inSight™ Lite assessment were performed at this site which found seven (7) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in fair condition and performing as designed, however, a few deficiencies were noted. The outlet guardrail had significant slack within the steel wires. The visual assessment identified one (1) separated joint of approximately 40 mm with black caulking evident, recorded as V-4.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of -1.9%, 10.00 m from the inlet and a maximum vertical deviation of -1.9%, 10.00 m from the inlet.

The inSight™ Lite assessment did identify some areas of potential void within the annular space between the existing and sliplined culverts. This assessment required five (5) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected areas.

As noted in V-1, V-3 and V-6, visible annular voids between the existing culvert and the sliplined HDPE were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at these locations. V-1, and V-7 were identified as locations of no void. A control point was also taken and recorded as V-5 to ensure the accuracy of the inSight™ Lite assessment. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended the steel wire slack in the outlet guardrail be repaired to maintain the structural integrity of the guardrail. Additionally, it is recommended that the areas with confirmed annular voids between the existing culvert and the Sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2019

No.6

Highway 118 in Haliburton County

General Summary

The asset No.6 located on Highway 118 in Haliburton County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 1.07 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.35 m and length of 22.90 m. The asset is located at latitude 45° 1' 1.274" N, longitude 78° 20' 57.557" W. The asset has approximately 1.50 m of cover from the obvert to the road surface and flows generally south to north.

Inversa Systems performed an in-depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 6 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- 7 voids were observed, 8 inSight™ BCT images were completed
- Outcome: Continue Monitoring

Asset ID	No.6
County Name	Haliburton County
GPS	45° 1' 1.274" N, 78° 20' 57.557" W
Inspection Date	July 16, 2019
Written By	Joey Stafford, Field Technician.
Reviewed By	Jocelin Bourgeois, B.Sc.Eng., MBA
Approved By	Steven Godbout, B.Sc.Eng.



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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

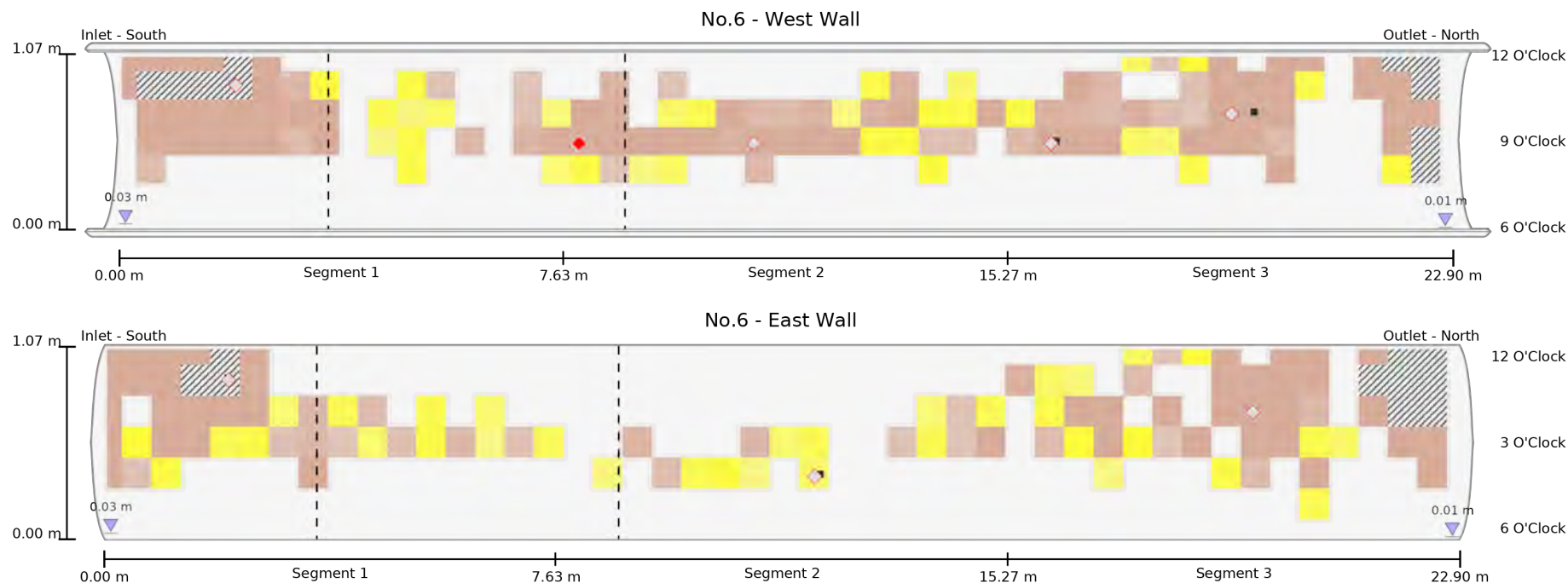
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

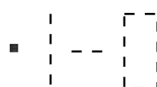
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

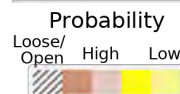
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



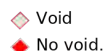
Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

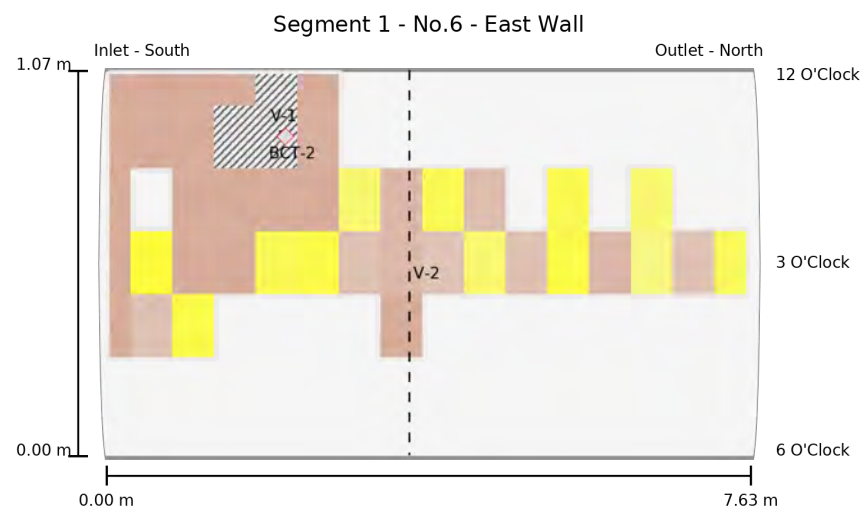
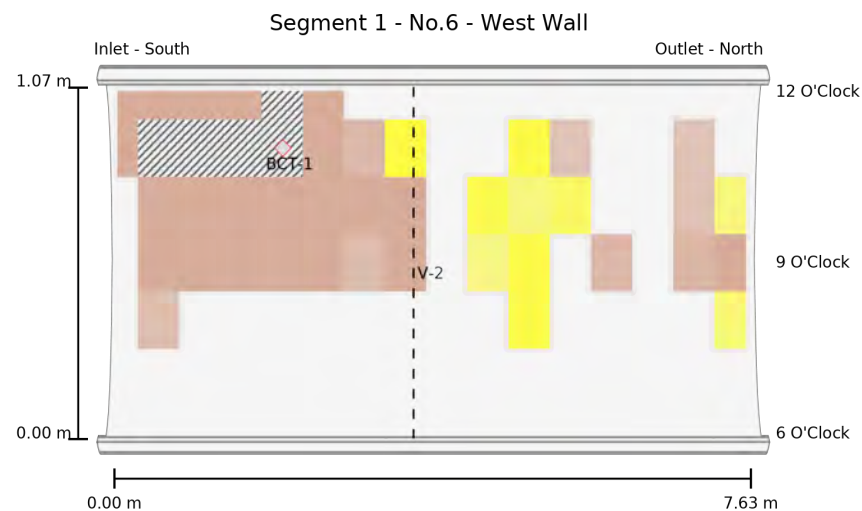


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	2.10 m	-	01:00	-	Endoscope camera showing visible void.
V-2	3.60 m	3.60 m	-	-	Separated joint of approximately 70 mm with visible supporting grout material.

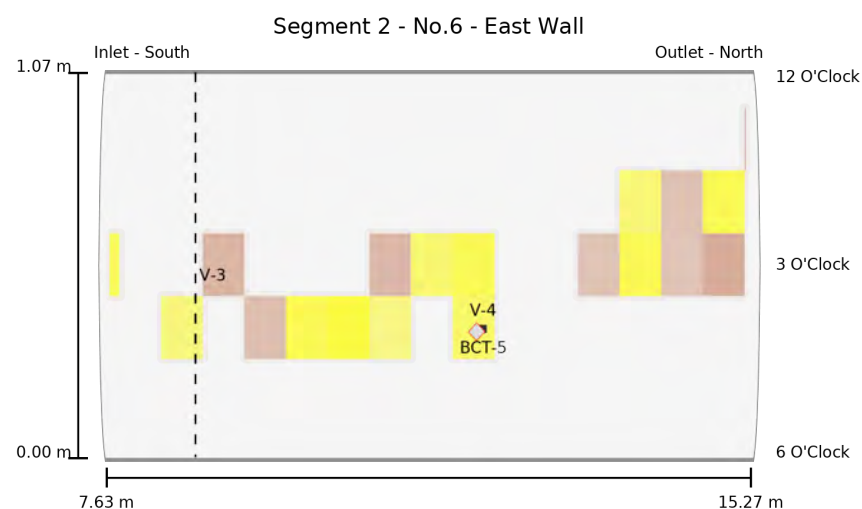
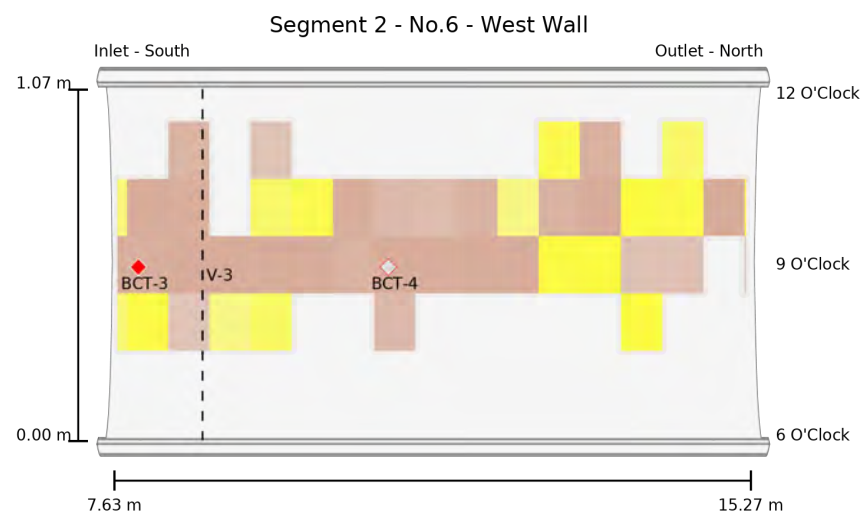
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-1	2.10 m	11:00	5344	Full annular void between existing CMP and sliplined HDPE.
BCT-2	2.20 m	01:00	5337	Full annular void between existing CMP and sliplined HDPE.

Segment 2



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-3	8.70 m	8.70 m	-	-	Joint with visible silicone sealant.
V-4	12.10 m	-	04:00	-	Endoscope camera showing visible void.

Acoustic Anomalies

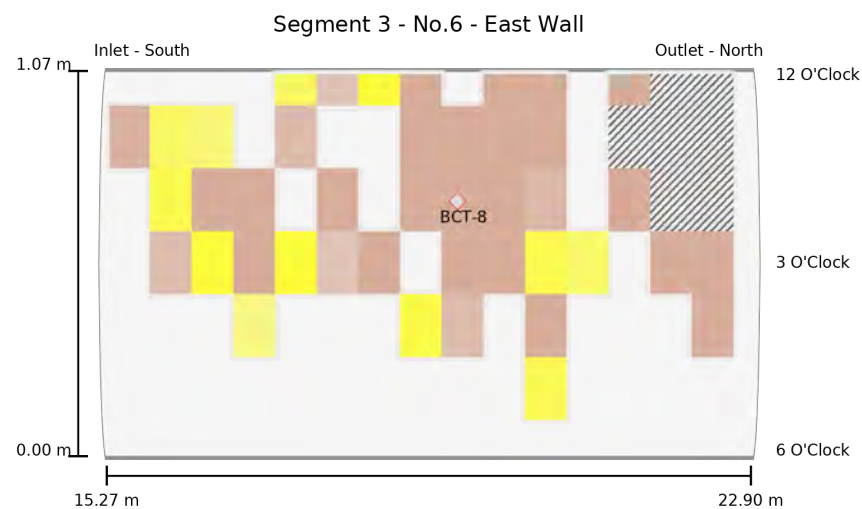
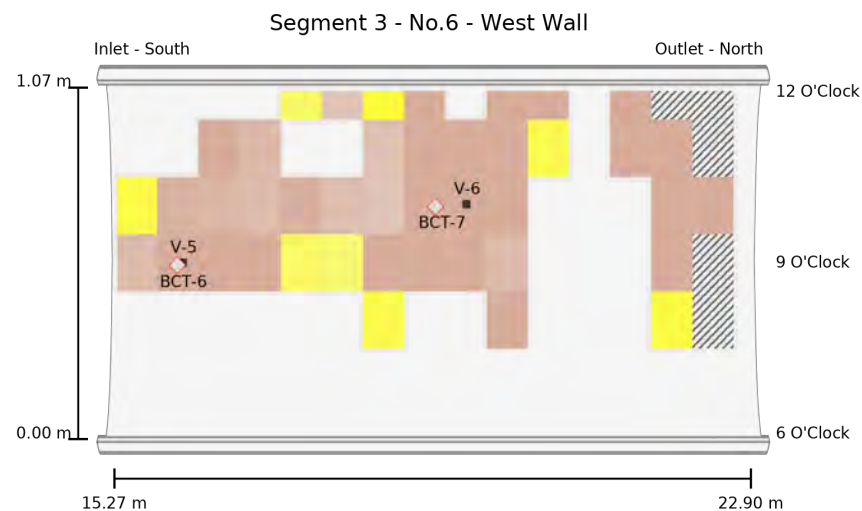
X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-3	8.00 m	09:00	5338	No void.
BCT-4	11.00 m	09:00	5339	Full annular void between existing CMP and sliplined HDPE.
BCT-5	12.10 m	04:00	5340	Annular void between existing CMP and sliplined HDPE.

Segment 3



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-5	16.10 m	-	09:00	-	Endoscope camera showing visible void.
V-6	19.50 m	-	10:00	-	Endoscope camera showing visible void.

Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
No acoustic anomalies found.				

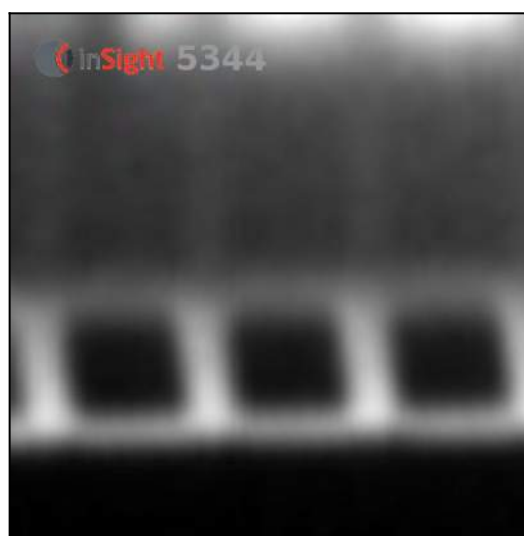
InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-6	16.10 m	09:00	5341	Full annular void between existing CMP and sliplined HDPE.
BCT-7	19.20 m	10:00	5342	Full annular void between existing CMP and sliplined HDPE.
BCT-8	19.50 m	02:00	5343	Annular void between existing CMP and sliplined HDPE.

Areas for diagnostic Backscatter Computed Tomography (BCT) imaging were selected based on the results from the visual, acoustic and InSight™ Lite assessment. The BCT scanner was positioned against the pipe wall covering a region of 200 mm along the pipe wall, at each location, to verify supporting soil presence. The depth of the image is set to a target depth up to 225 mm from the scanners face.

BCT images provide a cross-sectional view of the pipe wall. The lower portion of the image indicates the front (accessible) side of the pipe wall. An increase in the Y direction indicates the depth behind the wall. The X axis is the range along the length of the pipe wall.

The following images are used to verify supporting soil condition and presence. The unique InSight™ scan ID corresponds to a scan location on the pipe map. Voids are only reported if they are greater than 10 mm².



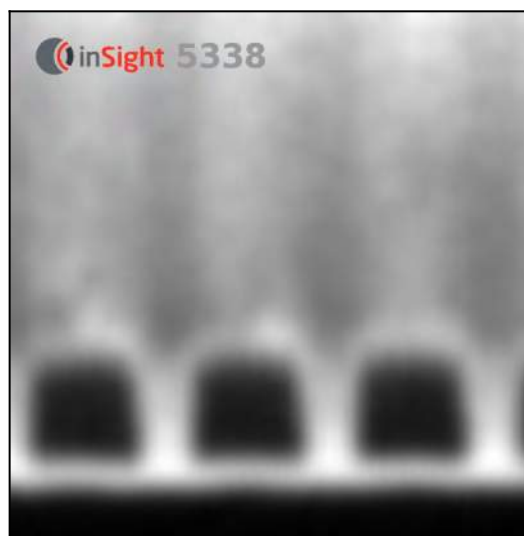
BCT-1 (Scan ID: 5344)

Full annular void between existing CMP and sliplined HDPE.



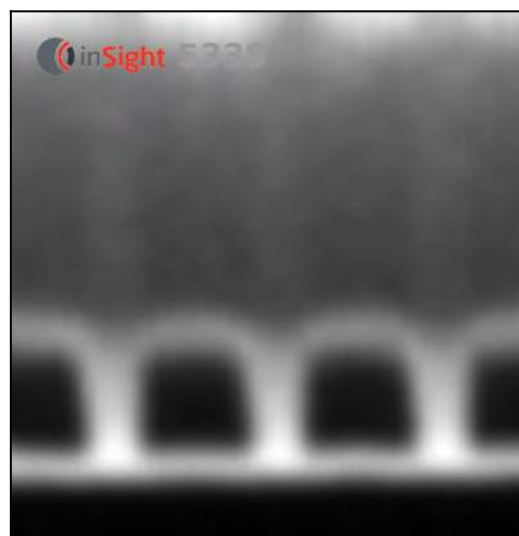
BCT-2 (Scan ID: 5337)

Full annular void between existing CMP and sliplined HDPE.



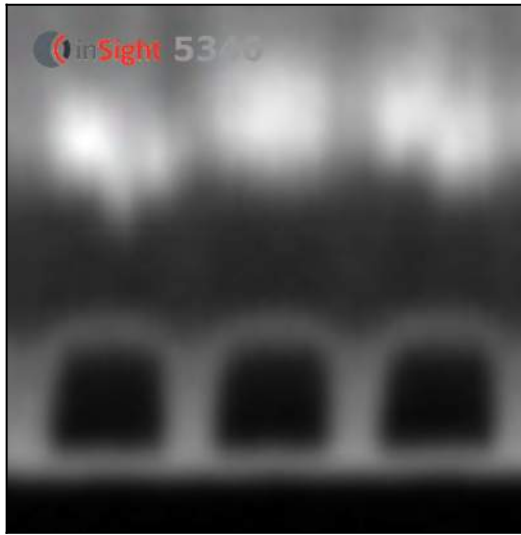
BCT-3 (Scan ID: 5338)

No void.

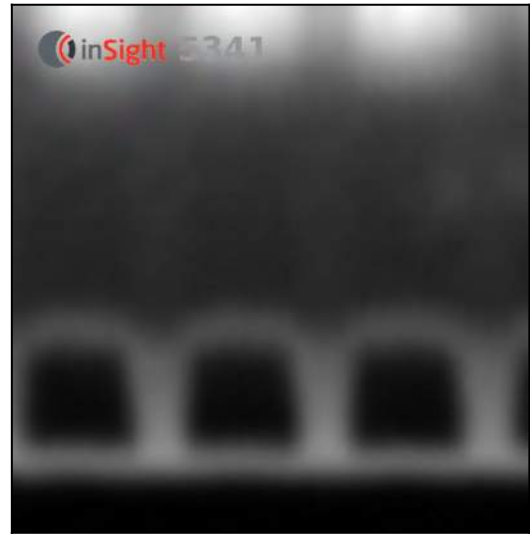


BCT-4 (Scan ID: 5339)

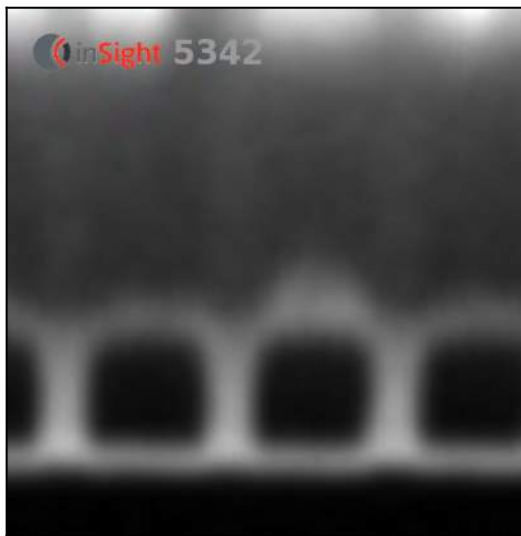
Full annular void between existing CMP and sliplined HDPE.



BCT-5 (Scan ID: 5340)
Annular void between existing CMP and sliplined HDPE.



BCT-6 (Scan ID: 5341)
Full annular void between existing CMP and sliplined HDPE.



BCT-7 (Scan ID: 5342)
Full annular void between existing CMP and sliplined HDPE.



BCT-8 (Scan ID: 5343)
Annular void between existing CMP and sliplined HDPE.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement		Rank 1
Pavement in excellent condition.		
		
Photo 1 - Highway 118 facing west.	Photo 2 - Highway 118 facing east.	

Guardrail	Rank N/A
Inlet guardrail.: Inlet guardrail not present. Outlet guardrail.: Outlet guardrail not present.	

Embankment

Rank 2

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Erosion channel(s) present: **Frequency:** 2 - 5 channels; **Severity:** Severe (200 - 300 mm (8 - 12 in) Width).
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 3 - Erosion channel on the outlet embankment measuring approximately 300 mm in width.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 6 - Inlet overview.:
Annular space of 80 mm
between the existing CMP and
the sliplined HDPE.



Photo 7 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.

Scour

Rank 2

Outlet End

- Outfall is perched/elevated: **Severity:** Severe (< 300 mm (12 in) Height).

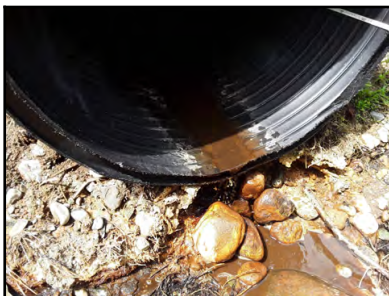


Photo 10 - Outlet is perched by approximately 260 mm in height.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 3

- Joint separation(s) present: **Severity:** Light (< 100 mm (4 in) Width).
 - Coupling device visible through joint separation(s).
 - Substrate visible through joint separation(s).

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Maximum shape deviation of approximately -1.9%. No dents or localized damage found.

Pipe Alignment

Rank 2

Minor vertical misalignment at the inlet end.

- Vertical misalignment of terminal pipe ends present.



Photo 11 - Upstream pipe alignment and shape.



Photo 12 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for No.6 is 1070 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1070 mm	0.0%	1050 mm	-1.9%
10.00 m	1060 mm	-0.9%	1050 mm	-1.9%
22.90 m	1060 mm	-0.9%	1050 mm	-1.9%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 118 facing west.



Photo 2 - Highway 118 facing east.



Photo 3 - Erosion channel on the outlet embankment measuring approximately 300 mm in width.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.



Photo 6 - Inlet overview.: Annular space of 80 mm between the existing CMP and the sliplined HDPE.



Photo 7 - Outlet overview.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.



Photo 10 - Outlet is perched by approximately 260 mm in height.



Photo 11 - Upstream pipe alignment and shape.



Photo 12 - Downstream pipe alignment and shape.



Photo 13 - V-1: Endoscope camera showing visible void.



Photo 14 - V-1: Endoscope camera showing visible void.



Photo 15 - V-2: Separated joint of approximately 70 mm with visible supporting grout material.



Photo 16 - V-2: Separated joint of approximately 70 mm with visible supporting grout material.



Photo 17 - V-3: Joint with visible silicone sealant.



Photo 18 - V-4: Endoscope camera showing visible void.



Photo 19 - V-4: Endoscope camera showing visible void.



Photo 20 - V-4: Endoscope camera showing visible void.



Photo 21 - V-5: Endoscope camera showing visible void.



Photo 22 - V-5: Endoscope camera showing visible void.



Photo 23 - V-5: Endoscope camera showing visible void.



Photo 24 - V-6: Endoscope camera showing visible void.



Photo 25 - V-6: Endoscope camera showing visible void.



Photo 26 - V-6: Endoscope camera showing visible void.

The asset No.6 located on Highway 118 in Haliburton County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 1.07 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.35 m and length of 22.90 m. A visual, acoustic and inSight™ Lite assessments were performed at this site which found six (6) visual indicators, no acoustic anomalies and inSight™ Lite anomalous regions inside the culvert. This resulted in eight (8) BCT images. The images found seven (7) locations of voiding.

Three (3) levels of preliminary screening tools (Visual Inspection, Acoustic Assessment, and inSight™ Lite Screening) were used during this condition assessment to determine where to deploy the BCT equipment, which in turn provides conclusive void identification and quantification.

The visual assessment identified two (2) visual indicators, V-2 and V-3. V-2 consisted of a separated joint measuring approximately 70 mm showing visible grout material. V-3 was a joint with apparent silicone sealant.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of -0.9%, 10.00 m from the inlet and a maximum vertical deviation of -1.9%, 0.00 m from the inlet.

The acoustic assessment did not reveal any anomalous regions, however, the inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. These assessments required eight (8) BCT images to be captured, which resulted in seven (7) locations of voiding. Annular voiding was confirmed in seven (7) of the eight (8) scan locations (exception of BCT-3). Each confirmed void was identified as being full annular void between the existing CMP and sliplined HDPE. Each BCT scan was located within an area of potential void identified by the inSight™ Lite assessment.

Four (4) holes were drilled at BCT scan locations and/or areas of potential voiding identified by the insight™ Lite assessment. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide an image of the inspected area. As noted in V-1, V-4, V-5, and V-6, visible voids were recorded at each location, confirming the BCT imaging at all locations. Following the inspection, each hole was sealed with an appropriate silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing CMP and the Sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host CMP fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured BCT scan images are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The BCT images should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the soilsight™ Pipe Map and segment views for the exact locations of the voids.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2019

No.14

Highway 118 in Haliburton County

General Summary

The asset No.14 located on Highway 118 in Haliburton County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 0.91 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.21 m and length of 22.20 m. The asset is located at latitude 44° 59' 42.128" N, longitude 78° 17' 58.490" W. The asset has approximately 1.00 m of cover from the obvert to the road surface and flows generally east to west.

Inversa Systems performed an in-depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 6 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- 8 voids were observed, 10 inSight™ BCT images were completed
- Outcome: Continue Monitoring

Asset ID	No.14
County Name	Haliburton County
GPS	44° 59' 42.128" N, 78° 17' 58.490" W
Inspection Date	July 17, 2019
Written By	Joey Stafford, Field Technician.
Reviewed By	Jocelin Bourgeois, B.Sc.Eng., MBA
Approved By	Steven Godbout, B.Sc.Eng.



SoilSight™ Condition Assessment

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

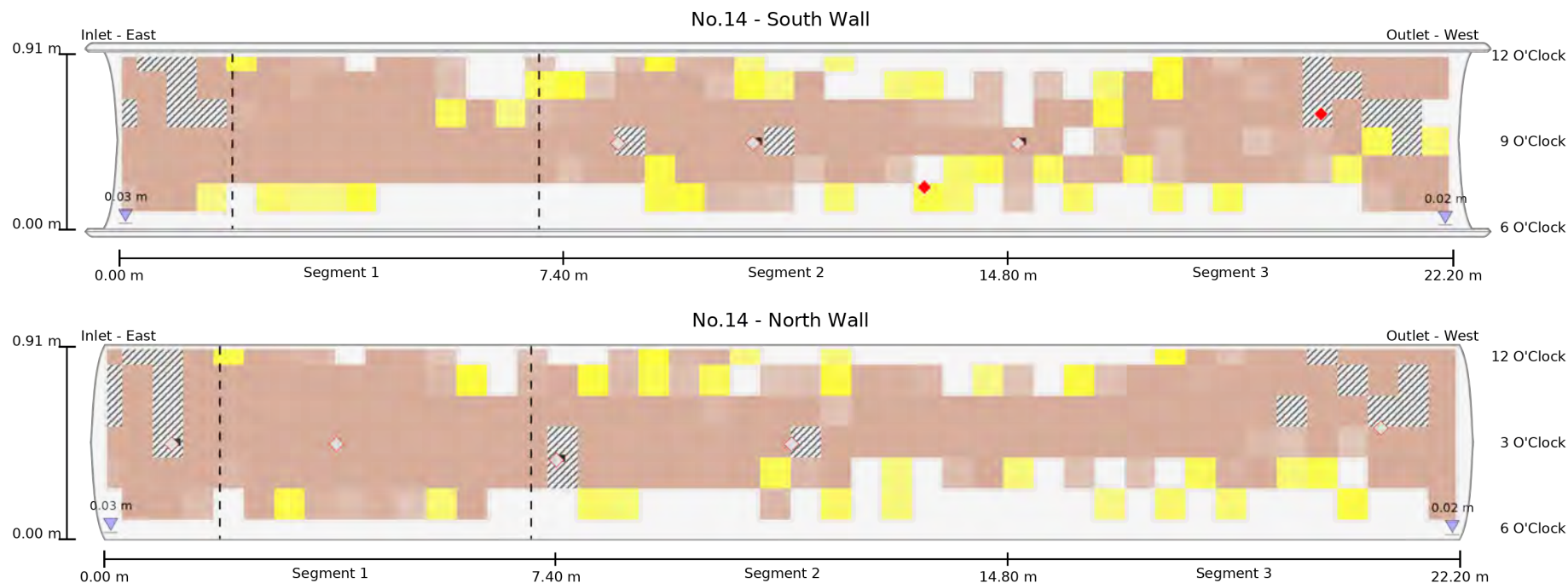
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

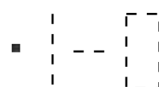
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

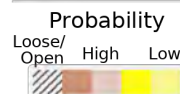
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



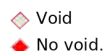
Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

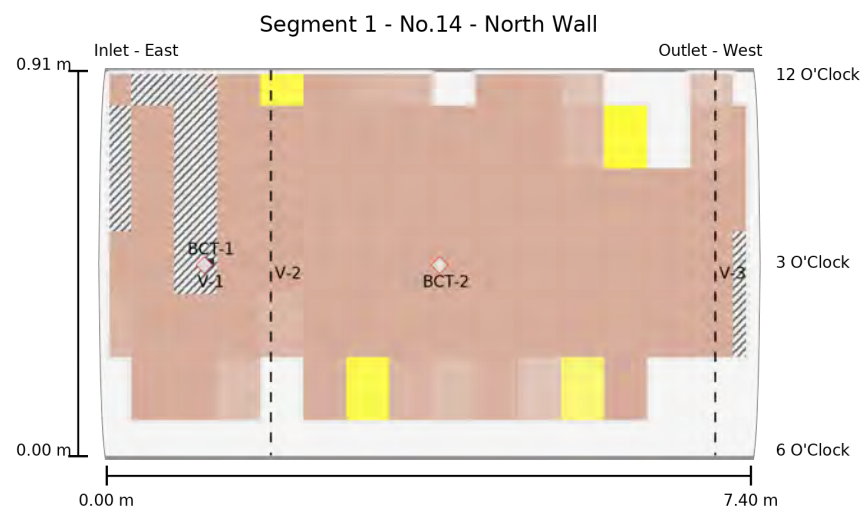
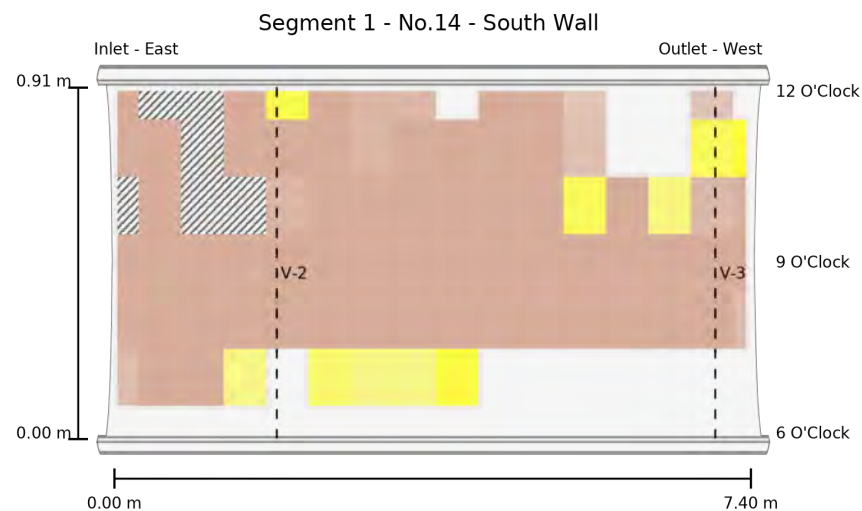


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.20 m	-	03:00	-	Endoscope camera showing visible void.
V-2	1.90 m	1.90 m	-	-	Joint with visible expansion foam.
V-3	7.00 m	7.00 m	-	-	Separated joint of approximately 30 mm with a visible coupler.

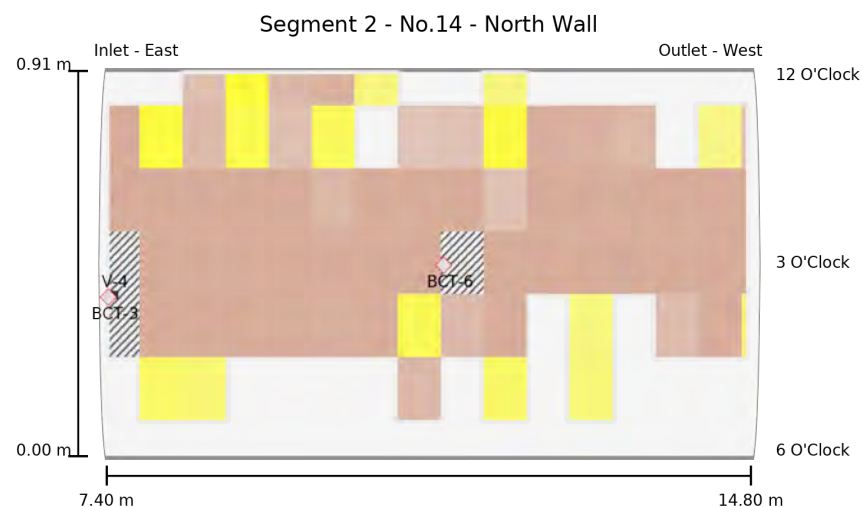
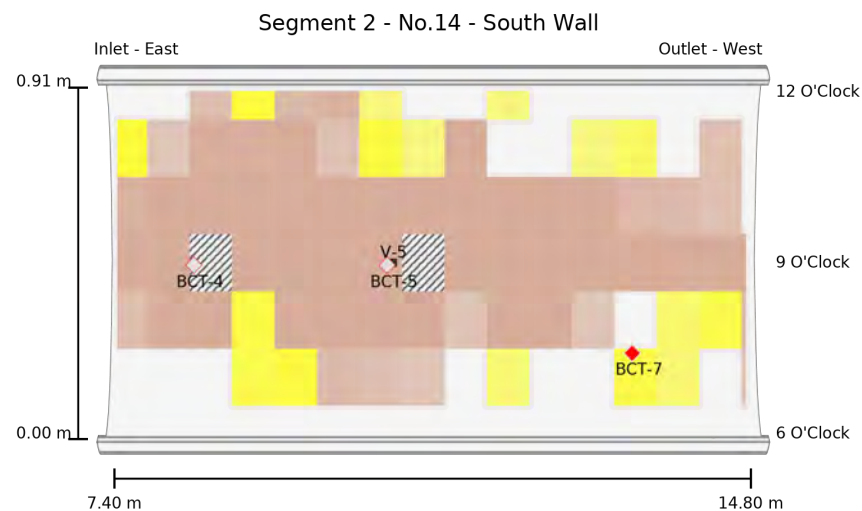
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-1	1.20 m	03:00	5351	Full annular void between existing CMP and sliplined HDPE.
BCT-2	3.90 m	03:00	5352	Full annular void between existing CMP and sliplined HDPE.

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-4	7.50 m	-	03:30	-	Endoscope camera showing visible void.
V-5	10.65 m	-	09:00	-	Endoscope camera showing visible void.

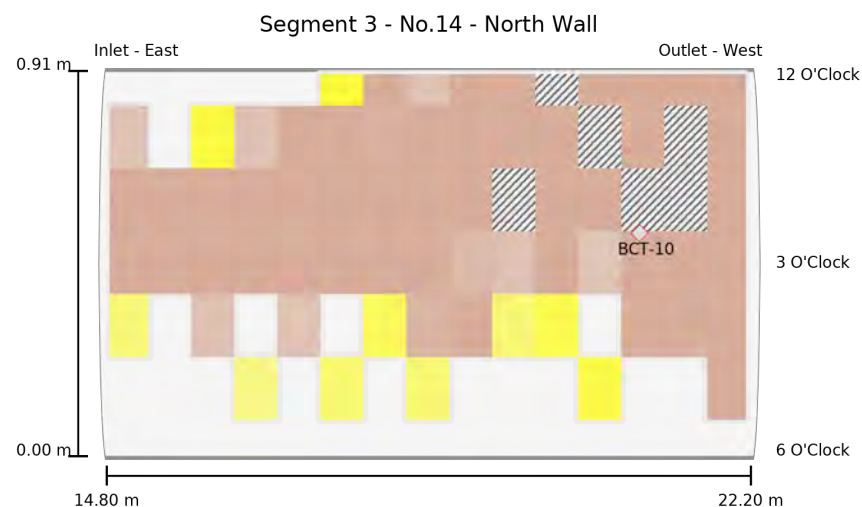
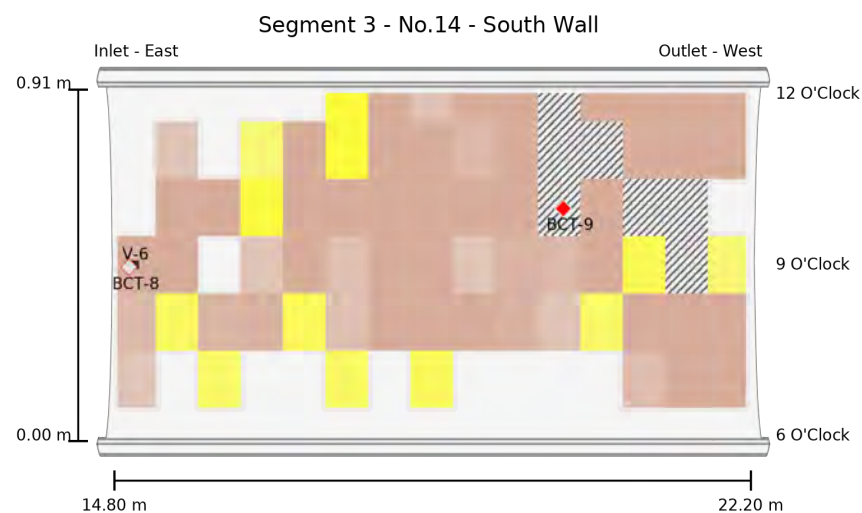
Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
No acoustic anomalies found.				

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-3	7.50 m	03:30	5353	Full annular void between existing CMP and sliplined HDPE.
BCT-4	8.40 m	09:00	5355	Full annular void between existing CMP and sliplined HDPE.
BCT-5	10.65 m	09:00	5356	Full annular void between existing CMP and sliplined HDPE.
BCT-6	11.35 m	03:00	5354	Full annular void between existing CMP and sliplined HDPE.
BCT-7	13.50 m	07:30	5357	No void (control point).

Segment 3



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-6	15.05 m	-	09:00	-	Endoscope camera showing visible void.

Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
No acoustic anomalies found.				

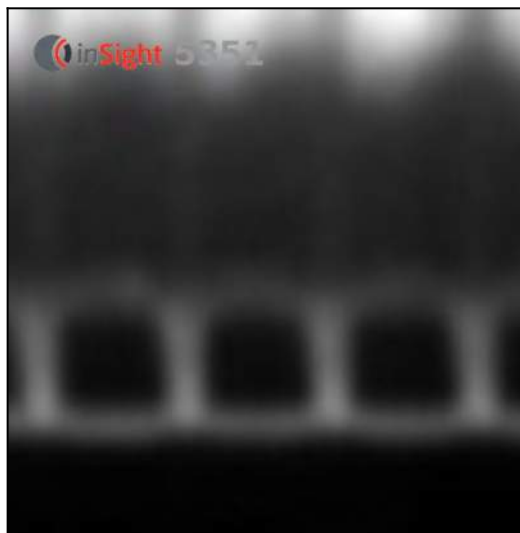
Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-8	15.05 m	09:00	5358	Full annular void between existing CMP and sliplined HDPE.
BCT-9	20.10 m	10:00	5359	No void. Low density grout.
BCT-10	21.00 m	02:30	5360	200 mm x 80 mm void.

Areas for diagnostic Backscatter Computed Tomography (BCT) imaging were selected based on the results from the visual, acoustic and InSight™ Lite assessment. The BCT scanner was positioned against the pipe wall covering a region of 200 mm along the pipe wall, at each location, to verify supporting soil presence. The depth of the image is set to a target depth up to 225 mm from the scanners face.

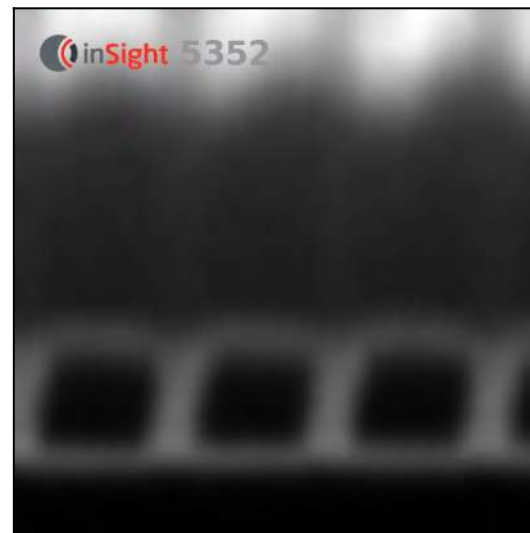
BCT images provide a cross-sectional view of the pipe wall. The lower portion of the image indicates the front (accessible) side of the pipe wall. An increase in the Y direction indicates the depth behind the wall. The X axis is the range along the length of the pipe wall.

The following images are used to verify supporting soil condition and presence. The unique InSight™ scan ID corresponds to a scan location on the pipe map. Voids are only reported if they are greater than 10 mm².



BCT-1 (Scan ID: 5351)

Full annular void between existing CMP and sliplined HDPE.



BCT-2 (Scan ID: 5352)

Full annular void between existing CMP and sliplined HDPE.



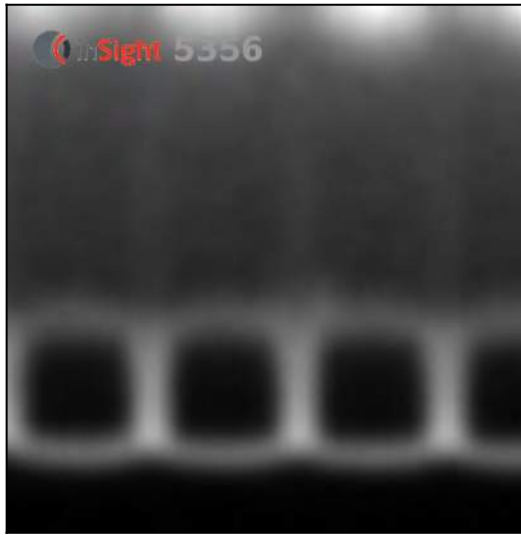
BCT-3 (Scan ID: 5353)

Full annular void between existing CMP and sliplined HDPE.



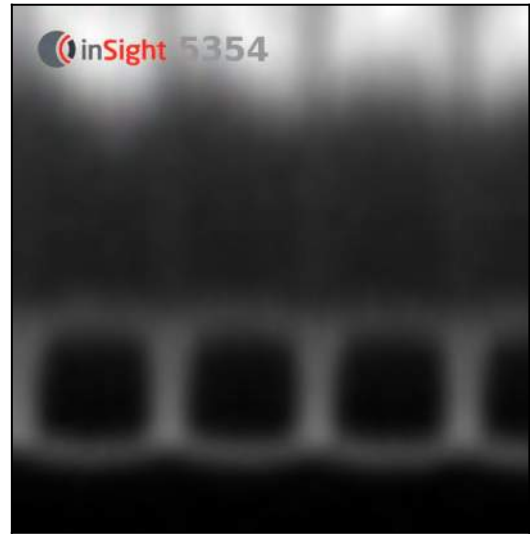
BCT-4 (Scan ID: 5355)

Full annular void between existing CMP and sliplined HDPE.



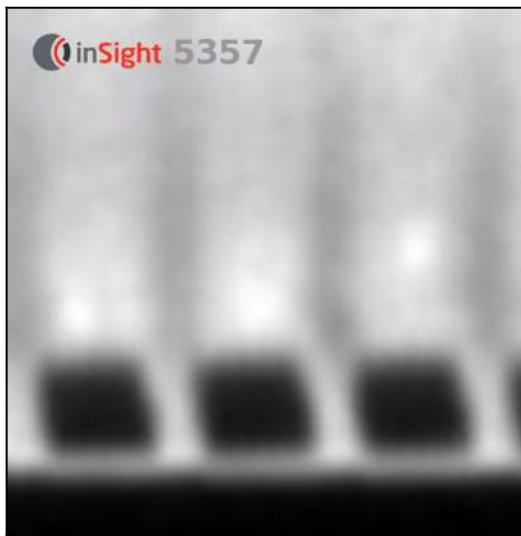
BCT-5 (Scan ID: 5356)

Full annular void between existing CMP and sliplined HDPE.

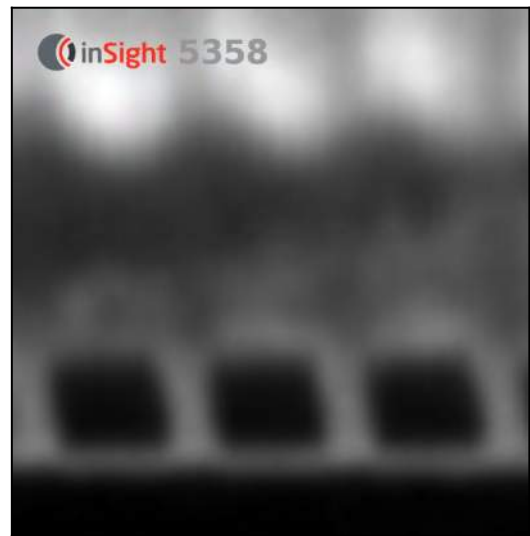


BCT-6 (Scan ID: 5354)

Full annular void between existing CMP and sliplined HDPE.

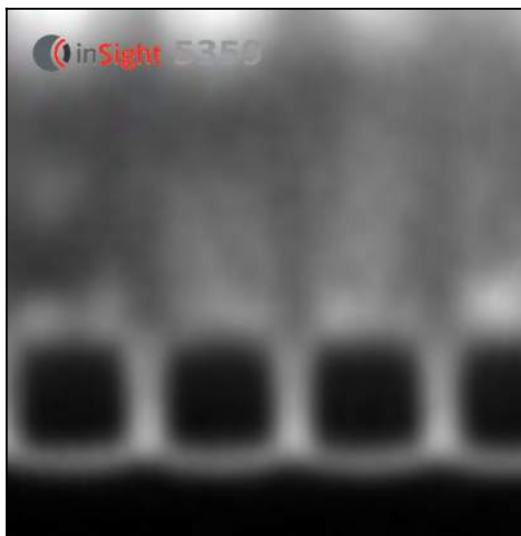


BCT-7 (Scan ID: 5357)
No void (control point).

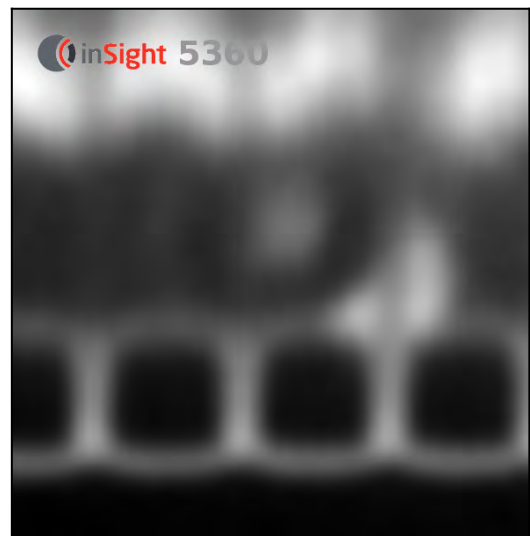


BCT-8 (Scan ID: 5358)

Full annular void between existing CMP and sliplined HDPE.





BCT-9 (Scan ID: 5359)
No void. Low density grout.



BCT-10 (Scan ID: 5360)
200 mm x 80 mm void.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement	Rank 1
Pavement in excellent condition.	
	
Photo 1 - Highway 118 facing south.	Photo 2 - Highway 118 facing north.

Guardrail	Rank N/A
<p>Inlet guardrail.: Inlet guardrail not present.</p> <p>Outlet guardrail.: Outlet guardrail not present.</p>	

Embankment

Rank 2

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Erosion channel(s) present: **Frequency:** > 5 channels; **Severity:** Moderate (100 - 200 mm (4 - 8 in) Width).
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 3 - Minor erosion channels on the outlet embankment with the most severe measuring approximately 190 mm in width.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 2

- Joint separation(s) present: **Severity:** Light (< 100 mm (4 in) Width).
- Coupling device visible through joint separation(s).

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Maximum shape deviation of approximately 1.1%. No dents or localized damage found.

Pipe Alignment

Rank 2

Minor vertical misalignment at the pipe outlet.

- Vertical misalignment of terminal pipe ends present.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for No.14 is 910 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	910 mm	0.0%	910 mm	0.0%
10.00 m	920 mm	1.1%	920 mm	1.1%
22.20 m	920 mm	1.1%	920 mm	1.1%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 118 facing south.



Photo 2 - Highway 118 facing north.



Photo 3 - Minor erosion channels on the outlet embankment with the most severe measuring approximately 190 mm in width.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.



Photo 12 - V-1: Endoscope camera showing visible void.



Photo 13 - V-1: Endoscope camera showing visible void.



Photo 14 - V-2: Joint with visible expansion foam.

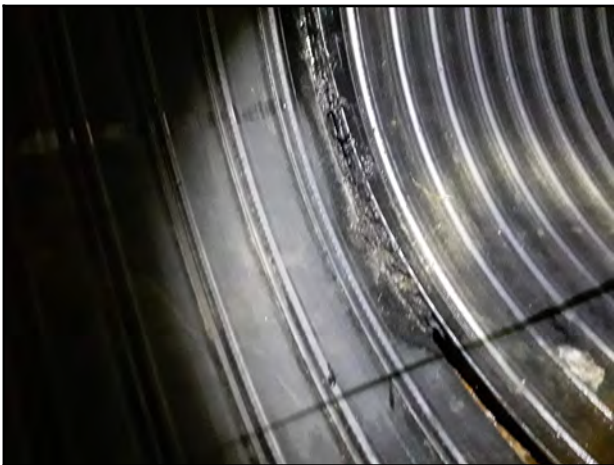


Photo 15 - V-3: Separated joint of approximately 30 mm with a visible coupler.



Photo 16 - V-3: Separated joint of approximately 30 mm with a visible coupler.

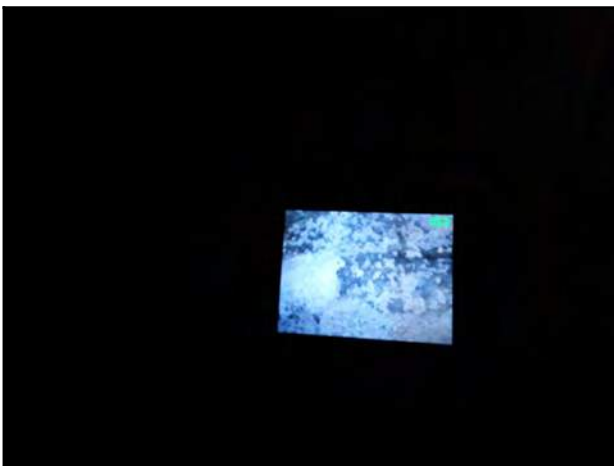


Photo 17 - V-4: Endoscope camera showing visible void.

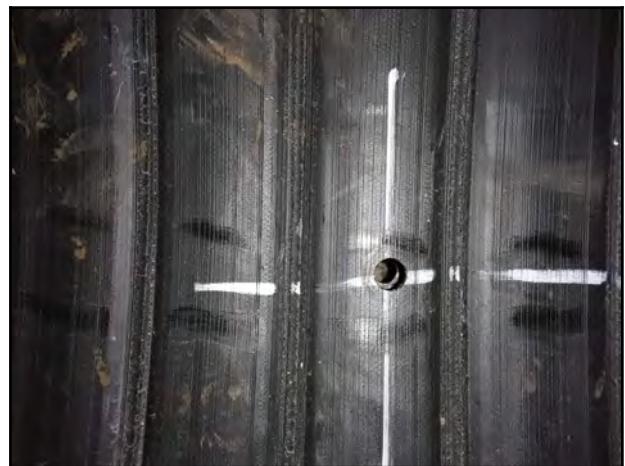


Photo 18 - V-4: Endoscope camera showing visible void.



Photo 19 - V-5: Endoscope camera showing visible void.



Photo 20 - V-5: Endoscope camera showing visible void.

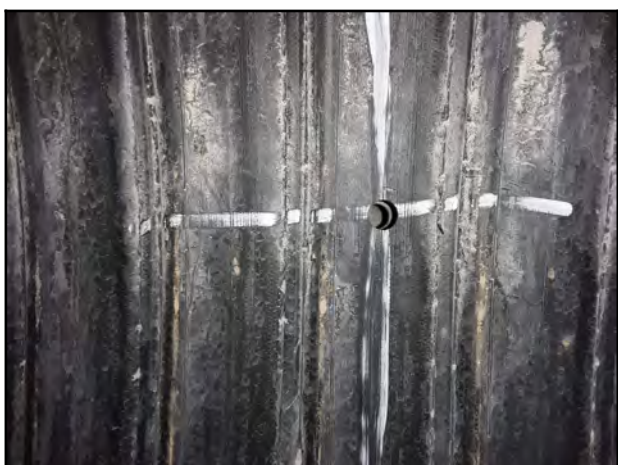


Photo 21 - V-6: Endoscope camera showing visible void.



Photo 22 - V-6: Endoscope camera showing visible void.



Photo 23 - Radiography image at outlet obvert.



Photo 24 - Radiography image at inlet obvert.



Photo 25 - Annular space of 170 mm between the existing CMP and the sliplined HDPE at outlet.



Photo 26 - Annular space of 120 mm between the existing CMP and the sliplined HDPE at inlet.

The asset No.14 located on Highway 118 in Haliburton County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 0.91 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.21 m and length of 22.20 m. A visual, acoustic and inSight™ Lite assessments were performed at this site which found six (6) visual indicators, no acoustic anomalies and inSight™ Lite anomalous regions inside the culvert. This resulted in ten (10) BCT images. The images found eight (8) locations of voiding.

It should be noted that three (3) levels of preliminary screening tools (Visual Inspection, Acoustic Assessment, and inSight™ Lite Screening) were used during this condition assessment to determine where to deploy the BCT equipment, which in turn provides conclusive void identification and quantification.

The visual assessment did identify two (2) visual indicators, V-2 and V-3. V-2 was a joint with visible expansion foam, and V-3 was a separated joint of approximately 30 mm. It is unknown why expansion foam was utilized during construction.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of 1.1%, 10.00 m from the inlet and a maximum vertical deviation of 1.1%, 10.00 m from the inlet.

The acoustic assessment did not reveal any anomalous regions, however, the inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. These assessments required ten (10) BCT images to be captured, which resulted in eight (8) locations of voiding. Annular voiding was confirmed in eight (8) of the ten (10) scan locations. BCT-7 was a planned control point to help confirm the accuracy of the scans taken within identified areas of potential void. BCT-9 was located within an identified area of potential void and showed signs of low-density grout. The most significant voids were found at BCT-1, BCT-2, BCT-3, BCT-4, BCT-5, BCT-6, as well as BCT-8 and were identified as being full annular void between the existing CMP and sliplined HDPE.

Four (4) holes were drilled at BCT scan locations and/or areas of high potential void identified by the inSight™ Lite assessment. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide an image of the inspected area. As noted in V-1, V-4, V-5, and V-6, visible voids were recorded at each location, confirming the BCT imaging at all locations. Following the inspection, each hole was sealed with a silicone sealant.

An Ultrasonic (UT) examination was also undertaken by Applus RTD on this asset. Ultrasonic readings were taken at 3, 6, 9 and 12 o'clock at two (2) locations in the middle of the asset, spaced by approximately 24.0 in. As detailed in the attached report dated August 15, 2019, prepared by Applus RTD, each UT thickness reading resulted in a 6.0 mm HDPE wall thickness. No information could be gathered beyond the HDPE near-surface wall thickness. UT is not an appropriate method for inspection of material with an air gap, as found in the HDPE wall profile.

Similarly, Applus RTD captured radiograph imagery at the inlet and outlet obverts. As illustrated in the radiography images shown in Photo 23 and Photo 24, the images identified voids at the inlet and outlet obvert behind the first approximately 19 mm and 24 mm of grouting material at the inlet and outlet respectively. The grout installation tube is also identifiable in each photo. Radiography is not an appropriate method for inspection of grout placement, except at the terminal ends of the pipe, since the film/detector array needs to be on the opposite side of the wall from the source, which is not possible within the pipe.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing CMP and the Sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host CMP fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured BCT scan images are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The BCT images should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the soilsight™ Pipe Map and segment views for the exact locations of the voids.

Technical recommendations, as well as cost estimates, can be provided upon request.

Applus RTD Supporting Documents

ULTRASONIC EXAMINATION REPORT

PROJECT / CLIENT INFORMATION

CLIENT:	INVERSA SYSTEMS	REPORT NUMBER:	INVERSA SYSTEMS		
JOB LOCATION:	Bancroft , Highlands East Ontario ON Highway 118	DATE:	July 23, 2019	PAGE NO.:	1 of 2
PROJECT:	N/A	PROCEDURE NO.:	QA-TP-UT-01	REV. NO.:	02
A+RTD JOB NO.:	94609	PROCEDURE NO.:	N/A	REV. NO.:	
NDE REQUEST NO.:	N/A	TECHNIQUE NO.:	Contact Pulse Echo	REV. NO.:	
AFE / NOT NO.:	N/A	CODE/STANDARD:	For information only		
PO / WO NO.:	N/A	SPECIFICATION:	Record Thickness		

PART(S) EXAMINED, SURFACE CONDITIONS AND TECHNICAL DATA

PART(S) EXAMINED: <u>Culvert #14</u>		PART NO. / ID: <u>Culvert #14</u>	
MATERIAL: <u>Polystyrene Pipe</u>	THICKNESS: <u>6mm</u>	SIZING CURVE: <input type="checkbox"/> DAC <input type="checkbox"/> TCG <input type="checkbox"/> N/A	
SURFACE CONDITION: <u>Smooth</u>		DAMPING: <u>50</u> Ω	REJECT: <u>Off</u>
COUPLANT BRAND: <u>Sonaglide</u>	TYPE: <u>Grade 20</u>	CABLE TYPE: <u>BNC to microdot</u>	LENGTH: <u>5'</u>

EQUIPMENT/CALIBRATION BLOCK(S)

CALIBRATION DATA

Equipment / Cal. Block(s)			Serial / Asset No.	Calibration Due Date	Reference Reflector		Amplitude (%)		Sound Path		Ref. Gain (dB)
Olympus Epoch 600			112303	April 29, 2020	Back wall		80				32
Probe Make	Angle (°)	Style	Serial Number	Size		Frequency	Scanning Gain		Transfer	Range	
Olympus	0	Single	1009327	0.250 in.		5.0 MHz	Ref. Gain Level		N/A	10 mm	


INSPECTION DETAILS - RESULTS

RESULTS: For information only - details given below

INDICATIONS: See below for results

Ultrasonic Thickness readings were taken at two areas in the middle of the culvert at **24" apart** @ 0, 90, 180, and 270 degrees see below "A" and "B".

#6	0	90	180	270
"A"	6.0mm	6.0mm	6.0mm	6.0mm
"B"	6.0mm	6.0mm	6.0mm	6.0mm

	NAME	SIGNATURE	CERTIFICATION	DATE
TECHNICIAN:	Charlie McCreddie		<input checked="" type="checkbox"/> CGSB <input type="checkbox"/> SNT-TC-1A <input type="checkbox"/> PCN Level: <input type="checkbox"/> 1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 Discipline: <input checked="" type="checkbox"/> UT <input type="checkbox"/> TOFD <input type="checkbox"/> PAUT	July 23, 2019
REVIEWER:			<input type="checkbox"/> CGSB <input type="checkbox"/> SNT-TC-1A <input type="checkbox"/> PCN Level: <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 Discipline: <input type="checkbox"/> UT <input type="checkbox"/> TOFD <input type="checkbox"/> PAUT	July 23, 2019
CLIENT REP.:				

ULTRASONIC EXAMINATION REPORT

INSPECTION DETAILS - RESULTS (CONTINUED):

INVERSA SYSTEMS

Culvert #14 July 23 2019





SoilSight™ Condition Assessment

MTO 2019

No.4

Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road in Quinte West County

General Summary

The asset No.4 located on Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road in Quinte West County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 1.22 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.50 m and length of 41.60 m. The asset is located at latitude 44° 10' 42.218" N, longitude 77° 27' 1.173" W. The asset has approximately 3.00 m of cover from the obvert to the road surface and flows generally north to south.

Inversa Systems performed an in-depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 5 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- 9 voids were observed, 10 inSight™ BCT images were completed
- Outcome: Continue Monitoring

Asset ID	No.4
County Name	Quinte West County
GPS	44° 10' 42.218" N, 77° 27' 1.173" W
Inspection Date	July 17, 2019
Written By	Joey Stafford, Field Technician.
Reviewed By	Jocelin Bourgeois, B.Sc.Eng., MBA
Approved By	Steven Godbout, B.Sc.Eng.



SoilSight™ Condition Assessment

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

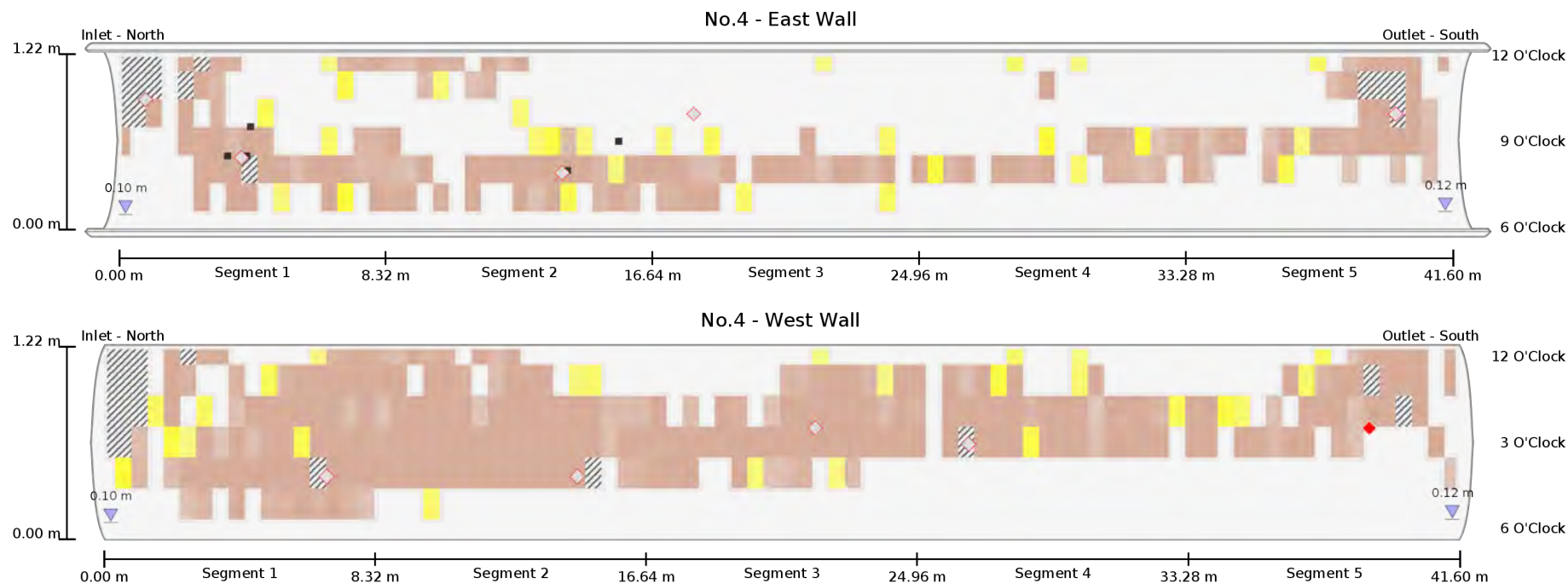
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

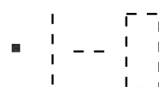
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



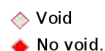
Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



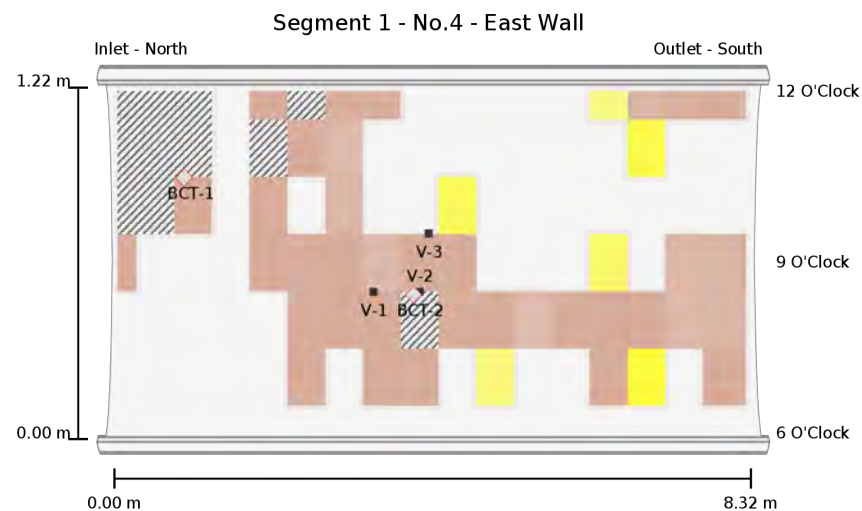
InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.



InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	3.40 m	-	08:30	-	Endoscope camera showing visible void.
V-2	4.00 m	-	08:30	-	Endoscope camera showing visible void.
V-3	4.12 m	-	09:30	-	Endoscope camera showing visible void.

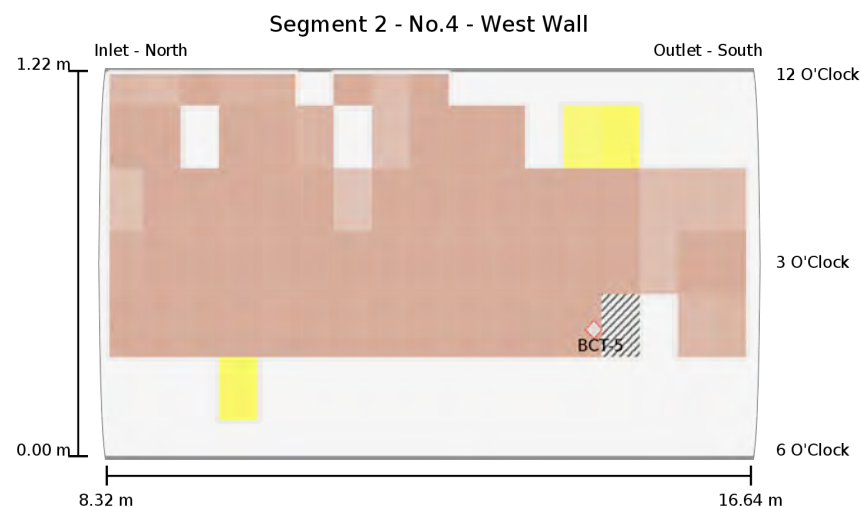
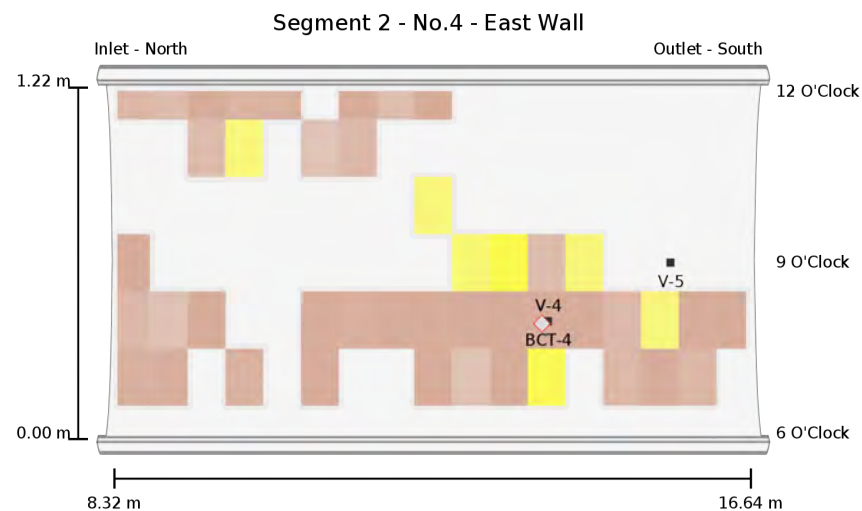
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-1	1.00 m	10:30	5328	50 mm x 80 mm void.
BCT-2	4.00 m	08:30	5329	Full annular void between existing CMP and sliplined HDPE.
BCT-3	7.00 m	04:00	5330	Full annular void between existing CMP and sliplined HDPE.

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-4	14.00 m	-	08:00	-	Endoscope camera showing visible void. Image is blurry, difficult to see void.
V-5	15.60 m	-	09:00	-	Localized damage at joint.

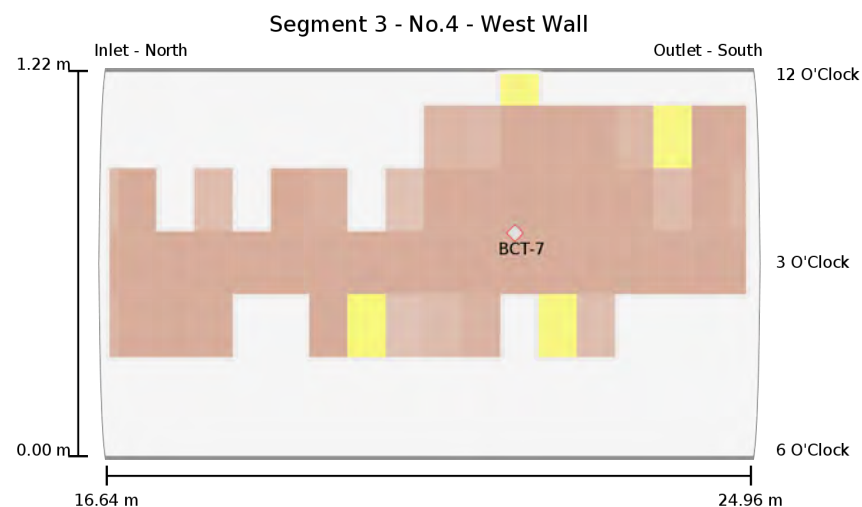
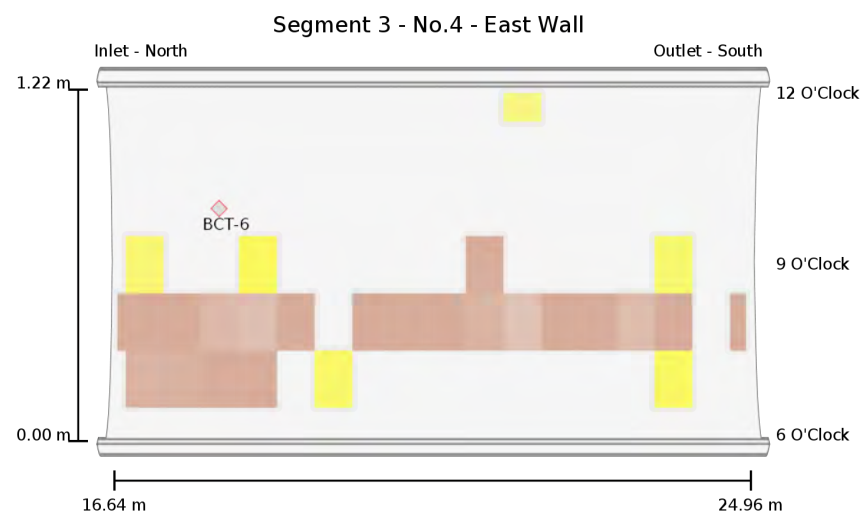
Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
No acoustic anomalies found.				

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-4	14.00 m	08:00	5331	Full annular void between existing CMP and sliplined HDPE.
BCT-5	14.70 m	04:00	5332	Full annular void between existing CMP and sliplined HDPE.

Segment 3



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

X1	X2	Clock 1	Clock 2	Comments
No visual indicators found.				

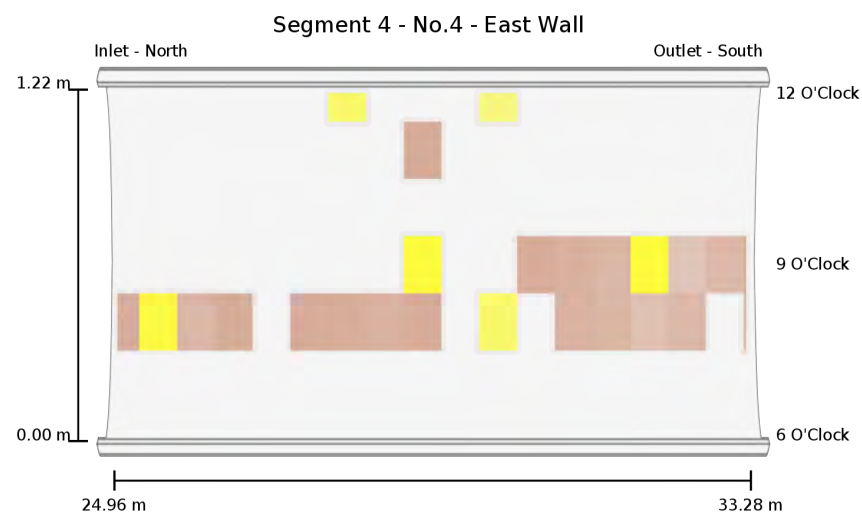
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-6	18.10 m	10:00	5333	Full annular void between existing CMP and sliplined HDPE.
BCT-7	22.00 m	02:30	5334	Full annular void between existing CMP and sliplined HDPE.

Segment 4



Visual Indicators

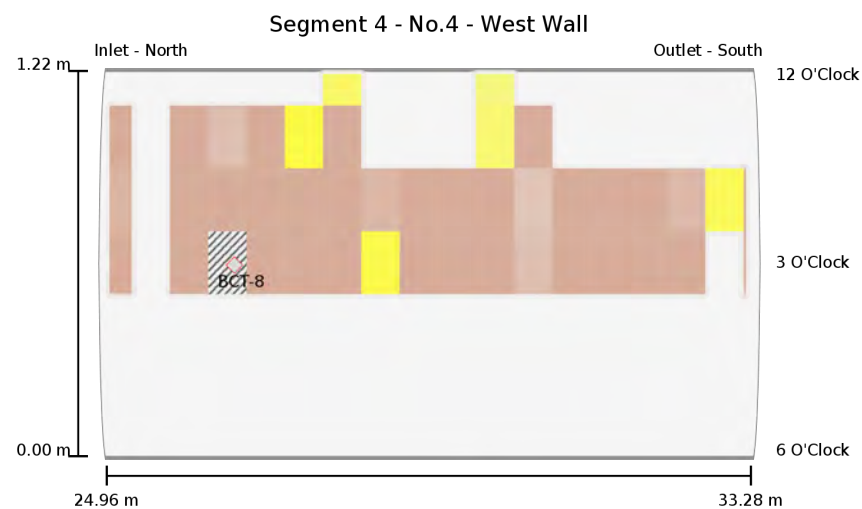
X1	X2	Clock 1	Clock 2	Comments
No visual indicators found.				

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

Insight™ BCT Images

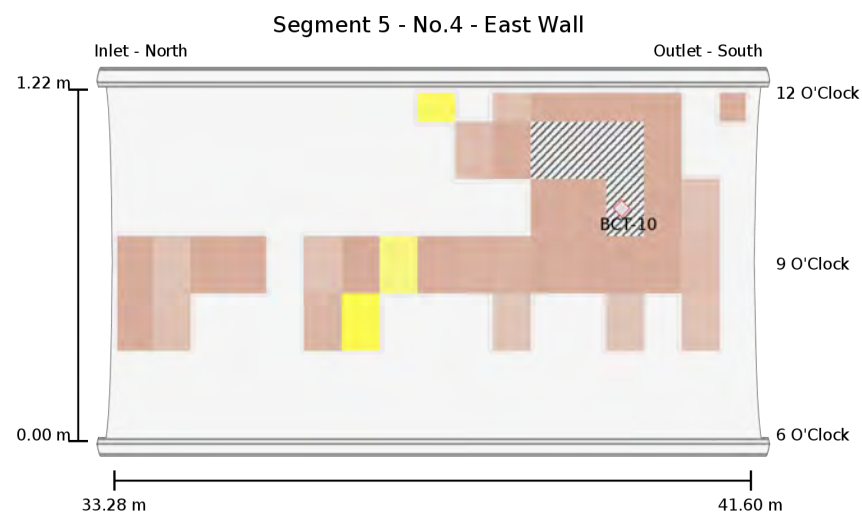
	X	Clock	Scan ID	Verdict
BCT-8	26.70 m	03:00	5335	Full annular void between existing CMP and sliplined HDPE.



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Segment 5



Visual Indicators

X1	X2	Clock 1	Clock 2	Comments
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No visual indicators found.

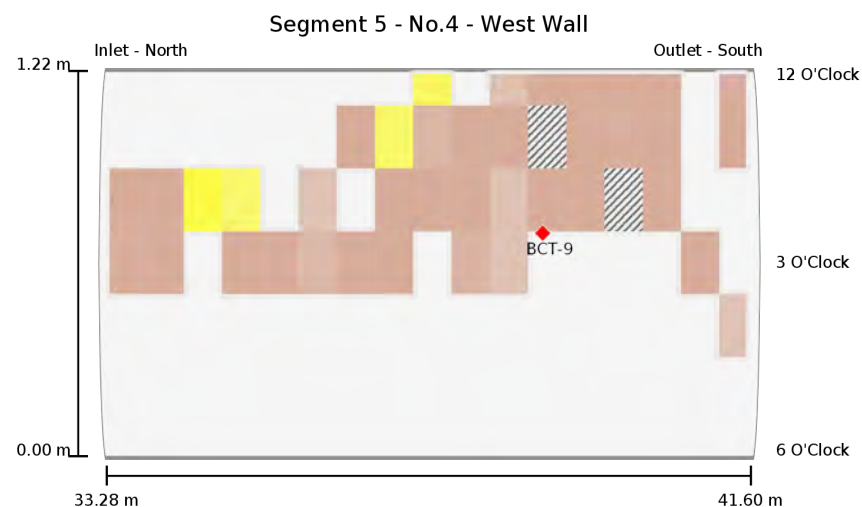
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-9	39.00 m	02:30	5326	No void.
BCT-10	40.00 m	10:00	5327	60 mm x 100 mm void.



Visual Indicators

InSight™ BCT Images

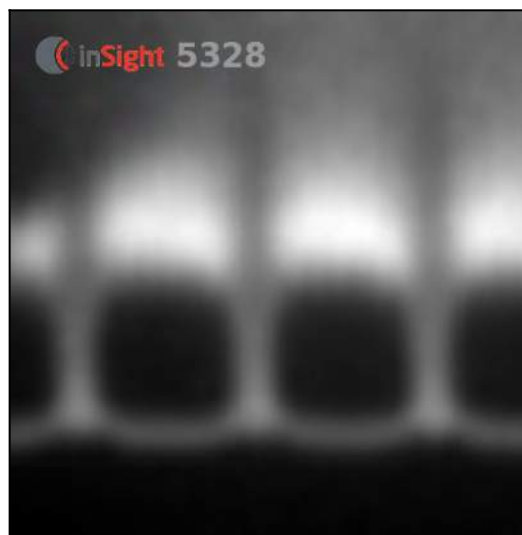
Acoustic Anomalies

InSight™ Lite Anomalies

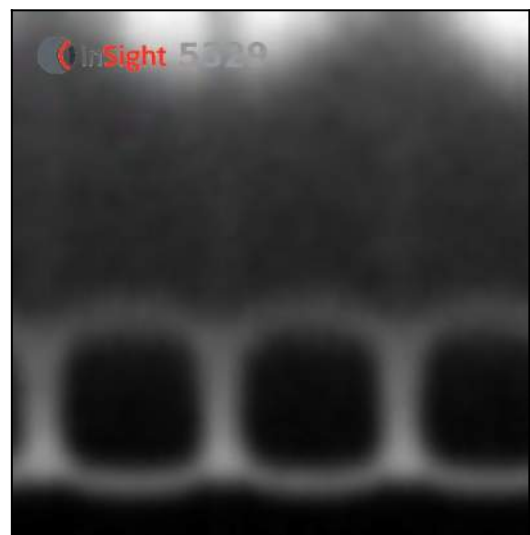
Areas for diagnostic Backscatter Computed Tomography (BCT) imaging were selected based on the results from the visual, acoustic and InSight™ Lite assessment. The BCT scanner was positioned against the pipe wall covering a region of 200 mm along the pipe wall, at each location, to verify supporting soil presence. The depth of the image is set to a target depth up to 225 mm from the scanners face.

BCT images provide a cross-sectional view of the pipe wall. The lower portion of the image indicates the front (accessible) side of the pipe wall. An increase in the Y direction indicates the depth behind the wall. The X axis is the range along the length of the pipe wall.

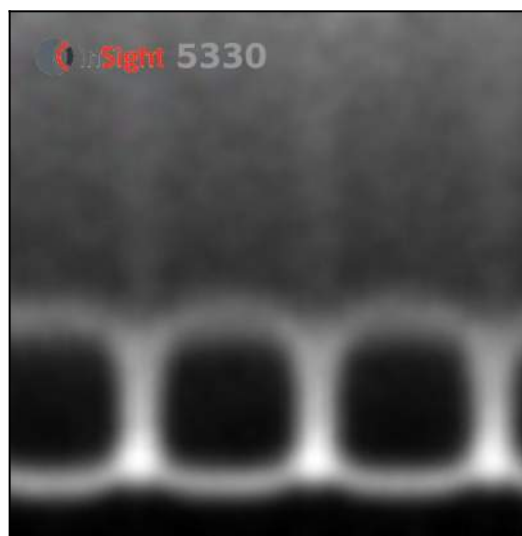
The following images are used to verify supporting soil condition and presence. The unique InSight™ scan ID corresponds to a scan location on the pipe map. Voids are only reported if they are greater than 10 mm².



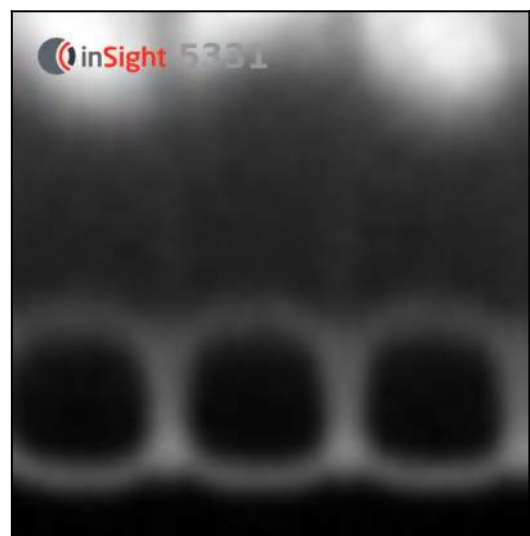
BCT-1 (Scan ID: 5328)
50 mm x 80 mm void.



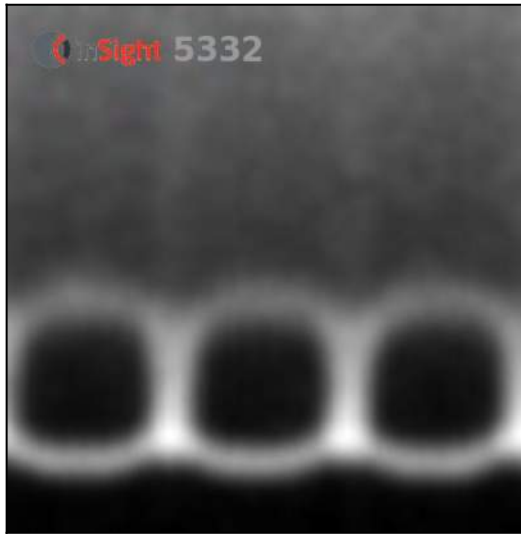
BCT-2 (Scan ID: 5329)
Full annular void between existing CMP and sliplined HDPE.



BCT-3 (Scan ID: 5330)
Full annular void between existing CMP and sliplined HDPE.

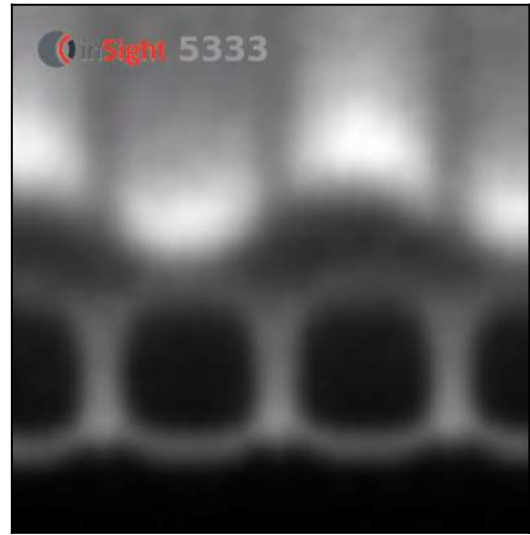


BCT-4 (Scan ID: 5331)
Full annular void between existing CMP and sliplined HDPE.



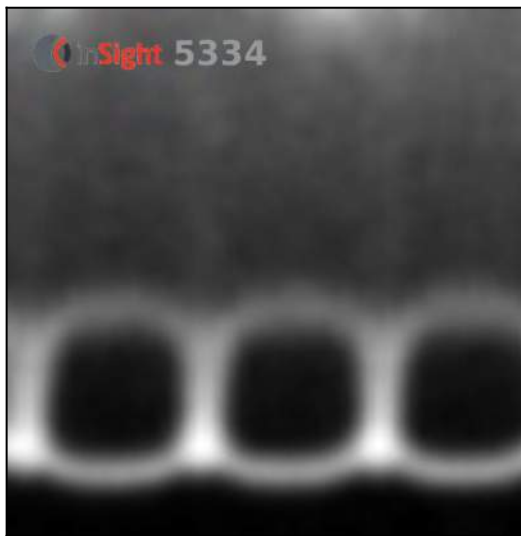
BCT-5 (Scan ID: 5332)

Full annular void between existing CMP and sliplined HDPE.



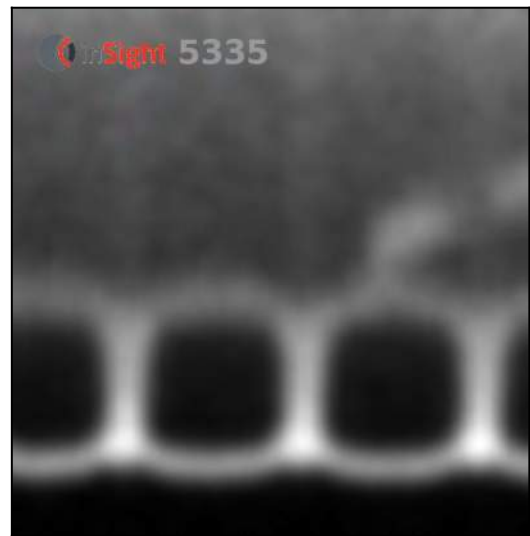
BCT-6 (Scan ID: 5333)

Full annular void between existing CMP and sliplined HDPE.



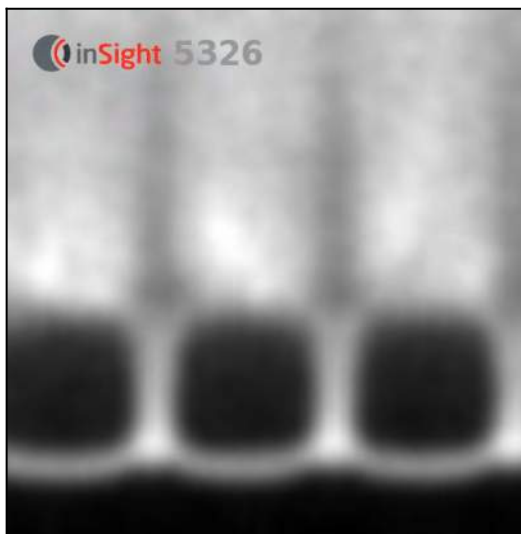
BCT-7 (Scan ID: 5334)

Full annular void between existing CMP and sliplined HDPE.



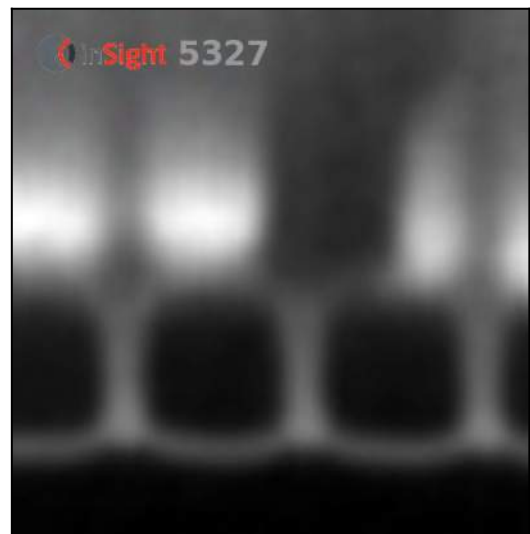
BCT-8 (Scan ID: 5335)

Full annular void between existing CMP and sliplined HDPE.



BCT-9 (Scan ID: 5326)

No void.




BCT-10 (Scan ID: 5327)

60 mm x 100 mm void.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement		Rank 1
Pavement in excellent condition.		
		
Photo 1 - Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road facing east.	Photo 2 - Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road facing west.	
Guardrail		Rank N/A
Inlet guardrail.: Inlet guardrail not present.		
Outlet guardrail.: Outlet guardrail not present.		

Embankment

Rank 1

Embankment stable, no visible ruts or erosion channels. No large vegetation present.

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 3 - Inlet embankment.



Photo 4 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 5 - Inlet overview.



Photo 6 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 7 - Upstream channel view.



Photo 8 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

Shape, Dents, and Localized Damage

Rank 2

Maximum shape deviation of approximately 2.5%.

- Localized damage present: **Severity:** Pipe performance not affected by localized damage.

Pipe Alignment

Rank 2

Minor horizontal misalignment at the outlet end.

- Pipe misalignment present: **Condition:** Horizontal misalignment.



Photo 9 - Upstream pipe alignment and shape.



Photo 10 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for No.4 is 1220 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1220 mm	0.0%	1240 mm	1.6%
10.00 m	1220 mm	0.0%	1220 mm	0.0%
20.00 m	1220 mm	0.0%	1220 mm	0.0%
30.00 m	1230 mm	0.8%	1220 mm	0.0%
41.60 m	1250 mm	2.5%	1220 mm	0.0%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road facing east.



Photo 2 - Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road facing west.



Photo 3 - Inlet embankment.



Photo 4 - Outlet embankment.



Photo 5 - Inlet overview.



Photo 6 - Outlet overview.



Photo 7 - Upstream channel view.



Photo 8 - Downstream channel view.



Photo 9 - Upstream pipe alignment and shape.



Photo 10 - Downstream pipe alignment and shape.



Photo 11 - V-1: Endoscope camera showing visible void.



Photo 12 - V-1: Endoscope camera showing visible void.



Photo 13 - V-2: Endoscope camera showing visible void.



Photo 14 - V-2: Endoscope camera showing visible void.



Photo 15 - V-3: Endoscope camera showing visible void.



Photo 16 - V-3: Endoscope camera showing visible void.

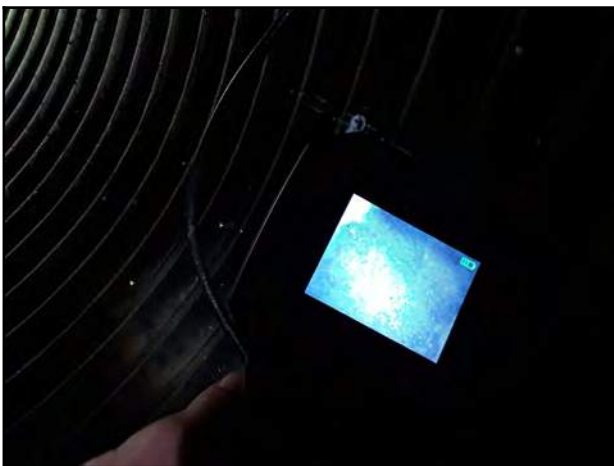


Photo 17 - V-3: Endoscope camera showing visible void.

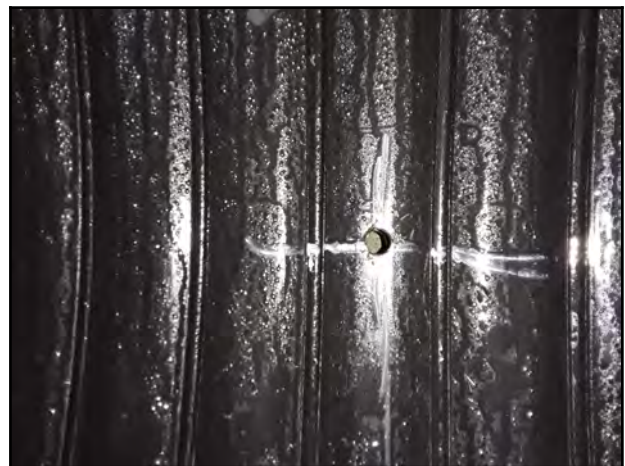


Photo 18 - V-4: Endoscope camera showing visible void. Image is blurry, difficult to see void.



Photo 19 - V-4: Endoscope camera showing visible void. Image is blurry, difficult to see void.



Photo 20 - V-4: Endoscope camera showing visible void. Image is blurry, difficult to see void.



Photo 21 - V-5: Localized damage at joint.



Photo 22 - 3.4 m at 8:30 with visible void.



Photo 23 - 4 m at 8:30 with visible void.



Photo 24 - Broken piece of grout at the inlet.



Photo 25 - Annular space of 120 mm between the existing CMP and the sliplined HDPE at inlet.



Photo 26 - Annular space of 200 mm between the existing CMP and the sliplined HDPE at outlet.

The asset No.4 located on Highway 401 East Bound Off-Ramp at Wallbridge Loyalist Road in Quinte West County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 1.22 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.50 m and length of 41.60 m. A visual, acoustic and inSight™ Lite assessments were performed at this site which found five (5) visual indicators, no acoustic anomalies and inSight™ Lite anomalous regions inside the culvert. This resulted in ten (10) BCT images. The images found nine (9) locations of voiding.

Three (3) levels of preliminary screening tools (Visual Inspection, Acoustic Assessment, and inSight™ Lite Screening) were used during this condition assessment to determine where to deploy the BCT equipment, which in turn provides conclusive void identification and quantification.

The visual assessment did not identify major deficiencies.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of 2.5%, 41.60 m from the inlet and a maximum vertical deviation of 1.6%, 0.00 m from the inlet.

The acoustic assessment did not reveal any anomalous regions, however, the inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. These assessments required ten (10) BCT images to be captured, which resulted in nine (9) locations of voiding. The most significant voids were found at BCT-2, BCT-3, BCT-4, BCT-5, BCT-6, BCT-7, and BCT-8 and were identified as being full annular void between the existing CMP and sliplined HDPE. BCT-9, the only scan that showed no voids, was located within an area of potential grout loss identified by the inSight™ Lite scanner.

Four (4) holes were drilled at BCT scan locations and/or areas of high potential void identified by the inSight™ Lite assessment. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide an image of the inspected area. As noted in V-1, V-2, V-3, and V-4, visible voids were recorded at each location, confirming the BCT imaging at all locations. Following the inspection, each hole was sealed with an appropriate silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing CMP and the sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host CMP fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured BCT scan images are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The BCT images should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the soilsight™ Pipe Map and segment views for the exact locations of the voids.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2019

No.2

Highway 17 in Renfrew County

General Summary

The asset No.2 located on Highway 17 in Renfrew County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 1.37 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.80 m and length of 31.00 m. The asset is located at latitude 45° 43' 49.261" N, longitude 76° 59' 50.726" W. The asset has approximately 1.50 m of cover from the obvert to the road surface and flows generally east to west.

Inversa Systems performed an in-depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 6 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- 9 voids were observed, 10 inSight™ BCT images were completed
- Outcome: Continue Monitoring

Asset ID	No.2
County Name	Renfrew County
GPS	45° 43' 49.261" N, 76° 59' 50.726" W
Inspection Date	July 15, 2019
Written By	Joey Stafford, Field Technician.
Reviewed By	Jocelin Bourgeois, B.Sc.Eng., MBA
Approved By	Steven Godbout, B.Sc.Eng.



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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

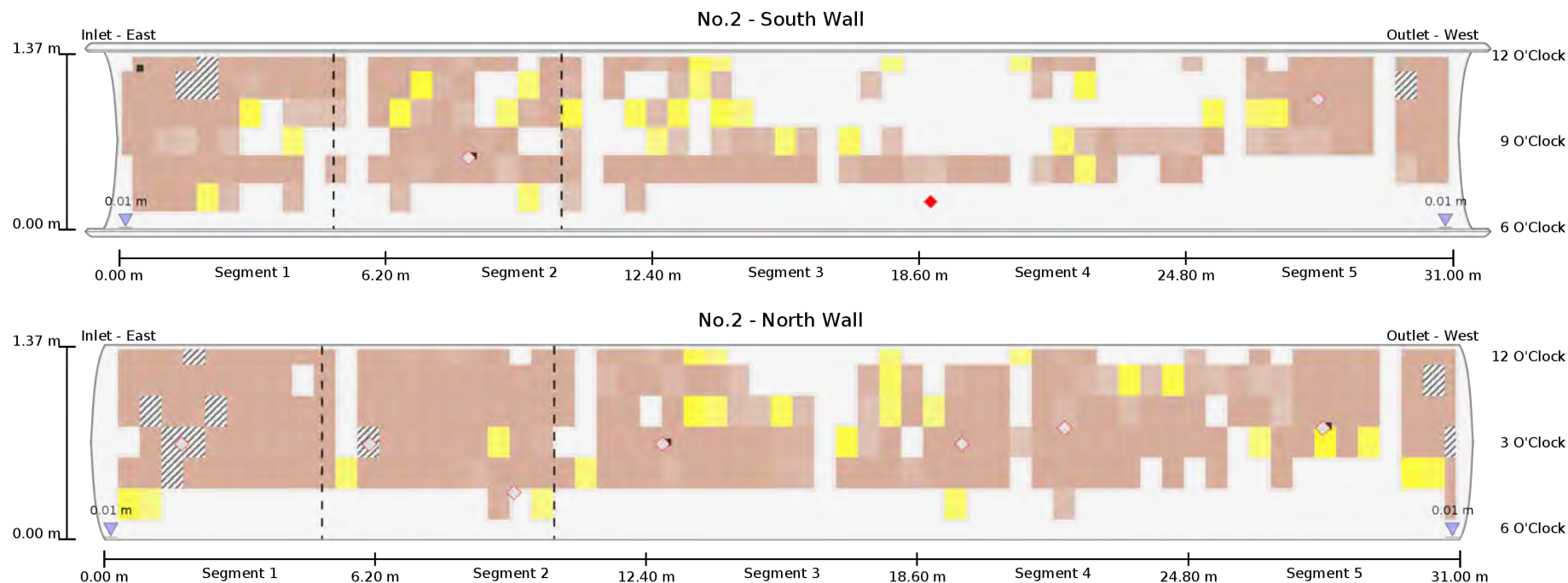
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

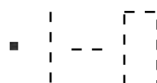
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

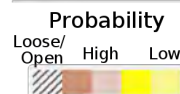
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



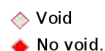
Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.



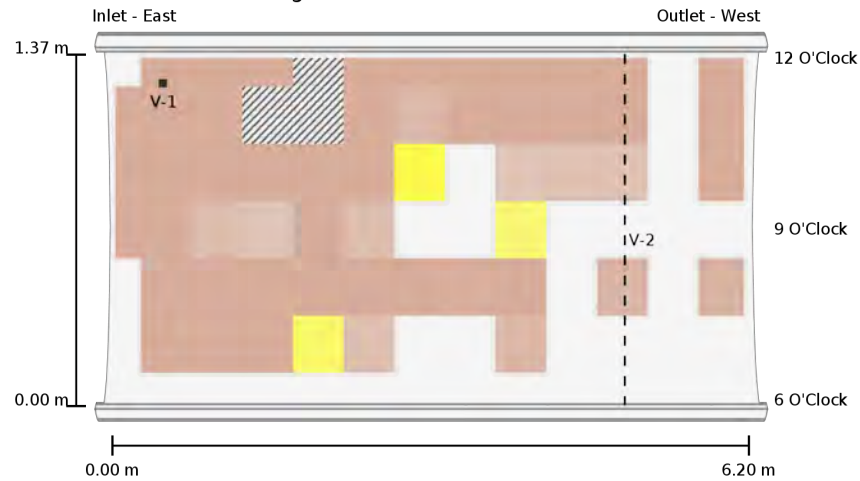
InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1

Segment 1 - No.2 - South Wall



Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	0.50 m	-	11:30	-	Endoscope camera showing visible void.
V-2	5.00 m	5.00 m	-	-	Joint with visible expansion foam and visible supporting material.

Acoustic Anomalies

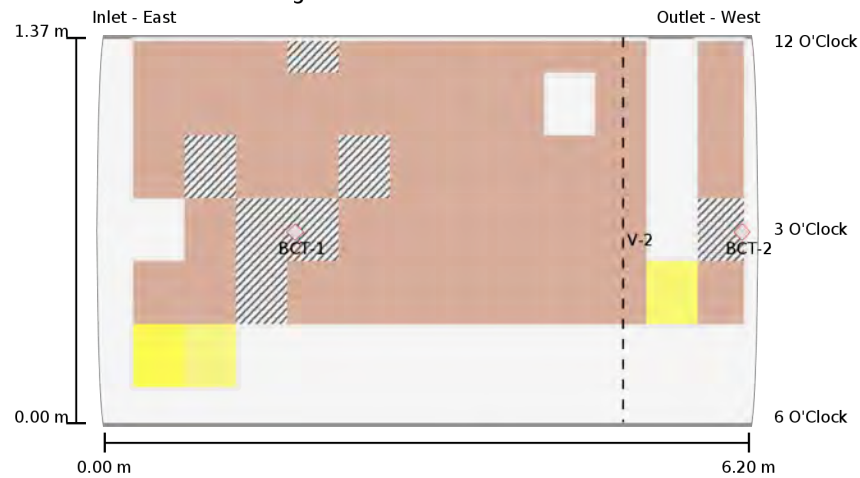
X1	X2	Clock 1	Clock 2
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No acoustic anomalies found.

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-1	1.90 m	03:00	5382	Full annular void between existing CMP and sliplined HDPE.
BCT-2	6.20 m	03:00	5381	Full annular void between existing CMP and sliplined HDPE.

Segment 1 - No.2 - North Wall



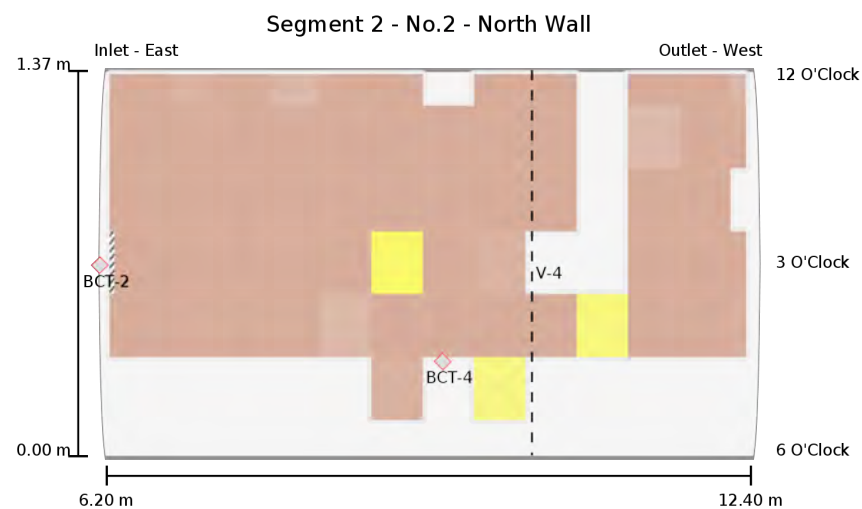
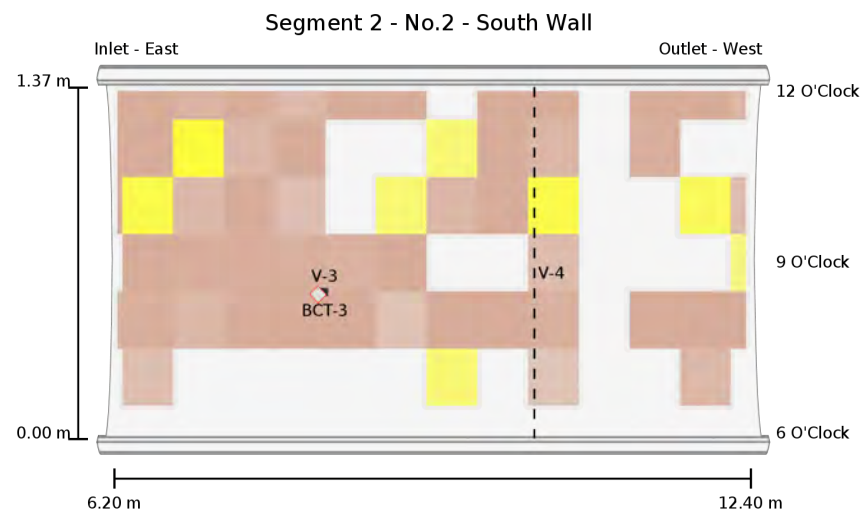
Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Segment 2



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-3	8.25 m	-	08:30	-	Endoscope camera showing visible void.
V-4	10.30 m	10.30 m	-	-	Joint with visible expansion foam and visible supporting material.

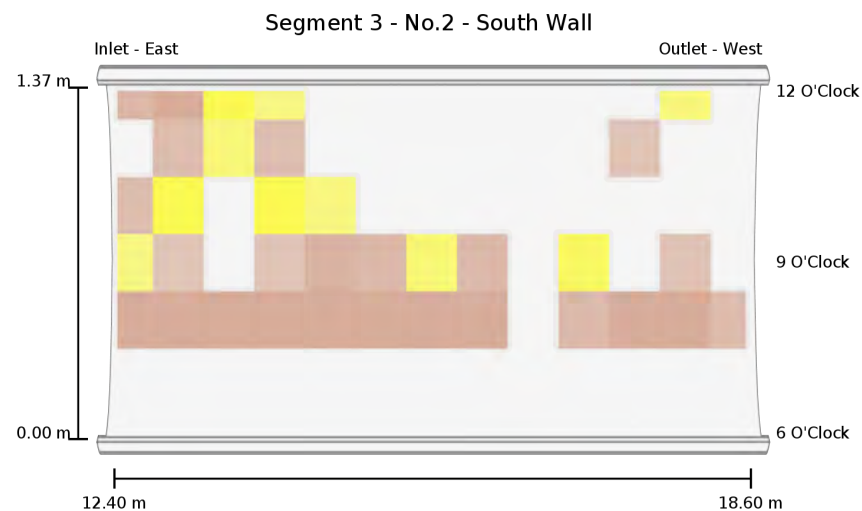
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-2	6.20 m	03:00	5381	Full annular void between existing CMP and sliplined HDPE.
BCT-3	8.25 m	08:30	5380	Full annular void between existing CMP and sliplined HDPE.
BCT-4	9.50 m	04:30	5395	Full annular void between existing CMP and sliplined HDPE.

Segment 3



Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-5	12.90 m	-	03:00	-	Endoscope camera showing visible void.

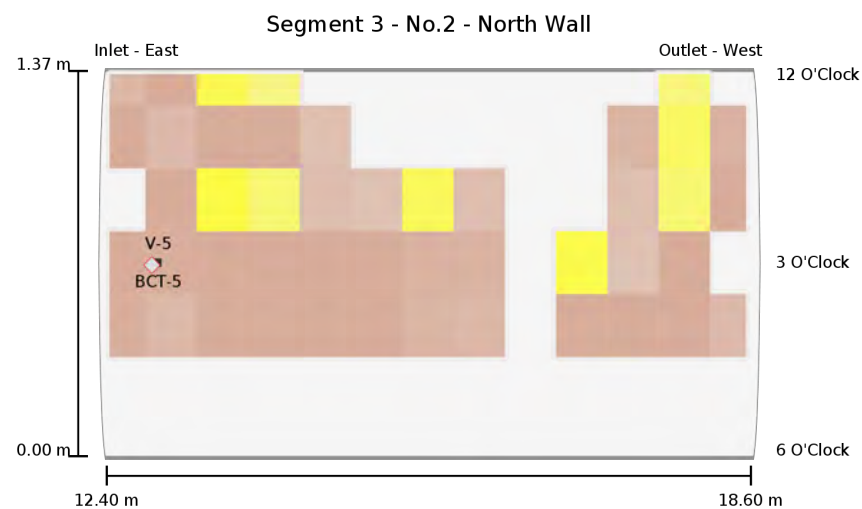
Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
--	----	----	---------	---------

No acoustic anomalies found.

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-5	12.90 m	03:00	5394	Full annular void between existing CMP and sliplined HDPE.



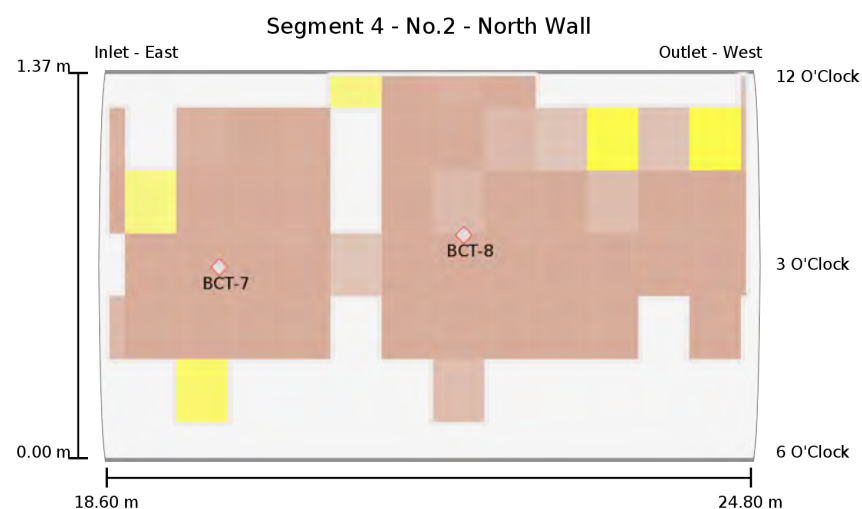
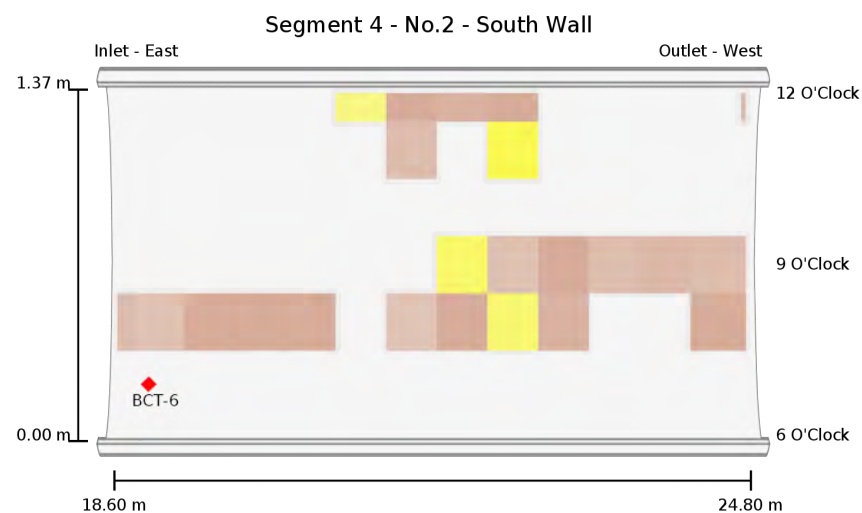
Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Segment 4



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

X1	X2	Clock 1	Clock 2	Comments
No visual indicators found.				

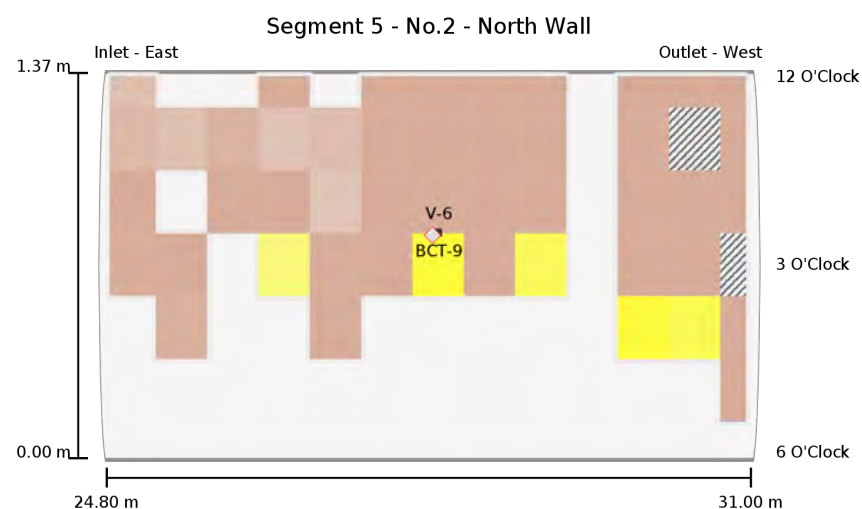
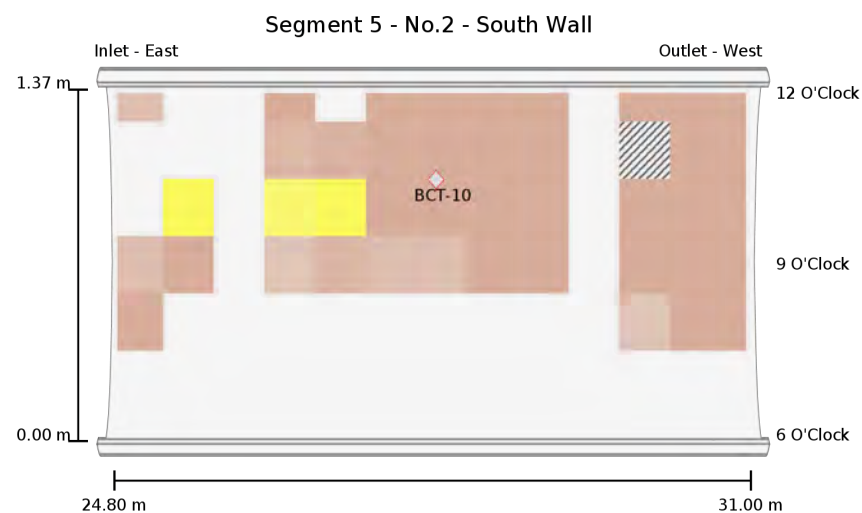
Acoustic Anomalies

X1	X2	Clock 1	Clock 2	Comments
No acoustic anomalies found.				

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-6	19.00 m	07:00	5393	No void (control point).
BCT-7	19.75 m	03:00	5392	Full annular void between existing CMP and sliplined HDPE.
BCT-8	22.10 m	02:30	5391	Full annular void between existing CMP and sliplined HDPE.

Segment 5



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-6	28.00 m	-	02:30	-	Endoscope camera showing visible void.

Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
No acoustic anomalies found.				

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-9	28.00 m	02:30	5390	Full annular void between existing CMP and sliplined HDPE.
BCT-10	28.00 m	10:30	5389	Full annular void between existing CMP and sliplined HDPE.

Areas for diagnostic Backscatter Computed Tomography (BCT) imaging were selected based on the results from the visual, acoustic and InSight™ Lite assessment. The BCT scanner was positioned against the pipe wall covering a region of 200 mm along the pipe wall, at each location, to verify supporting soil presence. The depth of the image is set to a target depth up to 225 mm from the scanners face.

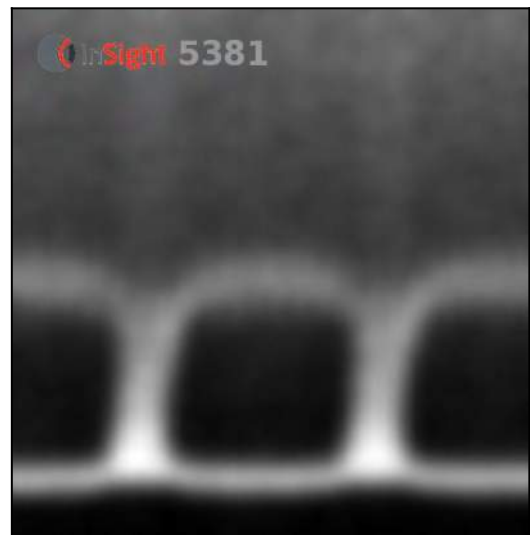
BCT images provide a cross-sectional view of the pipe wall. The lower portion of the image indicates the front (accessible) side of the pipe wall. An increase in the Y direction indicates the depth behind the wall. The X axis is the range along the length of the pipe wall.

The following images are used to verify supporting soil condition and presence. The unique InSight™ scan ID corresponds to a scan location on the pipe map. Voids are only reported if they are greater than 10 mm².



BCT-1 (Scan ID: 5382)

Full annular void between existing CMP and sliplined HDPE.



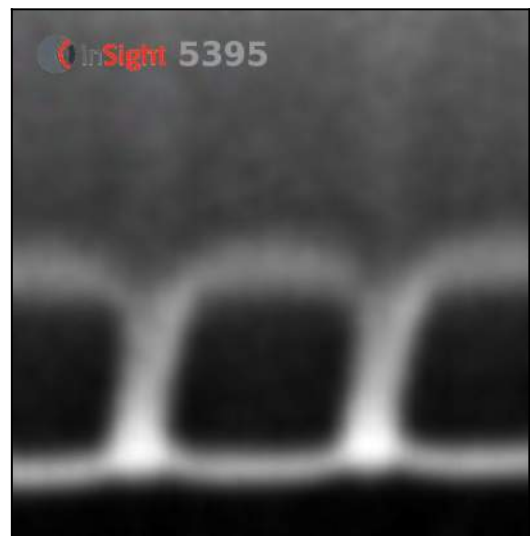
BCT-2 (Scan ID: 5381)

Full annular void between existing CMP and sliplined HDPE.



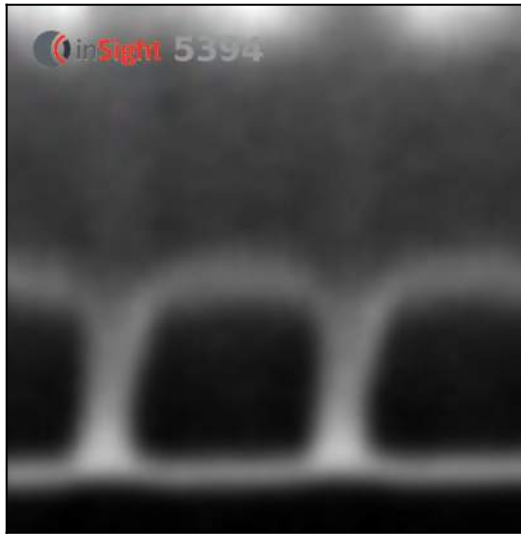
BCT-3 (Scan ID: 5380)

Full annular void between existing CMP and sliplined HDPE.

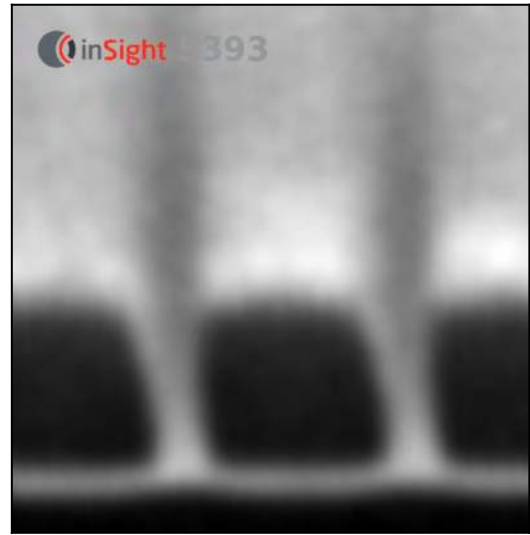


BCT-4 (Scan ID: 5395)

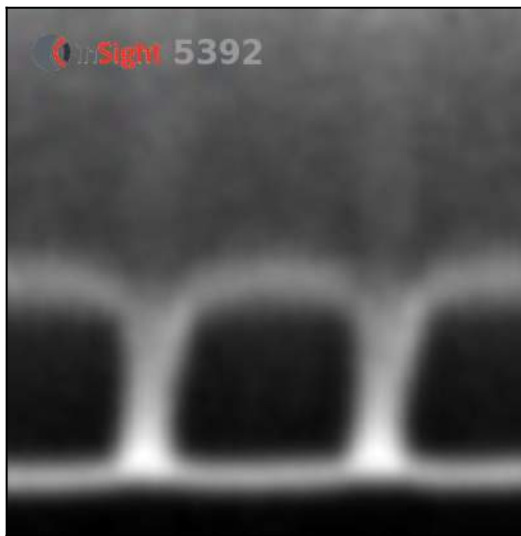
Full annular void between existing CMP and sliplined HDPE.



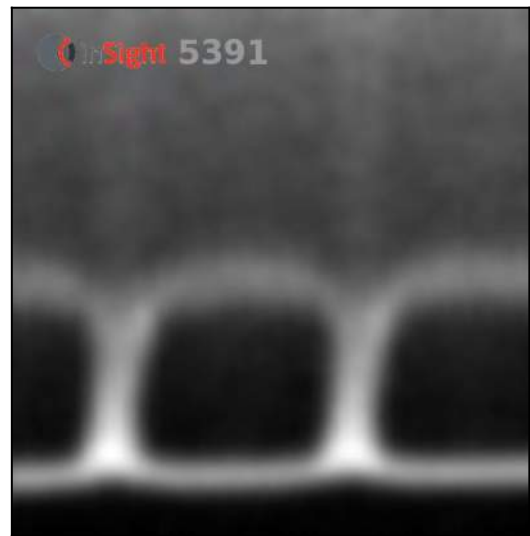
BCT-5 (Scan ID: 5394)
Full annular void between existing CMP and sliplined HDPE.



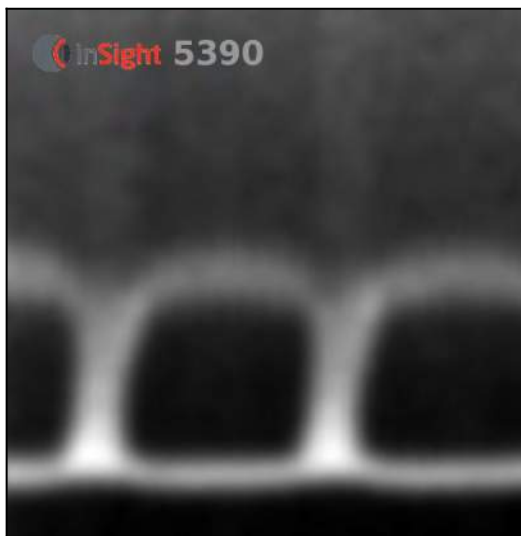
BCT-6 (Scan ID: 5393)
No void (control point).



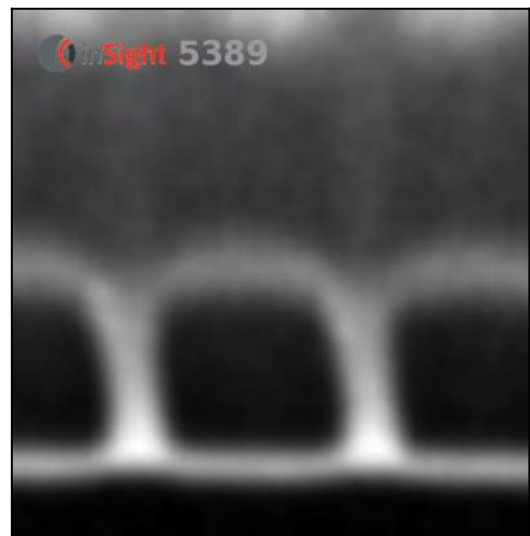
BCT-7 (Scan ID: 5392)
Full annular void between existing CMP and sliplined HDPE.



BCT-8 (Scan ID: 5391)
Full annular void between existing CMP and sliplined HDPE.






BCT-9 (Scan ID: 5390)
Full annular void between existing CMP and sliplined HDPE.



BCT-10 (Scan ID: 5389)
Full annular void between existing CMP and sliplined HDPE.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement		Rank 2
Pavement in good condition.		
Cracks		
• Transverse cracks present: Frequency: Medium (2 - 5 cracks); Severity: Light (< 5 mm (0.2 in) Width)		
		
Photo 1 - Minor transverse crack present above the asset.	Photo 2 - Highway 17 facing south.	Photo 3 - Highway 17 facing north.

Guardrail		Rank N/A
Inlet guardrail.: Inlet guardrail not present.		
Outlet guardrail.: Outlet guardrail not present.		

Embankment

Rank 1

Embankment stable, no visible ruts or erosion channels. No large vegetation present.

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.

Waterway Blockage

Rank 2

- Streambed material present: **Location:** Within pipe barrel.; X1: 1.00 m; X2: 11.00 m
Extent of blockage.: Equal to or less than 20%.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 2

- Joint separation(s) present: **Severity:** Light (< 100 mm (4 in) Width).
 - Causing soil loss and material build-up within the pipe.
 - Substrate visible through joint separation(s).

Shape, Dents, and Localized Damage

Rank 2

Maximum shape deviation of approximately 2.9%. No dents or localized damage found.

Pipe Alignment

Rank 2

Minor vertical misalignment at the outlet.

- Pipe misalignment present: **Condition:** Vertical misalignment.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for No.2 is 1370 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1410 mm	2.9%	1370 mm	0.0%
10.00 m	1370 mm	0.0%	1370 mm	0.0%
20.00 m	1370 mm	0.0%	1360 mm	-0.7%
31.00 m	1400 mm	2.2%	1340 mm	-2.2%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Minor transverse crack present above the asset.



Photo 2 - Highway 17 facing south.

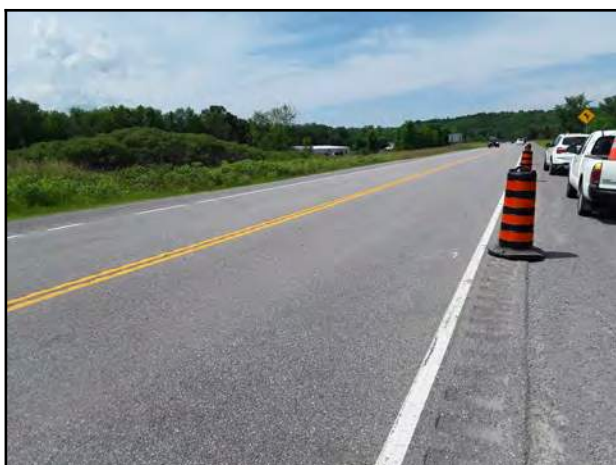


Photo 3 - Highway 17 facing north.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.



Photo 12 - V-1: Endoscope camera showing visible void.



Photo 13 - V-1: Endoscope camera showing visible void.



Photo 14 - V-1: Endoscope camera showing visible void.



Photo 15 - V-2: Joint with visible expansion foam and visible supporting material.



Photo 16 - V-2: Joint with visible expansion foam and visible supporting material.



Photo 17 - V-2: Joint with visible expansion foam and visible supporting material.



Photo 18 - V-3: Endoscope camera showing visible void.



Photo 19 - V-3: Endoscope camera showing visible void.



Photo 20 - V-3: Endoscope camera showing visible void.



Photo 21 - V-4: Joint with visible expansion foam and visible supporting material.



Photo 22 - V-4: Joint with visible expansion foam and visible supporting material.



Photo 23 - V-5: Endoscope camera showing visible void.



Photo 24 - V-5: Endoscope camera showing visible void.



Photo 25 - V-5: Endoscope camera showing visible void.



Photo 26 - V-6: Endoscope camera showing visible void.



Photo 27 - V-6: Endoscope camera showing visible void.

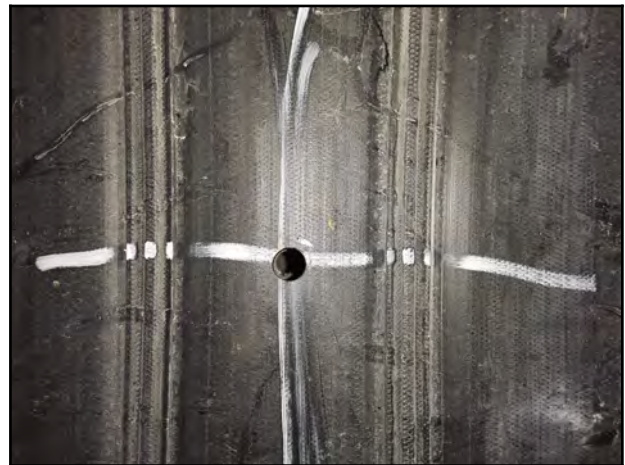


Photo 28 - V-6: Endoscope camera showing visible void.



Photo 29 - Annular space of 240 mm between the existing CMP and the sliplined HDPE at inlet.



Photo 30 - Annular space of 230 mm between the existing CMP and the sliplined HDPE at outlet.

The asset No.2 located on Highway 17 in Renfrew County, consists of a sliplined High Density Polyethylene (HDPE) culvert with an approximate diameter of 1.37 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.80 m and length of 31.00 m. A visual, acoustic and inSight™ Lite assessments were performed at this site which found six (6) visual indicators, no acoustic anomalies and inSight™ Lite anomalous regions inside the culvert. This resulted in ten (10) BCT images. The images found nine (9) locations of voiding.

Three (3) levels of preliminary screening tools (Visual Inspection, Acoustic Assessment, and inSight™ Lite Screening) were used during this condition assessment to determine where to deploy the BCT equipment, which in turn provides conclusive void identification quantification.

The visual assessment identified minor transverse crack documented in Photo 1 along the roadway above the asset. Negligible streambed material was also noted within the culvert located from 1.00 m to 11.00 m. Two (2) visual indicators, V-2 and V-4, were recorded as joints with visible expansion foam and supporting material near the invert. It is unknown why expansion foam was utilized during construction.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of 2.9%, 0.00 m from the inlet and a maximum vertical deviation of -2.2%, 31.00 m from the inlet.

The acoustic assessment did not reveal any anomalous regions, however, the inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. These assessments required ten (10) BCT images to be captured, which resulted in nine (9) locations of voiding. Annular voiding was confirmed in the nine (9) scan locations (exception of BCT-6). All confirmed void locations were identified as being full annular void between the existing CMP and sliplined HDPE.

Four (4) holes were drilled at BCT scan locations and/or areas of high potential void identified by the inSight™ Lite assessment. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide an image of the inspected area. As noted in V-1, V-3, V-5, and V-6, visible voids were recorded at each location, confirming the BCT imaging at all locations. Following the inspection, each hole was sealed with a silicone sealant.

An Ultrasonic (UT) examination was also undertaken by Applus RTD on this asset. Ultrasonic readings were taken at 3, 6, 9 and 12 o'clock at two (2) locations in the middle of the asset, spaced by approximately 24.0 in. As detailed in the attached report dated August 15, 2019, prepared by Applus RTD, each UT thickness reading resulted in an 8.5 mm HDPE wall thickness. No information could be gathered beyond the HDPE near-surface wall thickness. UT is not an appropriate method for inspection of material with an air gap, as found in the HDPE wall profile.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing CMP and the sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host CMP fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured BCT scan images are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The BCT images should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the soilsight™ Pipe Map and segment views for the exact locations of the voids.

Technical recommendations, as well as cost estimates, can be provided upon request.

Applus RTD Supporting Documents

ULTRASONIC EXAMINATION REPORT

PROJECT / CLIENT INFORMATION

CLIENT:	INVERSA SYSTEMS	REPORT NUMBER:	UT-01		
JOB LOCATION:	Bancroft , Highlands East Ontario ON Highway 118	DATE:	August 15, 2019	PAGE NO.:	1 of 2
PROJECT:	N/A	PROCEDURE NO.:	QA-TP-UT-01	REV. NO.:	02
A+RTD JOB NO.:	94609	PROCEDURE NO.:	N/A	REV. NO.:	
NDE REQUEST NO.:	N/A	TECHNIQUE NO.:	Contact Pulse Echo	REV. NO.:	
AFE / NOT NO.:	N/A	CODE/STANDARD:	For information only		
PO / WO NO.:	N/A	SPECIFICATION:	Record Thickness		

PART(S) EXAMINED, SURFACE CONDITIONS AND TECHNICAL DATA

PART(S) EXAMINED: Culvert # 1,2 & 14		PART NO. / ID: Culvert	
MATERIAL: Polystyrene Pipe	THICKNESS: 6mm/ 8mm	SIZING CURVE: <input type="checkbox"/> DAC <input type="checkbox"/> TCG <input type="checkbox"/> N/A	
SURFACE CONDITION: Smooth		DAMPING: 50 Ω	REJECT: Off
COUPLANT BRAND: Sonaglide	TYPE: Grade 20	CABLE TYPE: BNC to microdot	LENGTH: 5'

EQUIPMENT/CALIBRATION BLOCK(S)

CALIBRATION DATA


Equipment / Cal. Block(s)	Serial / Asset No.	Calibration Due Date	Reference Reflector	Amplitude (%)	Sound Path	Ref. Gain (dB)
Olympus Epoch 600	112303	April 29, 2020	Polystyrene Back wall	80		32
Step Wedge (Imperial)	1377-16			80		20

Probe Make	Angle (°)	Style	Serial Number	Size	Frequency	Scanning Gain	Transfer	Range
Olympus	0	Single	1009327	0.250 in.	5.0 MHz	Ref. Gain Level	N/A	10 mm

INSPECTION DETAILS - RESULTS

RESULTS: For information only - details given below INDICATIONS: See below for results

Ultrasonic Thickness readings were taken at two areas in the middle of the culvert at 24" apart @ 4 quadrant position
0, 90, 180, and 270 degrees on Culvert #1#2 and #14..... #1 is Coated metal, 2 & 14 are Polystyrene, see below .

	NAME	SIGNATURE	CERTIFICATION	DATE
TECHNICIAN:	Charlie McCreddie		<input checked="" type="checkbox"/> CGSB <input type="checkbox"/> SNT-TC-1A <input type="checkbox"/> PCN Level: <input type="checkbox"/> 1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 Discipline: <input checked="" type="checkbox"/> UT <input type="checkbox"/> TOFD <input type="checkbox"/> PAUT	August 15, 2019
REVIEWER:			<input type="checkbox"/> CGSB <input type="checkbox"/> SNT-TC-1A <input type="checkbox"/> PCN Level: <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 Discipline: <input type="checkbox"/> UT <input type="checkbox"/> TOFD <input type="checkbox"/> PAUT	
CLIENT REP.:				

INVERSA SYSTEMS

August 15, 2019

Page 2 of 2

ULTRASONIC EXAMINATION REPORT

INSPECTION DETAILS - RESULTS (CONTINUED):

UT-01

45° 43' 36.445" N, 76° 59' 47.606" W

Inspection 1

#1	0	90	180	270
A	6.5mm	6.5mm	6.5mm	6.5mm
B	6.5mm	6.5mm	6.5mm	6.5mm

45° 43' 49.261" N, 76° 59' 50.726" W

Inspection 2

#2	0	90	180	270
A	8.5mm	8.5mm	8.5mm	8.5mm
B	8.5mm	8.5mm	8.5mm	8.5mm

44° 59' 42.128" N, 78° 17' 58.49" W

Inspection 14

#14	0	90	180	270
A	6.0mm	6.0mm	6.0mm	6.0mm
B	6.0mm	6.0mm	6.0mm	6.0mm



SoilSight™ Condition Assessment

MTO 2019

No.1

Highway 17 in Renfrew County

General Summary

The asset No.1 located on Highway 17 in Renfrew County, consists of a sliplined spiral wound corrugated metal pipe (CMP) culvert with an approximate diameter of 1.60 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.80 m and length of 30.00 m. The asset is located at latitude 45° 43' 36.445" N, longitude 76° 59' 47.606" W. The asset has approximately 1.50 m of cover from the obvert to the road surface and flows generally east to west.

Inversa Systems performed an in-depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 8 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- 9 voids were observed, 10 inSight™ BCT images were completed
- Outcome: Continue Monitoring

Asset ID	No.1
County Name	Renfrew County
GPS	45° 43' 36.445" N, 76° 59' 47.606" W
Inspection Date	July 15, 2019
Written By	Joey Stafford, Field Technician.
Reviewed By	Jocelin Bourgeois, B.Sc.Eng., MBA
Approved By	Steven Godbout, B.Sc.Eng.



SoilSight™ Condition Assessment	
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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

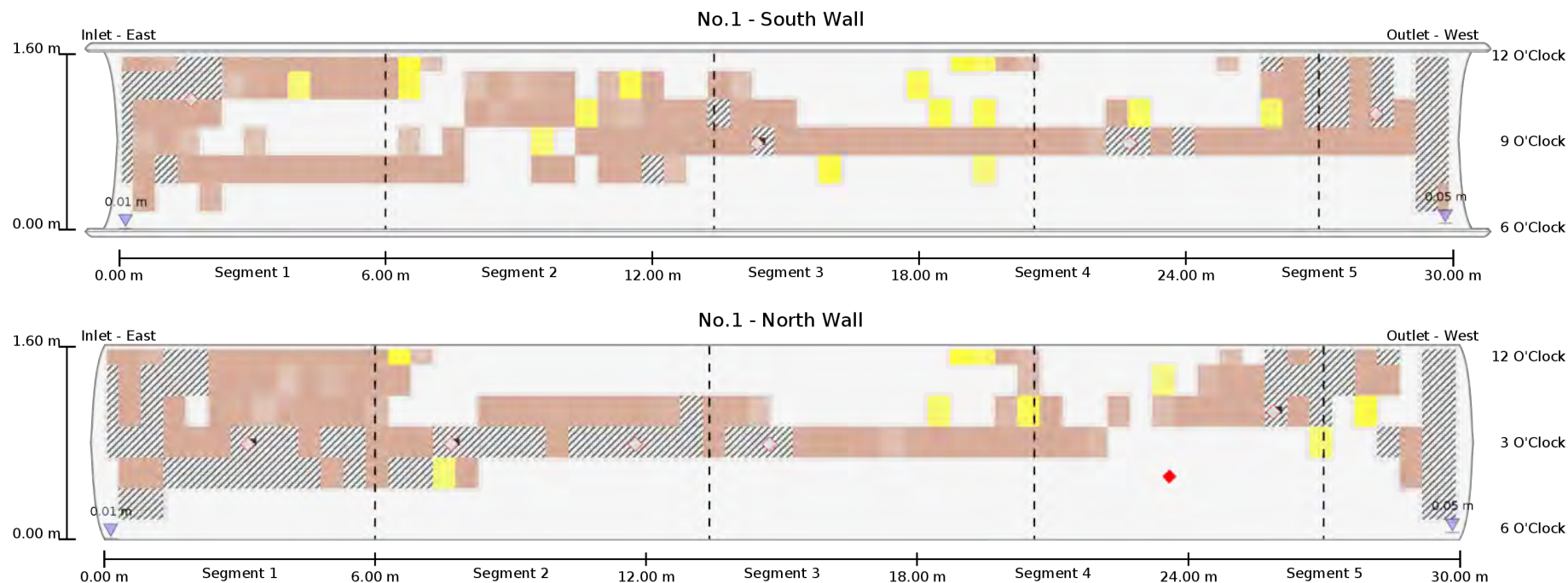
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

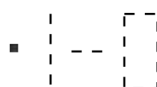
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

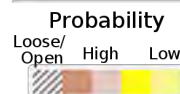
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



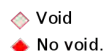
Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

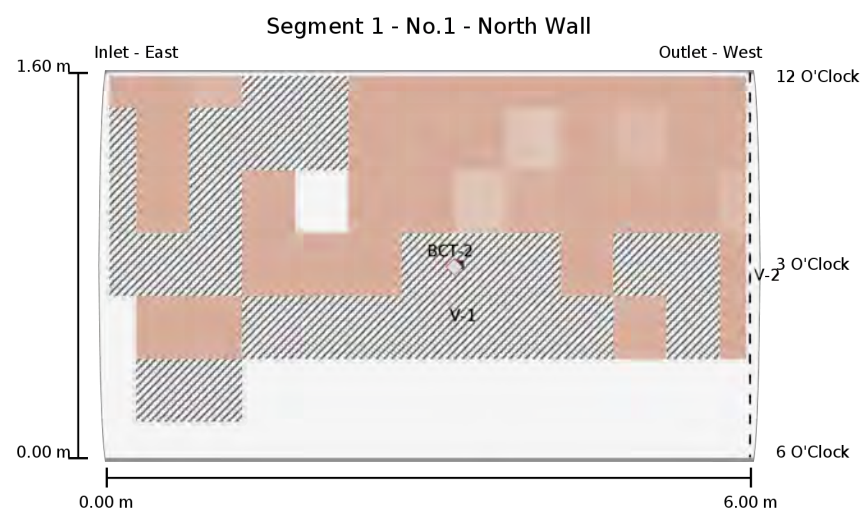
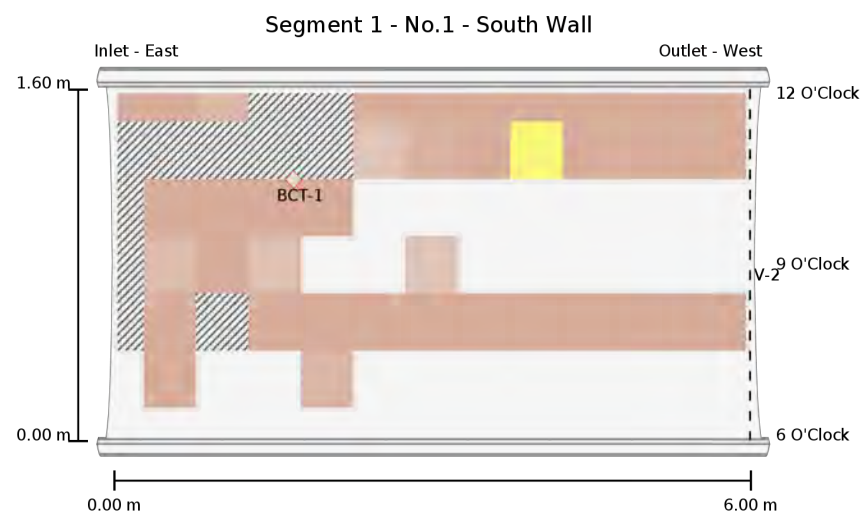


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	3.30 m	-	03:00	-	Endoscope camera showing visible void.
V-2	6.00 m	6.00 m	-	-	Joint with visible expansion foam and grout buildup on the invert.

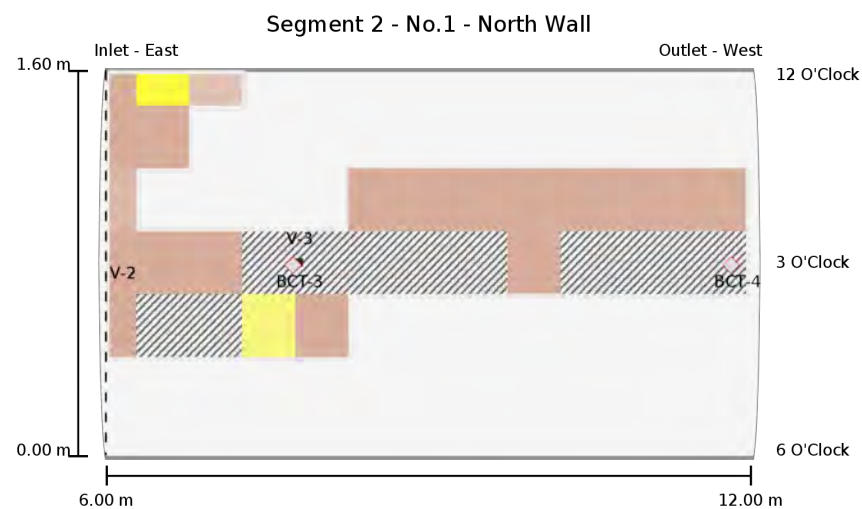
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-1	1.75 m	10:30	5379	Full annular void between existing CMP and sliplined CMP. Full void beyond existing CMP due to scan being taken at the un-buried end of the culvert.
BCT-2	3.30 m	03:00	5378	Full annular void between existing CMP and sliplined CMP.

Segment 2



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-2	6.00 m	6.00 m	-	-	Joint with visible expansion foam and grout buildup on the invert.
V-3	7.80 m	-	03:00	-	Endoscope camera showing visible void.

Acoustic Anomalies

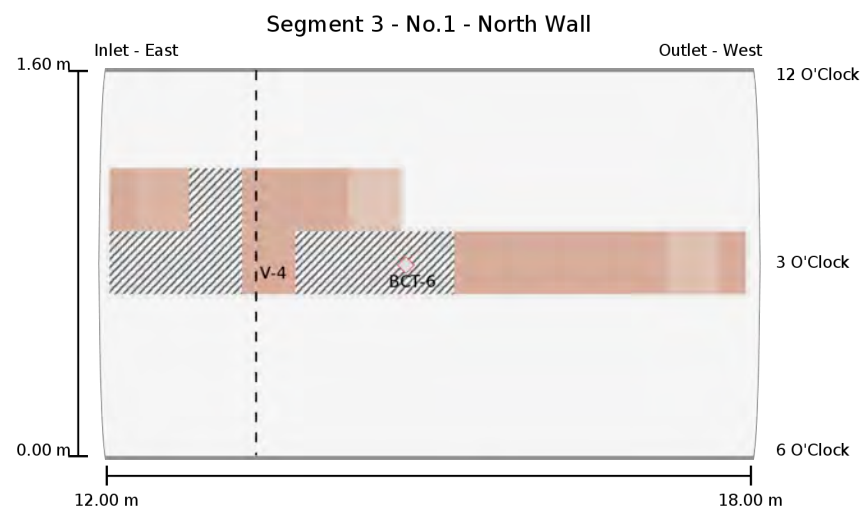
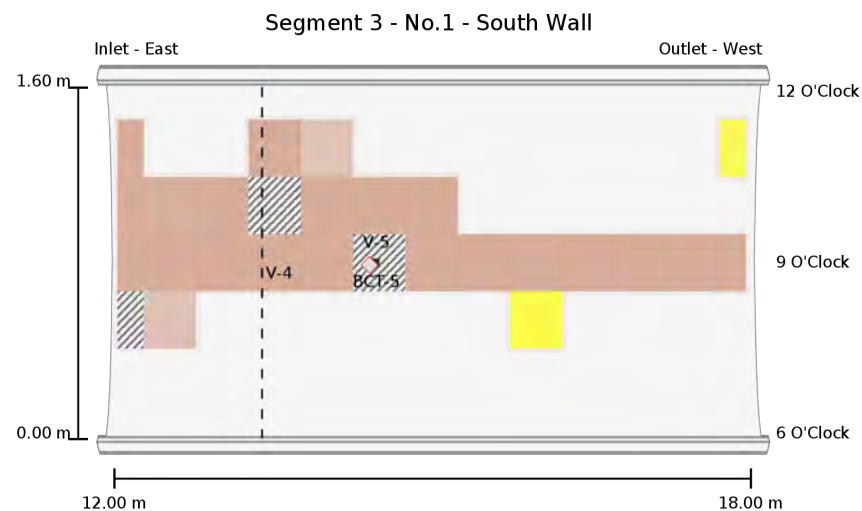
	X1	X2	Clock 1	Clock 2
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No acoustic anomalies found.

InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-3	7.80 m	03:00	5377	Full annular void between existing CMP and sliplined CMP.
BCT-4	11.88 m	03:00	5376	Full annular void between existing CMP and sliplined CMP.

Segment 3



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-4	13.40 m	13.40 m	-	-	Joint with visible expansion foam.
V-5	14.47 m	-	09:00	-	Endoscope camera showing visible void.

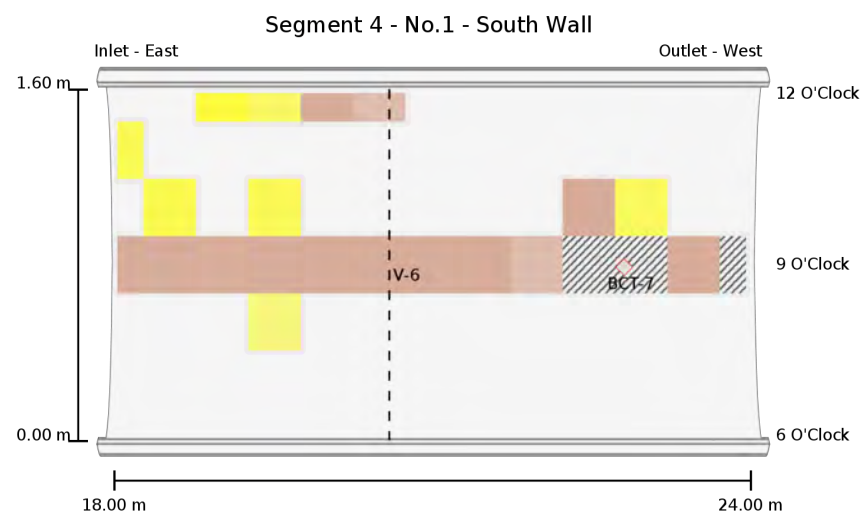
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-5	14.47 m	09:00	5375	Full annular void between existing CMP and sliplined CMP.
BCT-6	14.85 m	03:00	5374	Full annular void between existing CMP and sliplined CMP.

Segment 4



Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-6	20.60 m	20.60 m	-	-	Joint with visible expansion foam.

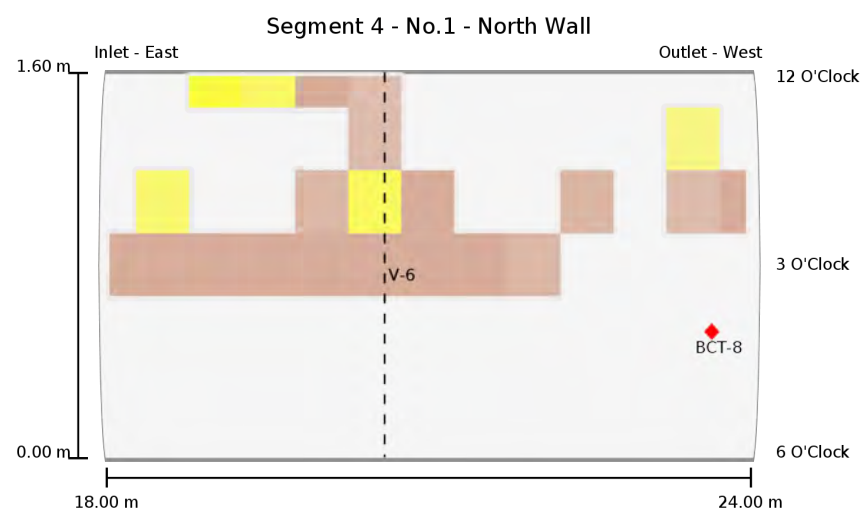
Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
--	----	----	---------	---------

No acoustic anomalies found.

Insight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-7	22.87 m	09:00	5373	Full annular void between existing CMP and sliplined CMP.
BCT-8	23.70 m	04:00	5372	No void (control point).



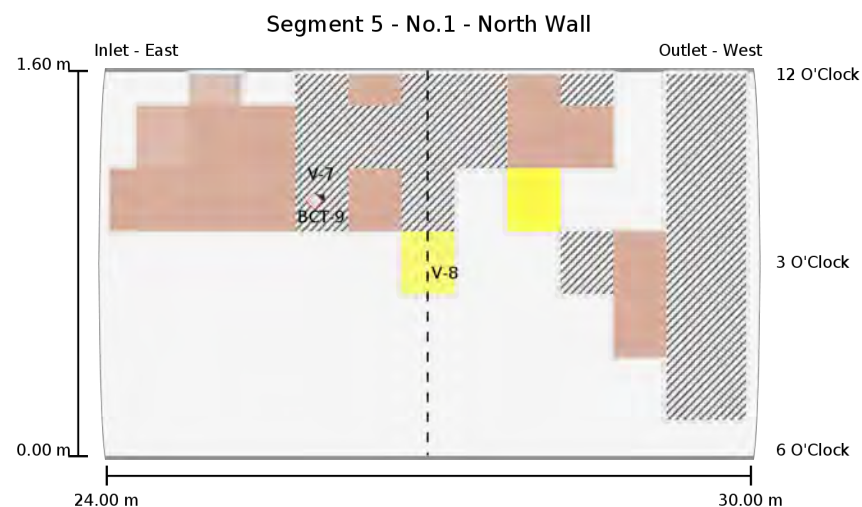
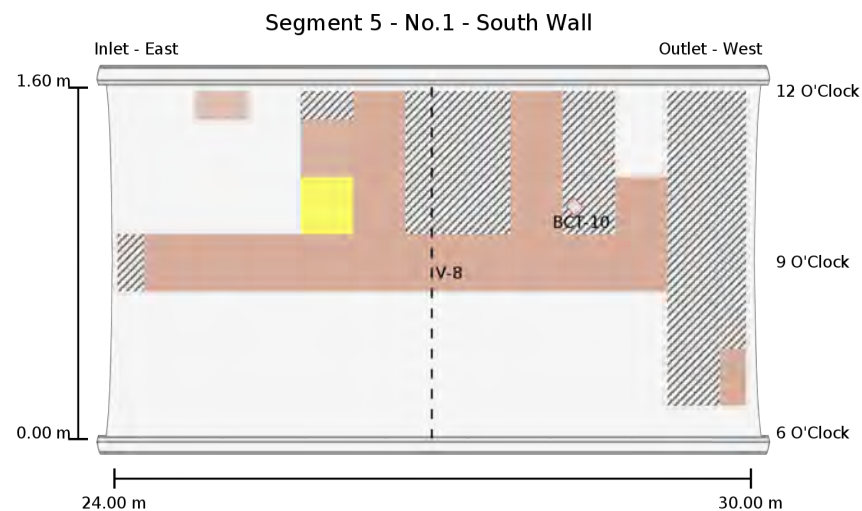
Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Segment 5



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-7	26.00 m	-	02:00	-	Endoscope camera showing visible void.
V-8	27.00 m	27.00 m	-	-	Joint with visible expansion foam.

Acoustic Anomalies

	X1	X2	Clock 1	Clock 2
No acoustic anomalies found.				

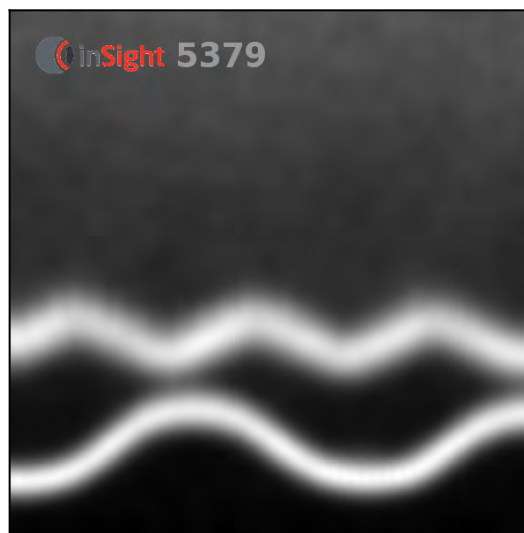
InSight™ BCT Images

	X	Clock	Scan ID	Verdict
BCT-9	26.00 m	02:00	5371	Full annular void between existing CMP and sliplined CMP.
BCT-10	28.40 m	10:00	5370	Full annular void between existing CMP and sliplined CMP. Full void beyond existing CMP due to scan being taken at the un-buried end of the culvert.

Areas for diagnostic Backscatter Computed Tomography (BCT) imaging were selected based on the results from the visual, acoustic and InSight™ Lite assessment. The BCT scanner was positioned against the pipe wall covering a region of 200 mm along the pipe wall, at each location, to verify supporting soil presence. The depth of the image is set to a target depth up to 225 mm from the scanners face.

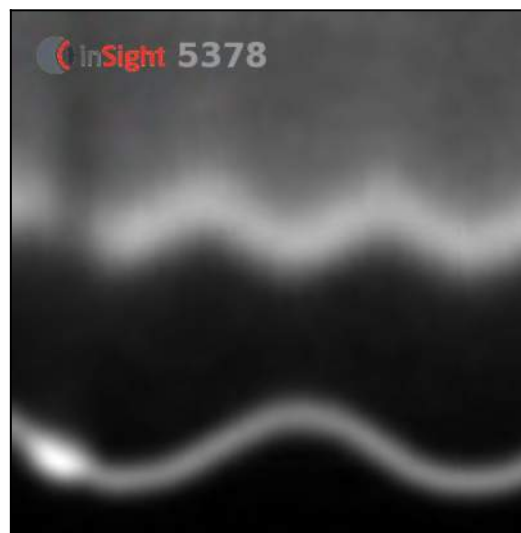
BCT images provide a cross-sectional view of the pipe wall. The lower portion of the image indicates the front (accessible) side of the pipe wall. An increase in the Y direction indicates the depth behind the wall. The X axis is the range along the length of the pipe wall.

The following images are used to verify supporting soil condition and presence. The unique InSight™ scan ID corresponds to a scan location on the pipe map. Voids are only reported if they are greater than 10 mm².



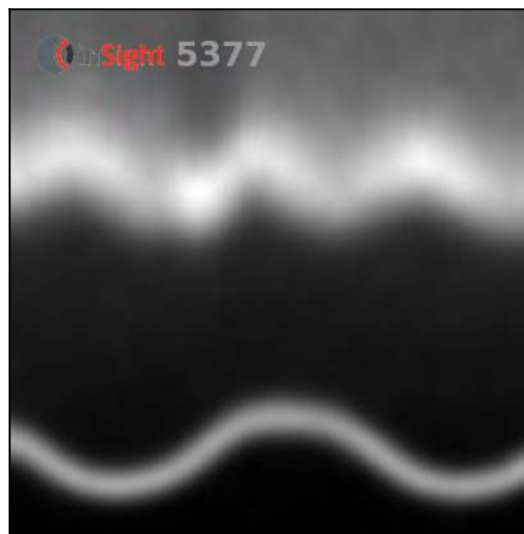
BCT-1 (Scan ID: 5379)

Full annular void between existing CMP and sliplined CMP.



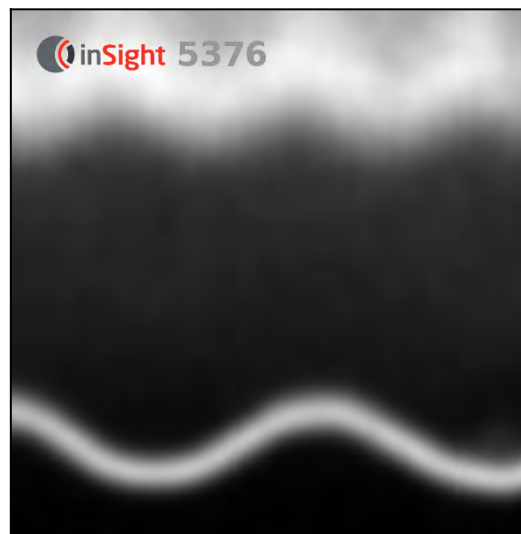
BCT-2 (Scan ID: 5378)

Full annular void between existing CMP and sliplined CMP.



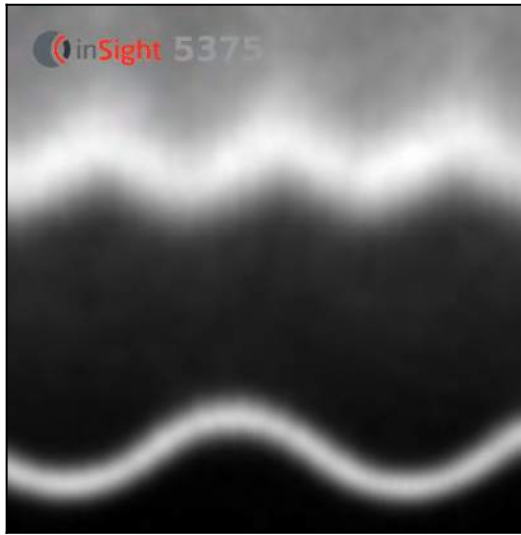
BCT-3 (Scan ID: 5377)

Full annular void between existing CMP and sliplined CMP.



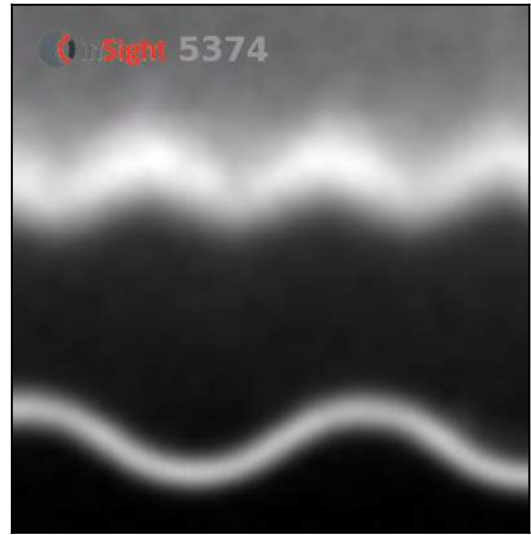
BCT-4 (Scan ID: 5376)

Full annular void between existing CMP and sliplined CMP.



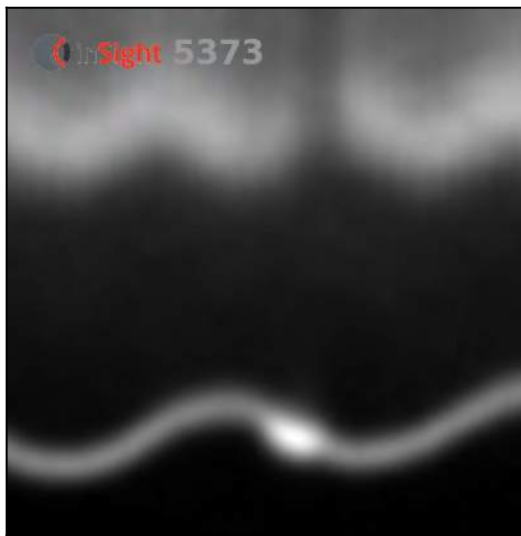
BCT-5 (Scan ID: 5375)

Full annular void between existing CMP and sliplined CMP.



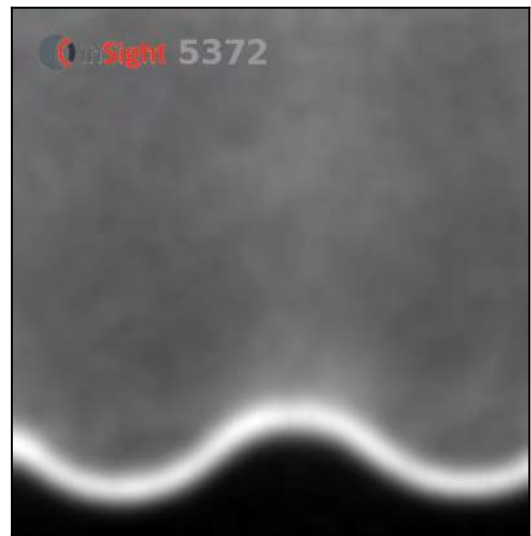
BCT-6 (Scan ID: 5374)

Full annular void between existing CMP and sliplined CMP.

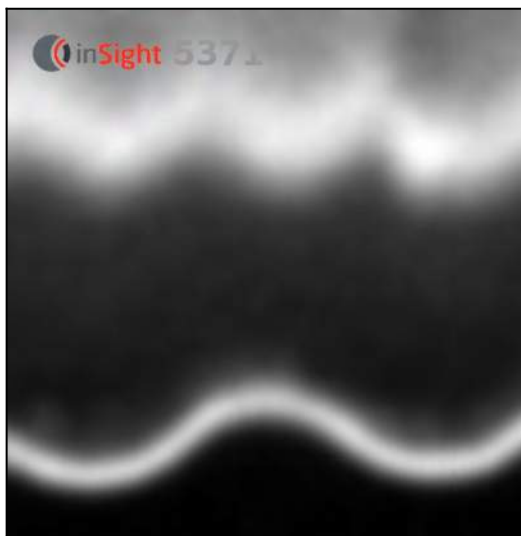


BCT-7 (Scan ID: 5373)

Full annular void between existing CMP and sliplined CMP.

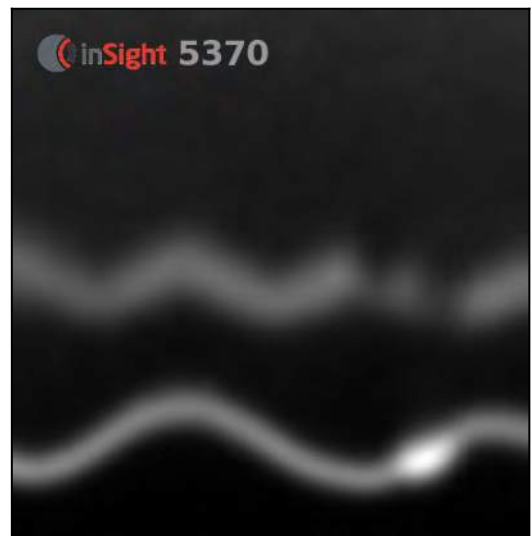


BCT-8 (Scan ID: 5372)
No void (control point).



BCT-9 (Scan ID: 5371)

Full annular void between existing CMP and sliplined CMP.






BCT-10 (Scan ID: 5370)

Full annular void between existing CMP and sliplined CMP.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement		Rank 2
Pavement in good condition.		
Cracks		
<ul style="list-style-type: none">Transverse cracks present: Frequency: Low (1 crack); Severity: Medium ((6 - 15 mm)(0.25 - 0.6 in) Width)		
		
Photo 1 - Transverse crack present above the asset.	Photo 2 - Highway 17 facing south.	Photo 3 - Highway 17 facing north.

Guardrail		Rank N/A
Inlet guardrail.: Inlet guardrail not present.		
Outlet guardrail.: Outlet guardrail not present.		

Embankment

Rank 2

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 4 - Minor soil movement at the outlet embankment.



Photo 5 - Inlet embankment.



Photo 6 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 7 - Inlet overview.



Photo 8 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 9 - Upstream channel view.



Photo 10 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank 1

No corrosion or rust evident on the pipe wall, no damage or discoloration of the coating.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Maximum shape deviation of approximately 1.9%. No dents or localized damage found.

Pipe Alignment

Rank 1

Pipe well aligned.



Photo 11 - Upstream pipe alignment and shape.



Photo 12 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for No.1 is 1600 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1630 mm	1.9%	1610 mm	0.6%
10.00 m	1600 mm	0.0%	1620 mm	1.3%
20.00 m	1600 mm	0.0%	1610 mm	0.6%
30.00 m	1620 mm	1.3%	1610 mm	0.6%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Transverse crack present above the asset.



Photo 2 - Highway 17 facing south.



Photo 3 - Highway 17 facing north.



Photo 4 - Minor soil movement at the outlet embankment.



Photo 5 - Inlet embankment.



Photo 6 - Outlet embankment.



Photo 7 - Inlet overview.



Photo 8 - Outlet overview.



Photo 9 - Upstream channel view.



Photo 10 - Downstream channel view.



Photo 11 - Upstream pipe alignment and shape.



Photo 12 - Downstream pipe alignment and shape.



Photo 13 - V-1: Endoscope camera showing visible void.



Photo 14 - V-1: Endoscope camera showing visible void.



Photo 15 - V-1: Endoscope camera showing visible void.



Photo 16 - V-2: Joint with visible expansion foam and grout buildup on the invert.



Photo 17 - V-2: Joint with visible expansion foam and grout buildup on the invert.

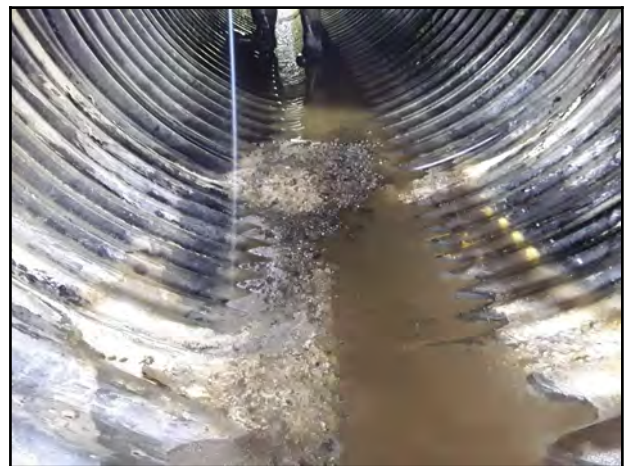


Photo 18 - V-2: Joint with visible expansion foam and grout buildup on the invert.



Photo 19 - V-3: Endoscope camera showing visible void.



Photo 20 - V-3: Endoscope camera showing visible void.



Photo 21 - V-3: Endoscope camera showing visible void.



Photo 22 - V-4: Joint with visible expansion foam.



Photo 23 - V-4: Joint with visible expansion foam.



Photo 24 - V-5: Endoscope camera showing visible void.



Photo 25 - V-5: Endoscope camera showing visible void.



Photo 26 - V-5: Endoscope camera showing visible void.



Photo 27 - V-6: Joint with visible expansion foam.



Photo 28 - V-6: Joint with visible expansion foam.



Photo 29 - V-7: Endoscope camera showing visible void.



Photo 30 - V-7: Endoscope camera showing visible void.



Photo 31 - V-7: Endoscope camera showing visible void.



Photo 32 - V-8: Joint with visible expansion foam.



Photo 33 - V-8: Joint with visible expansion foam.



Photo 34 - Annular space of 240 mm between existing pipe and sliplined culvert at outlet.



Photo 35 - Annular space of 80 mm between existing pipe and sliplined culvert at inlet.

The asset No.1 located on Highway 17 in Renfrew County, consists of a sliplined spiral wound corrugated metal pipe (CMP) culvert with an approximate diameter of 1.60 m installed within a circular corrugated metal pipe (CMP) culvert with an approximate diameter of 1.80 m and length of 30.00 m. A visual, acoustic and inSight™ Lite assessments were performed at this site which found eight (8) visual indicators, no acoustic anomalies and inSight™ Lite anomalous regions inside the culvert. This resulted in ten (10) BCT images. The images found nine (9) locations of voiding.

Three (3) levels of preliminary screening tools (Visual Inspection, Acoustic Assessment, and inSight™ Lite Screening) were used during this condition assessment to determine where to deploy the BCT equipment, which in turn provides conclusive void identification and quantification.

The visual assessment identified four (4) visual indicators, V-2, V-4, V-6 and V-8, which consisted of joints with visible expansion foam. It is unknown why expansion foam was utilized during construction. V-2 also had a grout buildup on the invert at the joint location.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of 1.9%, 0.00 m from the inlet and a maximum vertical deviation of 1.3%, 10.00 m from the inlet.

The acoustic assessment did not reveal any anomalous regions, however, the inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. These assessments required ten (10) BCT images to be captured, which resulted in nine (9) locations of voiding. Annular voiding was confirmed in nine (9) scan locations with the exception of BCT-8 which was a planned control point. BCT-1, BCT-2, BCT-3, BCT-4, BCT-5, BCT-6, BCT-7, BCT-9 and BCT-10 were all locations of confirmed annular voids between the existing CMP and the sliplined CMP. Seeing as BCT-1 and BCT-10 were located at the unburied ends of the culvert, these scans also showed full void beyond the original CMP wall.

An Ultrasonic (UT) examination was also undertaken by Applus RTD on this asset. Ultrasonic readings were taken at 3, 6, 9 and 12 o'clock at two (2) locations in the middle of the asset, spaced by approximately 24.0 in. As detailed in the attached report dated August 15, 2019, prepared by Applus RTD, each UT thickness reading resulted in a 6.5 mm wall thickness. No information could be gathered beyond the CMP near-surface wall thickness.

Four (4) holes were drilled at BCT scan locations and/or areas of high potential void identified by the inSight™ Lite assessment. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide an image of the inspected area. As noted in V-1, V-3, V-5, and V-7, visible voids were recorded at each location, confirming the BCT imaging at all locations. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing CMP and the sliplined CMP be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host CMP fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured BCT scan images are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The BCT images should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the soilsight™ Pipe Map and segment views for the exact locations of the voids.

Technical recommendations, as well as cost estimates, can be provided upon request.

Applus RTD Supporting Documents

ULTRASONIC EXAMINATION REPORT

PROJECT / CLIENT INFORMATION

CLIENT:	INVERSA SYSTEMS	REPORT NUMBER:	UT-01		
JOB LOCATION:	Bancroft , Highlands East Ontario ON Highway 118	DATE:	August 15, 2019	PAGE NO.:	1 of 2
PROJECT:	N/A	PROCEDURE NO.:	QA-TP-UT-01	REV. NO.:	02
A+RTD JOB NO.:	94609	PROCEDURE NO.:	N/A	REV. NO.:	
NDE REQUEST NO.:	N/A	TECHNIQUE NO.:	Contact Pulse Echo	REV. NO.:	
AFE / NOT NO.:	N/A	CODE/STANDARD:	For information only		
PO / WO NO.:	N/A	SPECIFICATION:	Record Thickness		

PART(S) EXAMINED, SURFACE CONDITIONS AND TECHNICAL DATA

PART(S) EXAMINED: <u>Culvert # 1,2 & 14</u>		PART NO. / ID: <u>Culvert</u>	
MATERIAL: <u>Polystyrene Pipe</u>	THICKNESS: <u>6mm/ 8mm</u>	SIZING CURVE: <input type="checkbox"/> DAC <input type="checkbox"/> TCG <input type="checkbox"/> N/A	
SURFACE CONDITION: <u>Smooth</u>		DAMPING: <u>50</u> Ω	REJECT: <u>Off</u>
COUPLANT BRAND: <u>Sonaglide</u>	TYPE: <u>Grade 20</u>	CABLE TYPE: <u>BNC to microdot</u>	LENGTH: <u>5'</u>

EQUIPMENT/CALIBRATION BLOCK(S)


CALIBRATION DATA

Equipment / Cal. Block(s)		Serial / Asset No.	Calibration Due Date	Reference Reflector		Amplitude (%)	Sound Path		Ref. Gain (dB)
Olympus Epoch 600		112303	April 29, 2020	Polystyrene Back wall		80			32
Step Wedge (Imperial)		1377-16				80			20
Probe Make	Angle (°)	Style	Serial Number	Size	Frequency	Scanning Gain	Transfer	Range	
Olympus	0	Single	1009327	0.250 in.	5.0 MHz	Ref. Gain Level	N/A	10 mm	

INSPECTION DETAILS - RESULTS

RESULTS: For information only - details given below INDICATIONS: See below for results

Ultrasonic Thickness readings were taken at two areas in the middle of the culvert at 24" apart @ 4 quadrant position
0, 90, 180, and 270 degrees on Culvert #1#2 and #14..... #1 is Coated metal, 2 & 14 are Polystyrene, see below .

	NAME	SIGNATURE	CERTIFICATION	DATE
TECHNICIAN:	Charlie McCreddie		<input checked="" type="checkbox"/> CGSB <input type="checkbox"/> SNT-TC-1A <input type="checkbox"/> PCN Level: <input type="checkbox"/> 1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 Discipline: <input checked="" type="checkbox"/> UT <input type="checkbox"/> TOFD <input type="checkbox"/> PAUT	August 15, 2019
REVIEWER:			<input type="checkbox"/> CGSB <input type="checkbox"/> SNT-TC-1A <input type="checkbox"/> PCN Level: <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 Discipline: <input type="checkbox"/> UT <input type="checkbox"/> TOFD <input type="checkbox"/> PAUT	
CLIENT REP.:				

INVERSA SYSTEMS

August 15, 2019

Page 2 of 2

ULTRASONIC EXAMINATION REPORT

INSPECTION DETAILS - RESULTS (CONTINUED):

UT-01

45° 43' 36.445" N, 76° 59' 47.606" W

Inspection 1

#1	0	90	180	270
A	6.5mm	6.5mm	6.5mm	6.5mm
B	6.5mm	6.5mm	6.5mm	6.5mm

45° 43' 49.261" N, 76° 59' 50.726" W

Inspection 2

#2	0	90	180	270
A	8.5mm	8.5mm	8.5mm	8.5mm
B	8.5mm	8.5mm	8.5mm	8.5mm

44° 59' 42.128" N, 78° 17' 58.49" W

Inspection 14

#14	0	90	180	270
A	6.0mm	6.0mm	6.0mm	6.0mm
B	6.0mm	6.0mm	6.0mm	6.0mm



SoilSight™ Condition Assessment

MTO 2020

58

Highway 60 in Muskoka County

General Summary

The asset 58 located on Highway 60 in Muskoka County, consists of a Sliplined High Density Polyethylene (HDPE) circular culvert. The asset is located at latitude 45° 20' 58.372" N, longitude 79° 8' 58.768" W. The dimensions of the asset were found to be approximately 1.37 m in diameter and 41.90 m in length. The asset has approximately 2.10 m of cover from the obvert to the road surface and flows generally west to east.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 7 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	58
County Name	Muskoka County
GPS	45° 20' 58.372" N, 79° 8' 58.768" W
Inspection Date	July 26, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.

SoilSight™ Condition Assessment	
General Summary	1
Condition Assessment Report Overview	3
Technical Explanation of Pipe Map Protocol	3
Acoustic Assessment	3
Visual Inspection	3
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InSight™ Lite Screening	4
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Photographs	14
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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

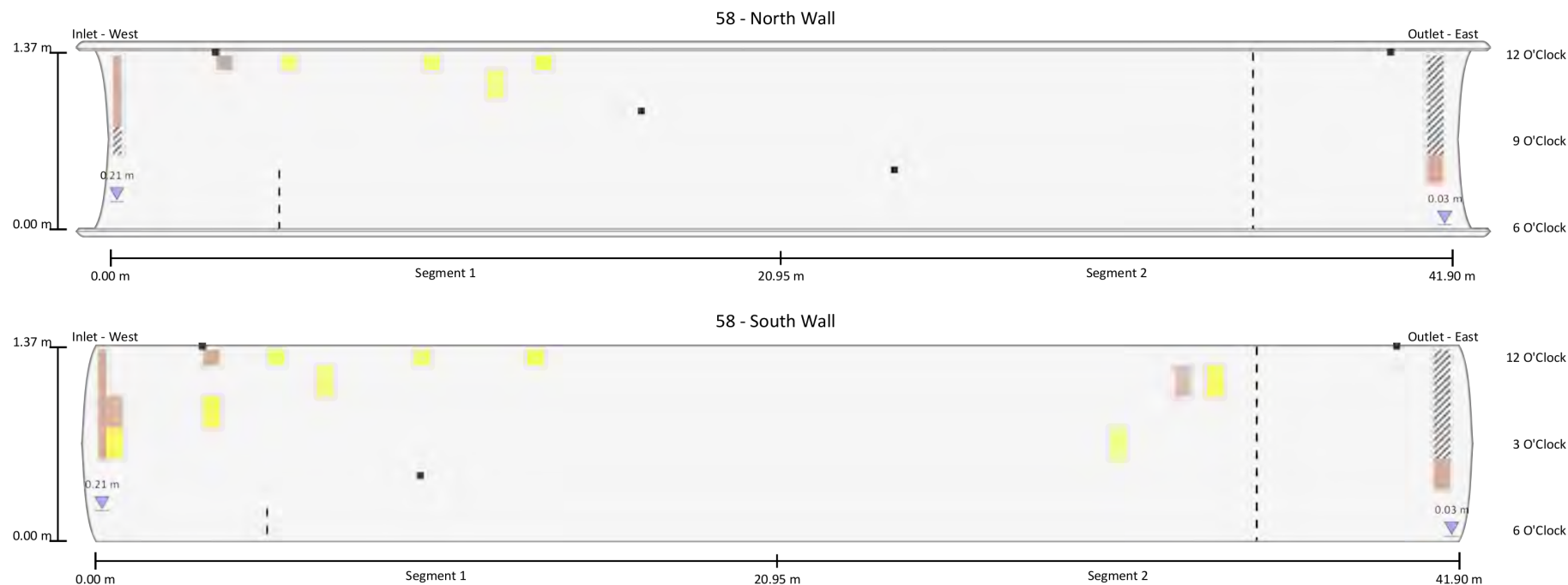
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

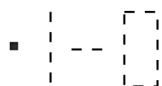
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

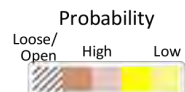
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

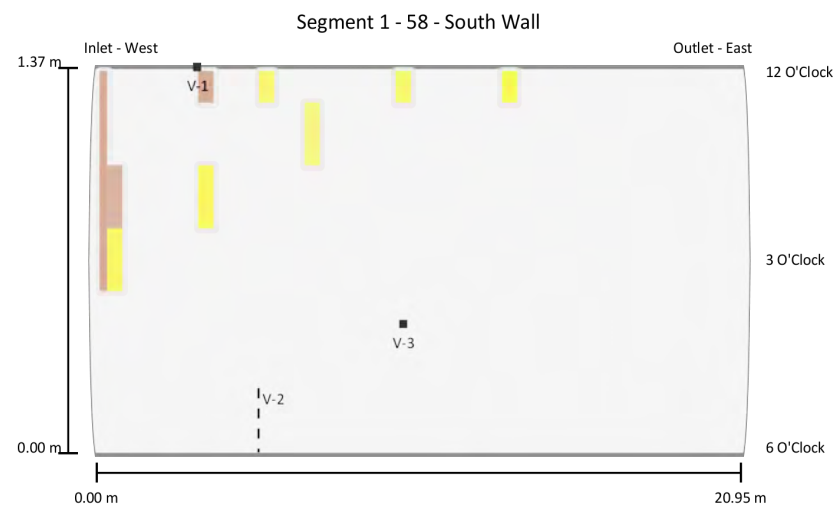
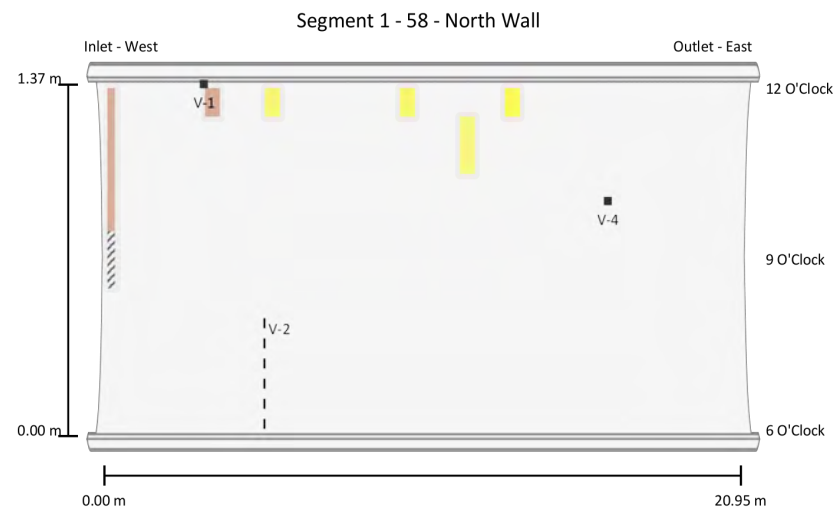


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



- □ Visual Indicators
- ◆ ◆ InSight™ BCT Images
- Acoustic Anomalies
- InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	3.30 m	-	12:00	-	Endoscope camera placed in the probe hole showing void (host pipe is resting on sliplined HDPE).
V-2	5.30 m	5.30 m	05:00	08:00	Pipe sections overlapping at joint.
V-3	10.00 m	-	04:00	-	Endoscope camera placed in the probe hole showing no void.
V-4	16.60 m	-	10:00	-	Endoscope camera placed in the probe hole showing no void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

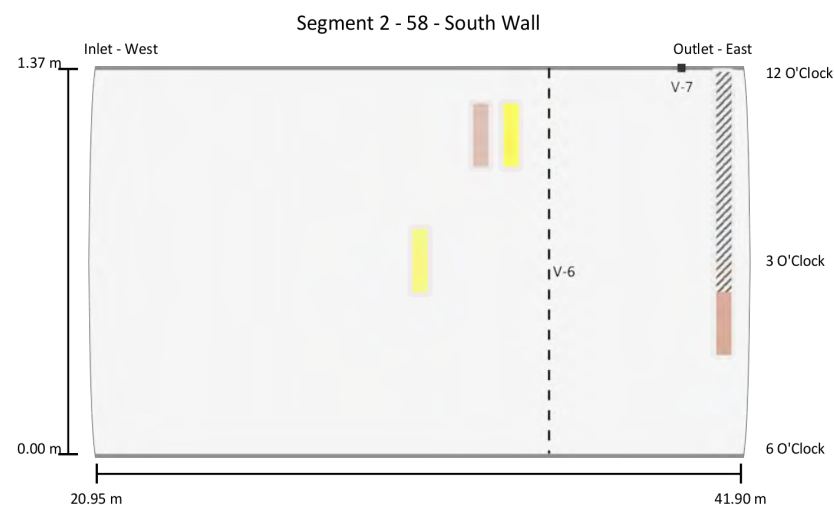
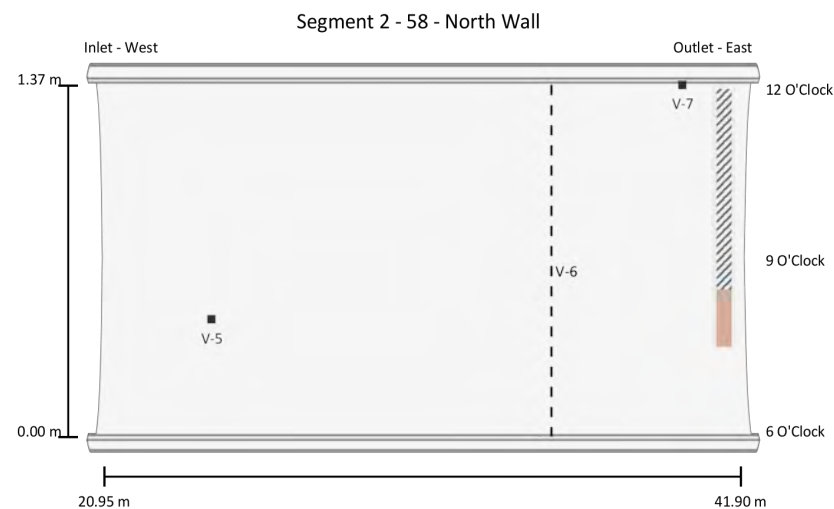
No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-5	24.50 m	-	08:00	-	Endoscope camera placed in the probe hole showing no void.
V-6	35.70 m	35.70 m	-	-	Pipe sections overlapping at joint with foam evident.
V-7	40.00 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.

Acoustic Anomalies





X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

X	Clock	Scan ID	Verdict
No BCT images included.			

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement	Rank 2	
Pavement in good condition.		
Cracks		
<ul style="list-style-type: none">• Longitudinal cracks: Frequency: Medium (2 - 5 cracks); Severity: Light (< 5 mm (0.2 in) Width)• Transverse cracks present: Frequency: Medium (2 - 5 cracks); Severity: Light (< 5 mm (0.2 in) Width)		
		
Photo 2 - Transverse crack.	Photo 1 - Longitudinal crack.	Photo 3 - Highway 60 facing north.
		
Photo 4 - Highway 60 facing south.		

Guardrail

Rank 2

Inlet guardrail has minor slack in metal wires.

Inlet guardrail.: Present.

Outlet guardrail.: Present.



Photo 5 - Inlet guardrail.



Photo 6 - Outlet guardrail.

Embankment

Rank 3

Outlet Embankment

- Erosion channel(s) present: **Frequency:** > 5 channels; **Severity:** Very severe (> 300 mm (12 in) Width).
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 7 - Multiple erosion channels on the outlet embankment with the most severe measuring approximately 400 mm in width.



Photo 8 - Inlet embankment.



Photo 9 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 10 - Inlet overview.



Photo 11 - Outlet overview.

Waterway Blockage

Rank 2

- Streambed material present: **Location:** Within pipe barrel.; X1: 0.00 m; X2: 36.00 m

Extent of blockage.: Equal to or less than 20%.



Photo 12 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 2

Some pipe sections were overlapping at joints.

Shape, Dents, and Localized Damage

Rank 3

Maximum shape deviation of approximately 6.6%.

Pipe Alignment

Rank 2

- Pipe misalignment present: **Condition:** Vertical misalignment.



Photo 13 - Pooling of approximately 100 mm evident within pipe due to the vertical misalignment at the outlet end.



Photo 14 - Upstream pipe alignment and shape.

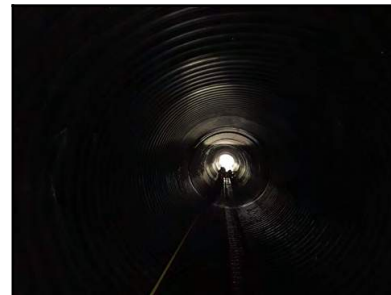


Photo 15 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 58 is 1370 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1390 mm	1.5%	1360 mm	-0.7%
5.00 m	1460 mm	6.6%	1290 mm	-5.8%
10.00 m	1410 mm	2.9%	1340 mm	-2.2%
15.00 m	1400 mm	2.2%	1350 mm	-1.5%
20.00 m	1390 mm	1.5%	1370 mm	0.0%
25.00 m	1380 mm	0.7%	1370 mm	0.0%
30.00 m	1420 mm	3.6%	1320 mm	-3.6%
35.00 m	1450 mm	5.8%	1300 mm	-5.1%
37.50 m	1420 mm	3.6%	1320 mm	-3.6%
41.80 m	1400 mm	2.2%	1360 mm	-0.7%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Longitudinal crack.



Photo 2 - Transverse crack.



Photo 3 - Highway 60 facing north.



Photo 4 - Highway 60 facing south.



Photo 5 - Inlet guardrail.



Photo 6 - Outlet guardrail.



Photo 7 - Multiple erosion channels on the outlet embankment with the most severe measuring approximately 400 mm in width.



Photo 8 - Inlet embankment.



Photo 9 - Outlet embankment.



Photo 10 - Inlet overview.



Photo 11 - Outlet overview.



Photo 12 - Downstream channel view.



Photo 13 - Pooling of approximately 100 mm evident within pipe due to the vertical misalignment at the outlet end.



Photo 14 - Upstream pipe alignment and shape.



Photo 15 - Downstream pipe alignment and shape.

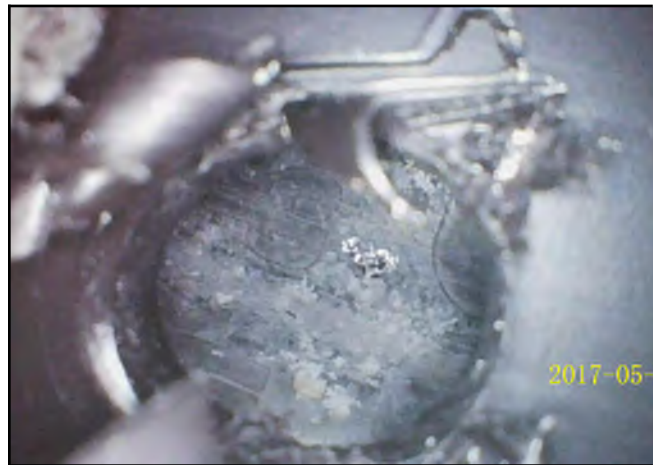


Photo 16 - V-1: Endoscope camera placed in the probe hole showing void (host pipe is resting on sliplined HDPE).

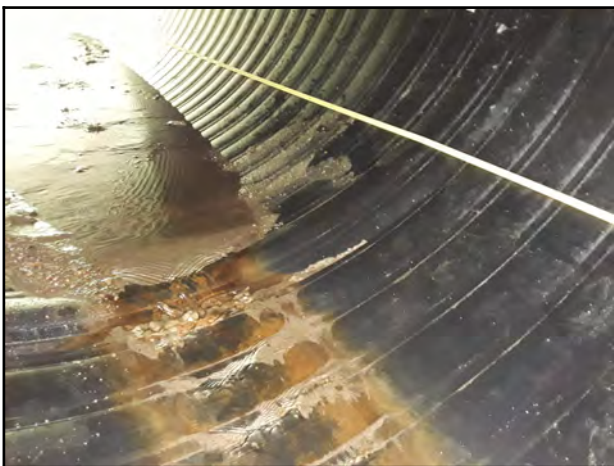


Photo 17 - V-2: Pipe sections overlapping at joint.



Photo 18 - V-2: Pipe sections overlapping at joint.



Photo 19 - V-3: Endoscope camera placed in the probe hole showing no void.

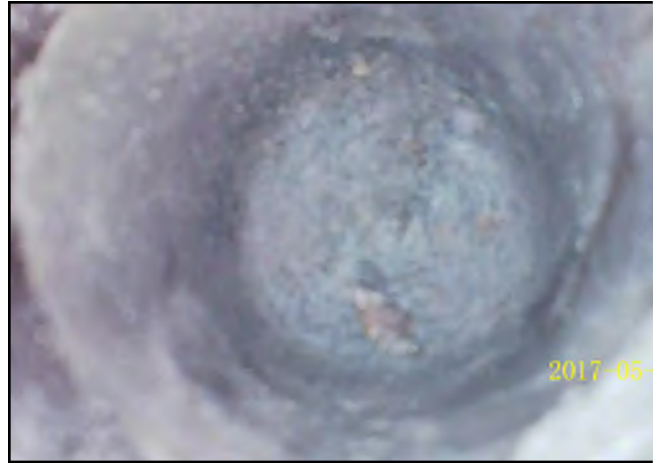


Photo 20 - V-3: Endoscope camera placed in the probe hole showing no void.



Photo 21 - V-4: Endoscope camera placed in the probe hole showing no void.

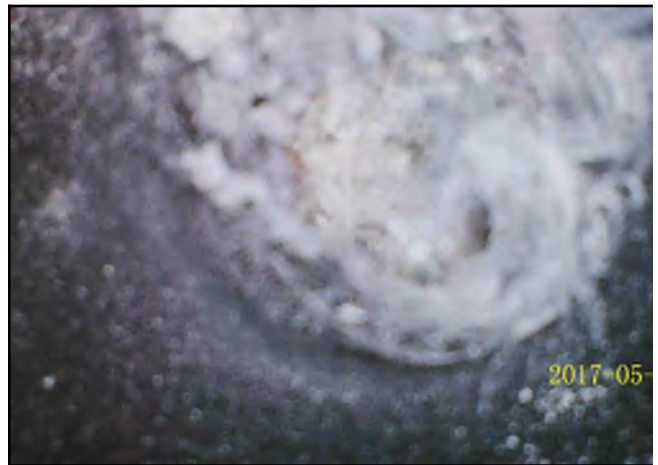


Photo 22 - V-4: Endoscope camera placed in the probe hole showing no void.



Photo 23 - V-5: Endoscope camera placed in the probe hole showing no void.

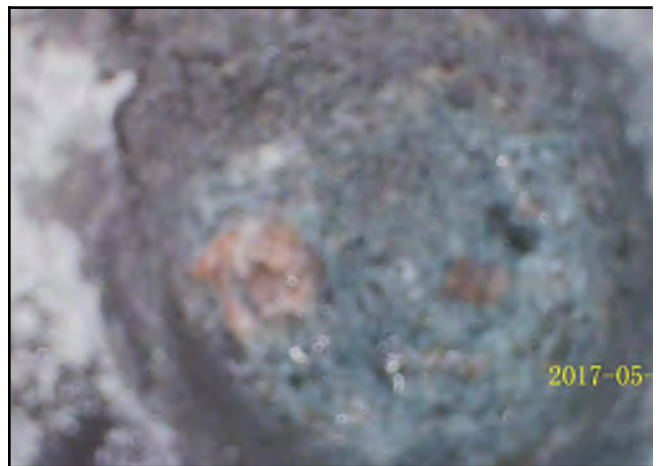


Photo 24 - V-5: Endoscope camera placed in the probe hole showing no void.



Photo 25 - V-6: Pipe sections overlapping at joint with foam evident.

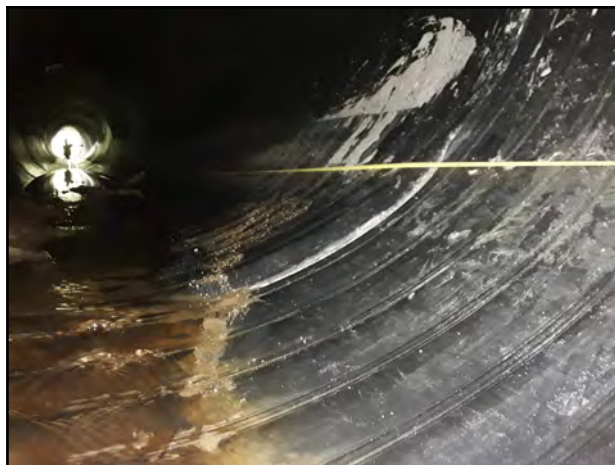


Photo 26 - V-6: Pipe sections overlapping at joint with foam evident.

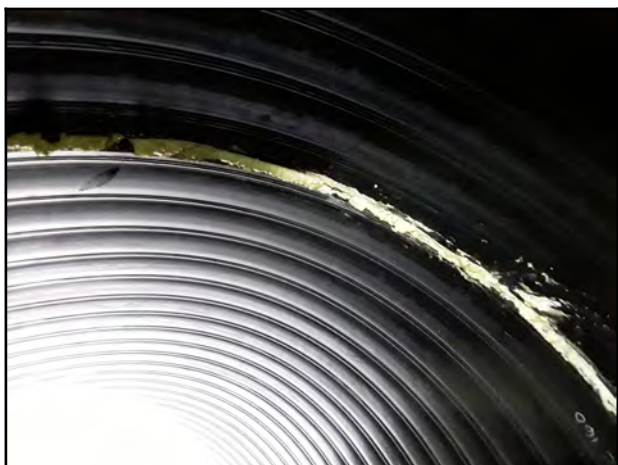


Photo 27 - V-6: Pipe sections overlapping at joint with foam evident.



Photo 28 - V-7: Endoscope camera placed in the probe hole showing no void.

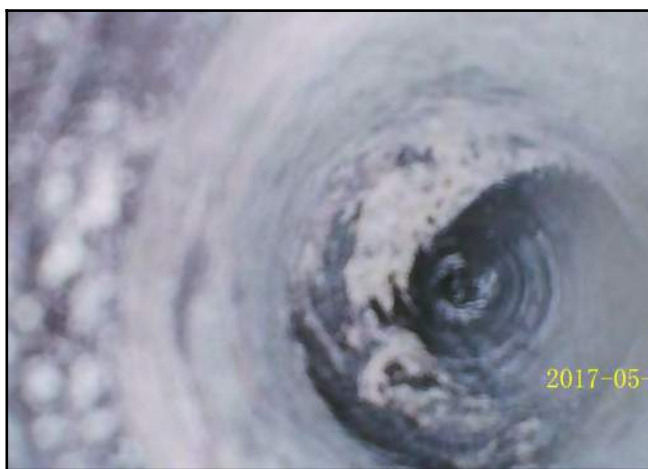


Photo 29 - V-7: Endoscope camera placed in the probe hole showing no void.

The asset 58 located on Highway 60 in Muskoka County, consists of a previously rehabilitated culvert by means of Sliplined High Density Polyethylene (HDPE) that has an approximate diameter of 1.37 m and length of 41.90 m. A visual inspection and inSight™ Lite assessment were performed at this site which found seven (7) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in good condition and performing as designed, however, a few deficiencies were noted. The outlet embankment had multiple erosion channels with the most severe measuring approximately 400 mm in width. The visual assessment identified two (2) visual indicators, V-2 and V-6, which were both overlapping pipe sections at joints. Additionally, V-6 had visible foam seeping through the joint.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of 6.6%, 5.00 m from the inlet and a maximum vertical deviation of -5.8%, 5.00 m from the inlet.

The inSight™ Lite assessment identified minor areas of potential void within the annular space between the existing and Sliplined culverts. This assessment required five (5) probe holes at areas of potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected areas.

As noted in V-1, V-4, V-5 and V-7, no visible annular voids between the existing and Sliplined culverts were recorded at each probe hole location, confirming the inSight™ Lite regions at these locations. A control point was also taken and recorded as V-3 to ensure the accuracy of the inSight™ Lite assessment. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, the annular space between the existing and Sliplined culverts was found to be well grouted. However, the outlet embankment was found to have multiple erosion channels. It is therefore recommended that the outlet embankment be repaired and stabilized to prevent further deterioration and/or potential failure. Following the maintenance of the outlet embankment, it is recommended that the asset continues to be monitored at its current inspection intervals. Subsequent inspections should emphasize monitoring the identified overlapping joints for signs of further movement.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

69

Highway 11 in Cochrane County

General Summary

The asset 69 located on Highway 11 in Cochrane County, consists of a sliplined High Density Polyethylene (HDPE) circular culvert. The asset is located at latitude 48° 38' 55.352" N, longitude 80° 42' 6.223" W. The dimensions of the asset were found to be approximately 1.21 m in diameter and 41.00 m in length. The asset has approximately 4.20 m of cover from the obvert to the road surface and flows generally west to east.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 8 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	69
County Name	Cochrane County
GPS	48° 38' 55.352" N, 80° 42' 6.223" W
Inspection Date	July 16, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.

SoilSight™ Condition Assessment

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

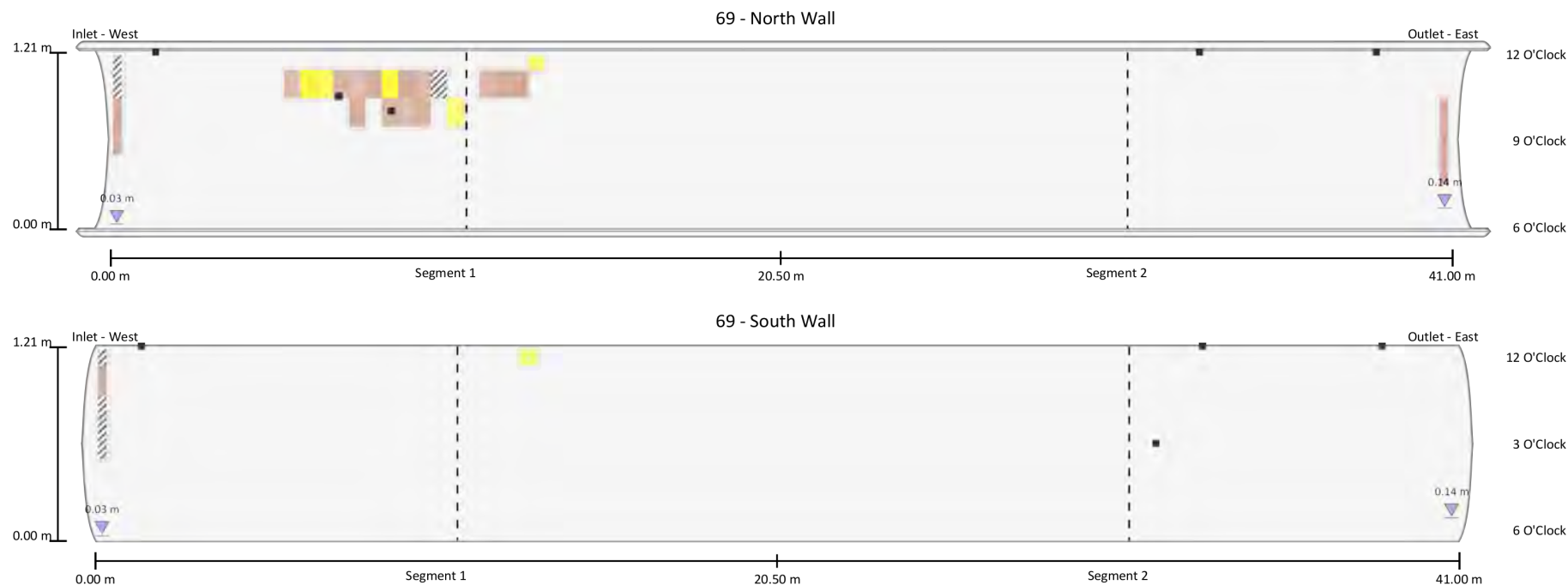
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

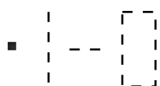
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

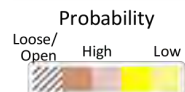
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

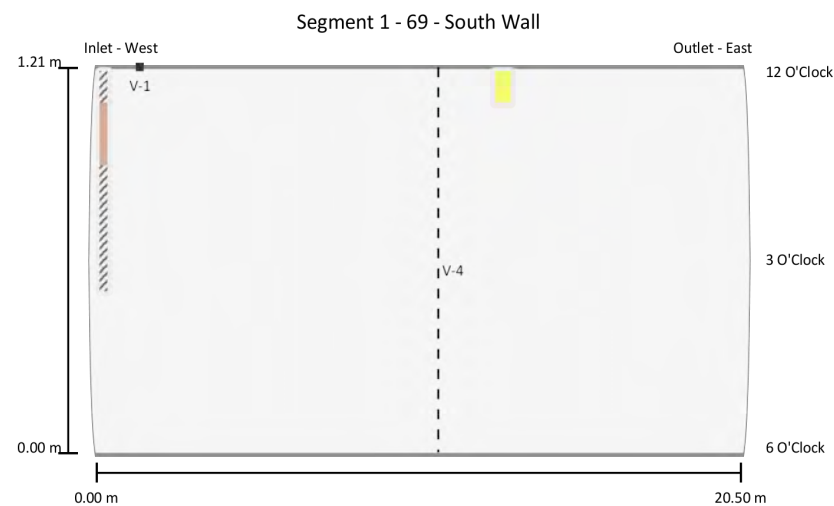
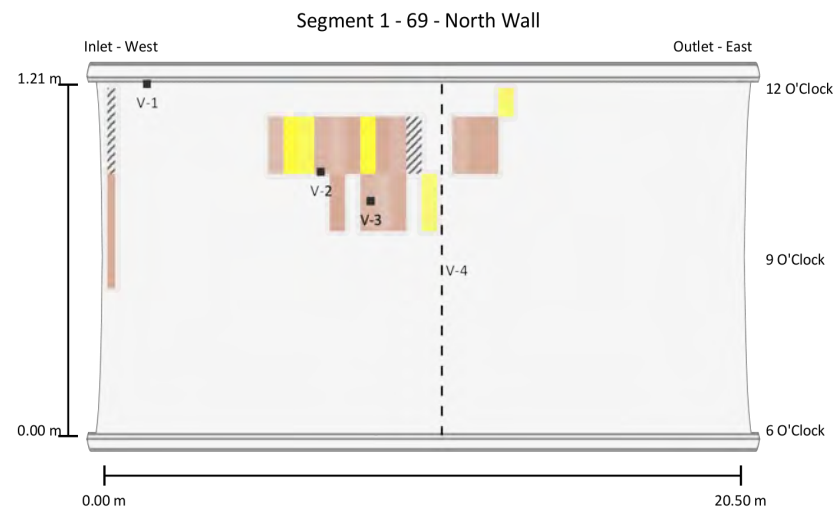


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.40 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.
V-2	7.00 m	-	10:30	-	Endoscope camera placed in the probe hole showing void.
V-3	8.60 m	-	10:00	-	Endoscope camera placed in the probe hole showing void.
V-4	10.90 m	10.90 m	-	-	Offset joint by approximately 20 mm.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

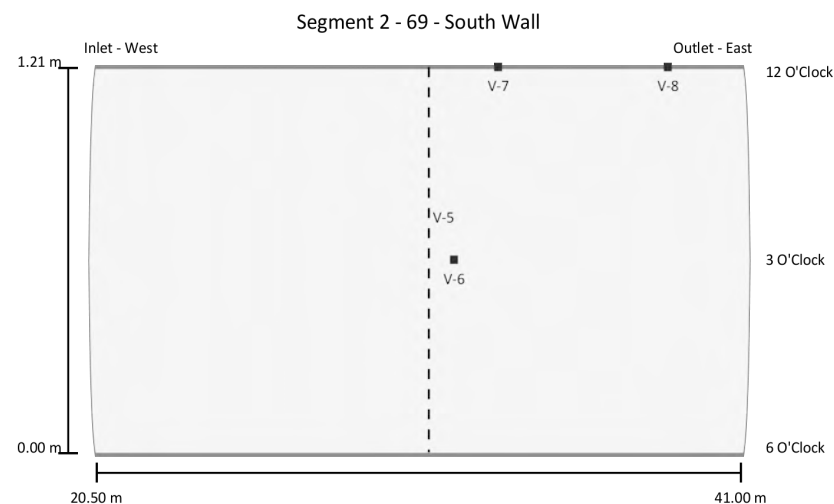
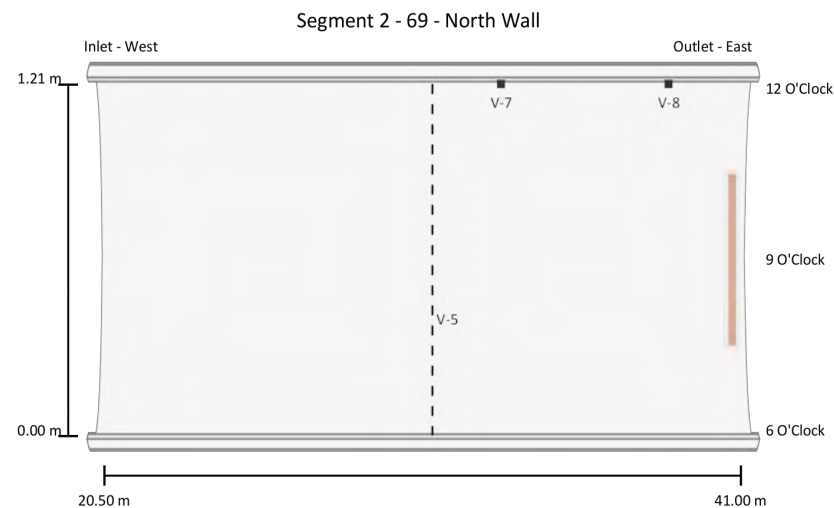
No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-5	31.10 m	31.10 m	-	-	Offset joint by approximately 40 mm with visible grouting and foam.
V-6	31.90 m	-	03:00	-	Endoscope camera placed in the probe hole showing no void (control point).
V-7	33.30 m	-	12:00	-	Dent protruding approximately 10 mm on the obvert.
V-8	38.70 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement

Rank 1

Pavement in excellent condition.



Photo 1 - Highway 11 facing north.



Photo 2 - Highway 11 facing south.

Guardrail

Rank 1

Guardrail in near new condition. No corrosion or missing components. No damage present. Location as designed. Structure well aligned both horizontally and vertically.

Inlet guardrail.: Present.

Outlet guardrail.: Outlet guardrail not present.



Photo 3 - Inlet guardrail.

Embankment

Rank 3

Inlet Embankment

- Rip-Rap stabilizing embankment present.
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Erosion channel(s) present: **Frequency:** > 5 channels; **Severity:** Very severe (> 300 mm (12 in) Width).
- Rip-Rap stabilizing embankment present.



Photo 4 - Multiple erosion channels on the outlet embankment, most severe measuring approximately 800 mm in width.



Photo 5 - Inlet embankment.



Photo 6 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 7 - Inlet overview.



Photo 8 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 9 - Upstream channel view.



Photo 10 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 2

- Joint offset(s) present: **Severity:** Light (< 100 mm (4 in) Width).
- Substrate visible through joint offset(s).

Shape, Dents, and Localized Damage

Rank 2

Maximum shape deviation of approximately -5%.

- Dent(s) present on the pipe wall: **Severity:** Light (< 25 mm (1 in) Depth).

Pipe Alignment

Rank 2

Slight horizontal misalignment at the outlet end.

- Pipe misalignment present: **Condition:** Horizontal misalignment.



Photo 11 - Upstream pipe alignment and shape.



Photo 12 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 69 is 1210 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	1220 mm	0.8%	1200 mm	-0.8%
5.00 m	1260 mm	4.1%	1170 mm	-3.3%
10.00 m	1260 mm	4.1%	1170 mm	-3.3%
15.00 m	1260 mm	4.1%	1150 mm	-5.0%
20.00 m	1250 mm	3.3%	1160 mm	-4.1%
25.00 m	1250 mm	3.3%	1170 mm	-3.3%
30.00 m	1260 mm	4.1%	1150 mm	-5.0%
35.00 m	1270 mm	5.0%	1150 mm	-5.0%
41.00 m	1210 mm	0.0%	1210 mm	0.0%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 11 facing north.



Photo 2 - Highway 11 facing south.



Photo 3 - Inlet guardrail.



Photo 4 - Multiple erosion channels on the outlet embankment, most severe measuring approximately 800 mm in width.



Photo 5 - Inlet embankment.



Photo 6 - Outlet embankment.



Photo 7 - Inlet overview.



Photo 8 - Outlet overview.



Photo 9 - Upstream channel view.



Photo 10 - Downstream channel view.



Photo 11 - Upstream pipe alignment and shape.



Photo 12 - Downstream pipe alignment and shape.



Photo 13 - V-1: Endoscope camera placed in the probe hole showing no void.



Photo 14 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 15 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 16 - V-2: Endoscope camera placed in the probe hole showing void.

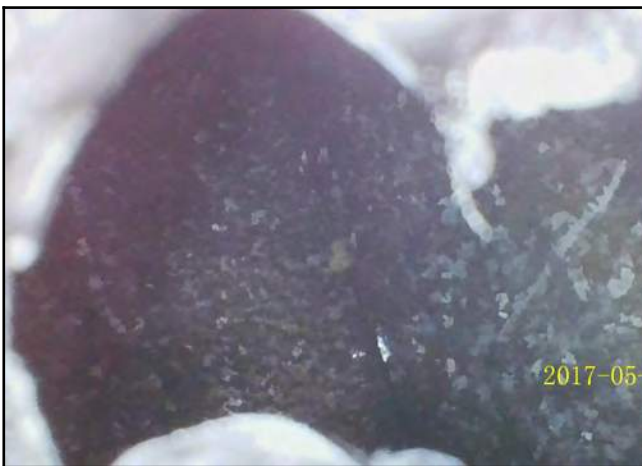


Photo 17 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 18 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 19 - V-3: Endoscope camera placed in the probe hole showing void.

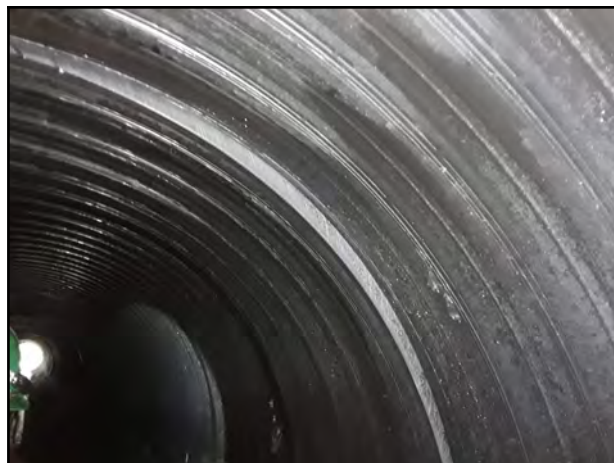


Photo 20 - V-4: Offset joint by approximately 20 mm.



Photo 21 - V-5: Offset joint by approximately 40 mm with visible grouting and foam.



Photo 22 - V-5: Offset joint by approximately 40 mm with visible grouting and foam.



Photo 23 - V-5: Offset joint by approximately 40 mm with visible grouting and foam.

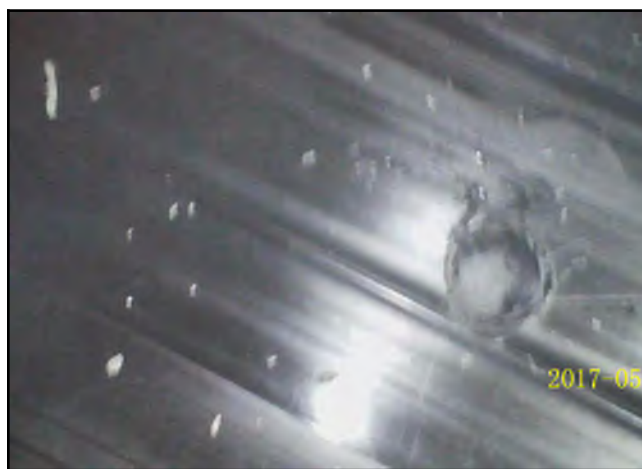


Photo 24 - V-6: Endoscope camera placed in the probe hole showing no void (control point).



Photo 25 - V-6: Endoscope camera placed in the probe hole showing no void (control point).

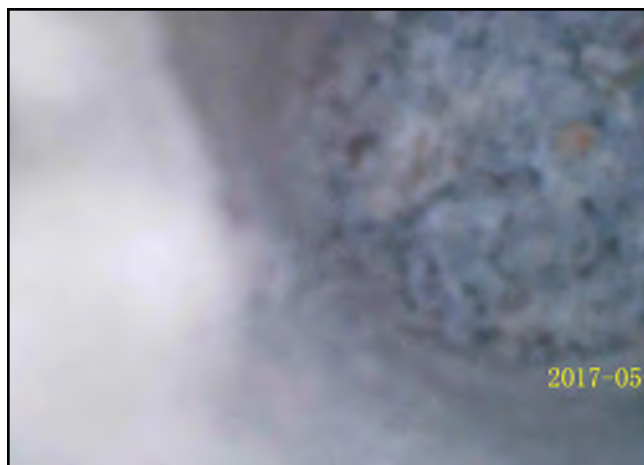


Photo 26 - V-6: Endoscope camera placed in the probe hole showing no void (control point).

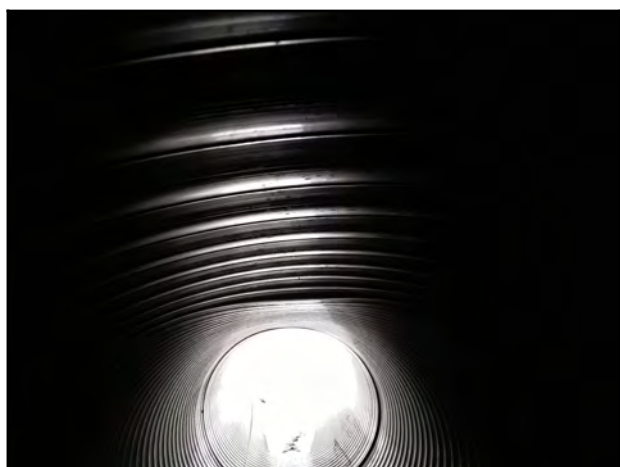


Photo 27 - V-7: Dent protruding approximately 10 mm on the obvert.

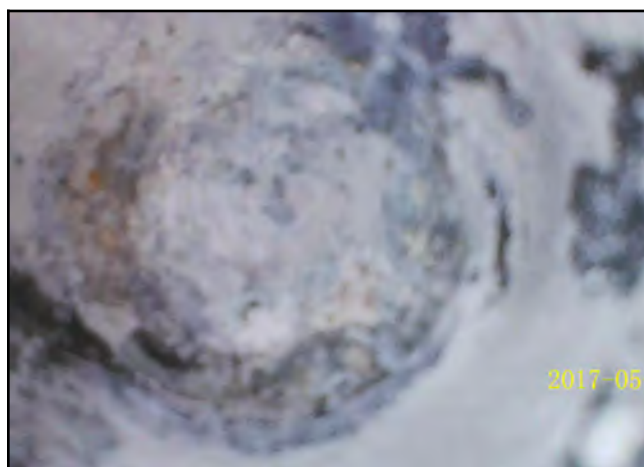


Photo 28 - V-8: Endoscope camera placed in the probe hole showing no void.



Photo 29 - V-8: Endoscope camera placed in the probe hole showing no void.

The asset 69 located on Highway 11 in Cochrane County, consists of a previously rehabilitated culvert by means of sliplined High Density Polyethylene (HDPE) that has an approximate diameter of 1.21 m and length of 41.00 m. A visual inspection and inSight™ Lite assessment were performed at this site which found eight (8) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in good condition and performing as designed, however, a few deficiencies were noted. The outlet embankment had multiple erosion channels with the most severe measuring approximately 800 mm in width. The visual assessment identified three (3) visual indicators. V-4 and V-5 were both offset joints of approximately 20 mm and 40 mm respectively. Additionally, V-5 had visible grout and foam seeping through the joint. V-7 was recorded as a dent and was found to be protruding by approximately 10 mm on the obvert.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of 5.0%, 35.00 m from the inlet and a maximum vertical deviation of -5.0%, 15.00 m from the inlet.

The inSight™ Lite assessment did identify some areas of potential void within the annular space between the existing and Sliplined culverts. This assessment required five (5) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected areas.

As noted in V-2 and V-3, visible annular voids between the existing culvert and the Sliplined HDPE were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at these locations. V-1, and V-8 were identified as locations of no void. A control point was also taken and recorded as V-6 to ensure the accuracy of the inSight™ Lite assessment. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended the outlet embankment be repaired and stabilized to prevent further deterioration and/or potential failure. Additionally, it is recommended that the areas with confirmed annular voids between the existing culvert and the sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

71

Highway 17 in Algoma County

General Summary

The asset 71 located on Highway 17 in Algoma County, consists of a Sliplined High Density Polyethylene (HDPE) circular culvert. The asset is located at latitude 46° 46' 42.443" N, longitude 84° 22' 14.590" W. The dimensions of the asset were found to be approximately 0.91 m in diameter and 31.60 m in length. The asset has approximately 2.90 m of cover from the obvert to the road surface and flows generally north to south.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 7 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	71
County Name	Algoma County
GPS	46° 46' 42.443" N, 84° 22' 14.590" W
Inspection Date	July 15, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.
Approved By	Steven Godbout, B.Sc.Eng.

SoilSight™ Condition Assessment

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

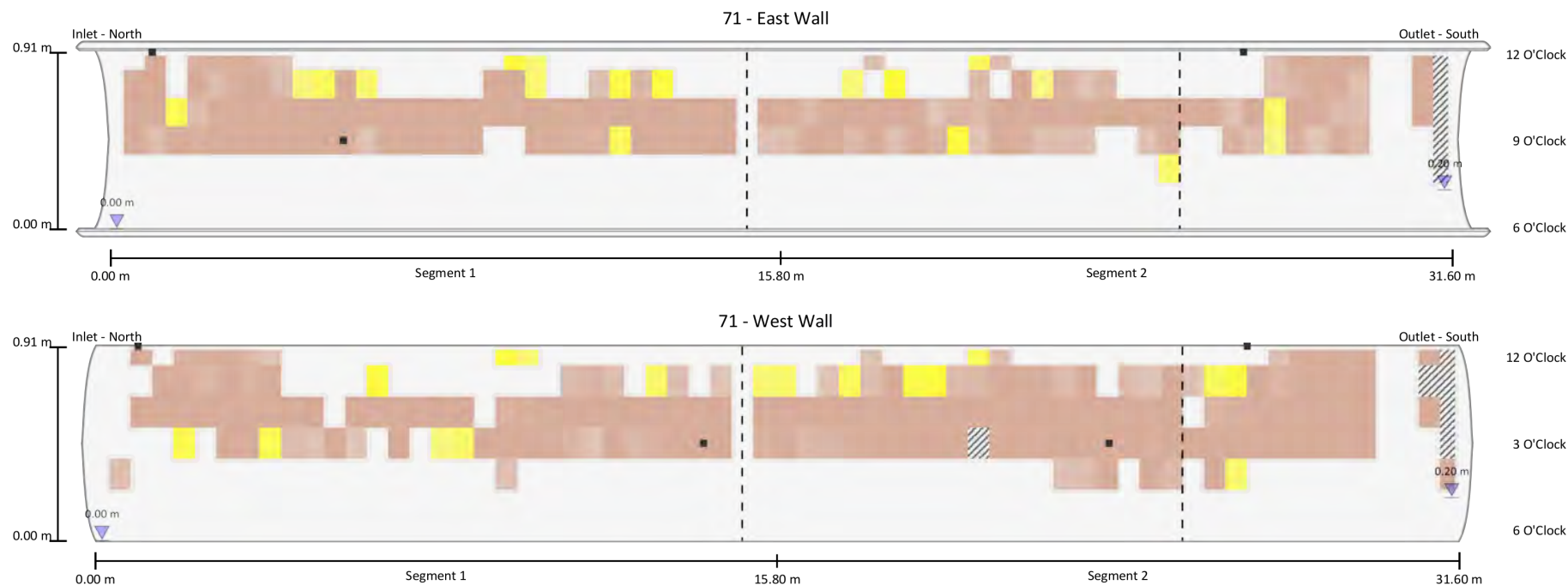
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

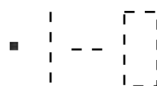
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

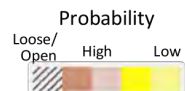
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

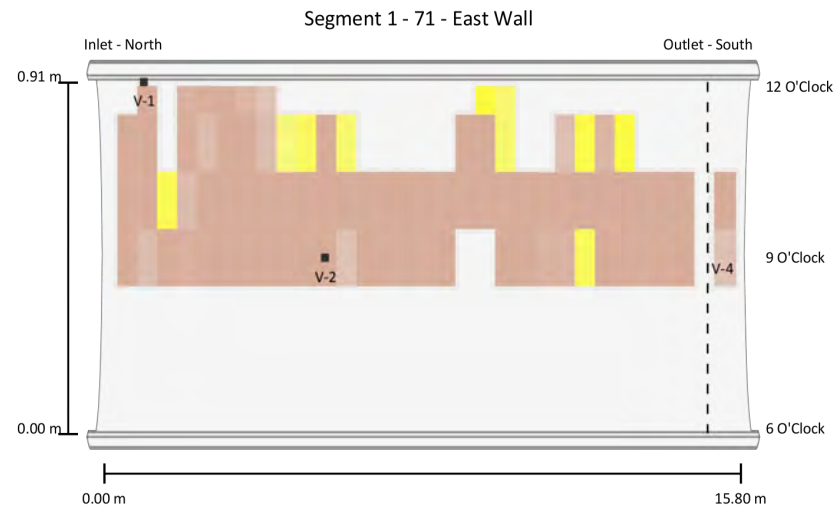


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.00 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-2	5.50 m	-	09:00	-	Endoscope camera placed in the probe hole showing void.
V-3	14.10 m	-	03:00	-	Endoscope camera placed in the probe hole showing no void.
V-4	15.00 m	15.00 m	-	-	Separated joint by approximately 40 mm.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
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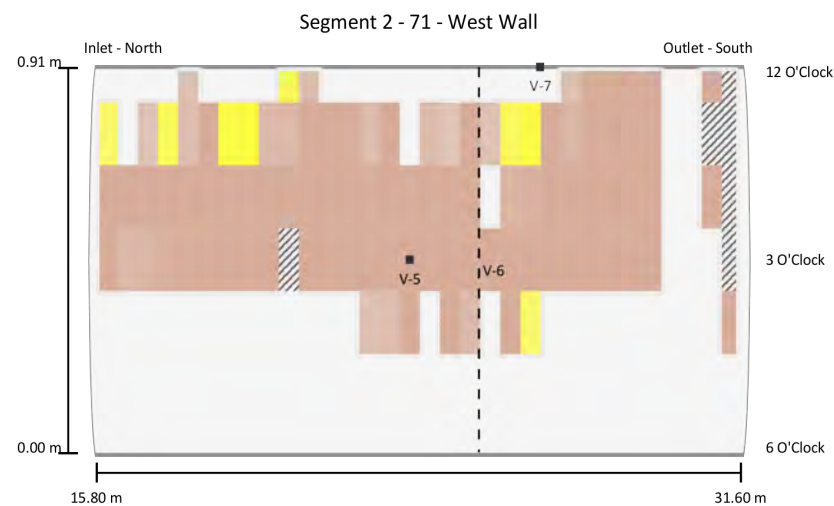
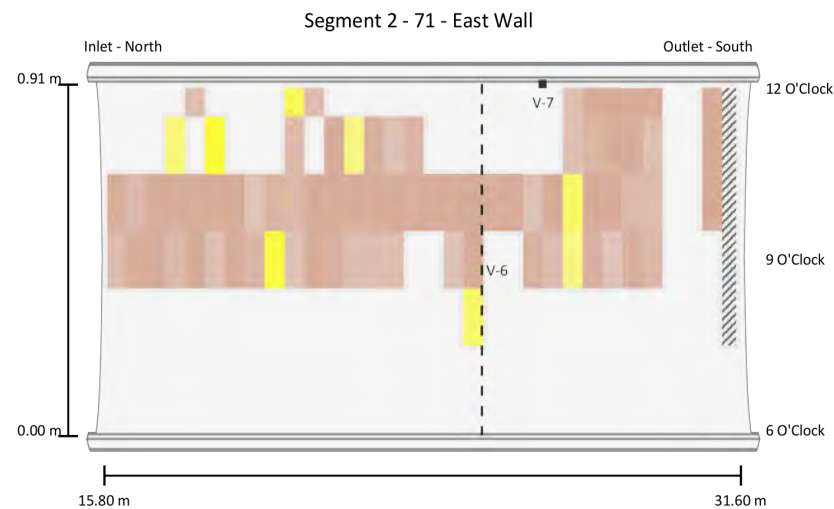
No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
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No BCT images included.

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-5	23.50 m	-	03:00	-	Endoscope camera placed in the probe hole showing void.
V-6	25.20 m	25.20 m	-	-	Separated joint by approximately 40 mm with minor localized damage evident.
V-7	26.70 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement

Rank 1

Pavement in excellent condition.



Photo 1 - Highway 17 facing east.



Photo 2 - Highway 17 facing west.

Guardrail

Rank 1

Guardrail in near new condition. No corrosion or missing components. No damage present. Location as designed. Structure well aligned both horizontally and vertically.

Inlet guardrail.: Inlet guardrail not present.

Outlet guardrail.: Present.



Photo 3 - Outlet guardrail.

Embankment

Rank 1

Embankment stable, no visible ruts or erosion channels. No large vegetation present.

Inlet Embankment

- Rip-Rap stabilizing embankment present.
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Rip-Rap stabilizing embankment present.
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.

Waterway Blockage

Rank 2

- Streambed material present: **Location:** Within pipe barrel.; X1: 24.00 m; X2: 31.60 m
Extent of blockage.: Equal to or less than 20%.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 2

- Joint separation(s) present: **Severity:** Light (< 100 mm (4 in) Width).

Shape, Dents, and Localized Damage

Rank 2

- Localized damage present: **Severity:** Pipe performance not affected by localized damage.

Pipe Alignment

Rank 2

Slight horizontal misalignment at the outlet end.

- Pipe misalignment present: **Condition:** Horizontal misalignment.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 71 is 910 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	910 mm	0.0%	910 mm	0.0%
5.00 m	910 mm	0.0%	910 mm	0.0%
10.00 m	910 mm	0.0%	910 mm	0.0%
15.00 m	910 mm	0.0%	910 mm	0.0%
20.00 m	910 mm	0.0%	910 mm	0.0%
25.00 m	910 mm	0.0%	-	-
31.60 m	910 mm	0.0%	-	-

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 17 facing east.



Photo 2 - Highway 17 facing west.



Photo 3 - Outlet guardrail.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.



Photo 12 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 13 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 14 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 15 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 16 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 17 - V-2: Endoscope camera placed in the probe hole showing void.

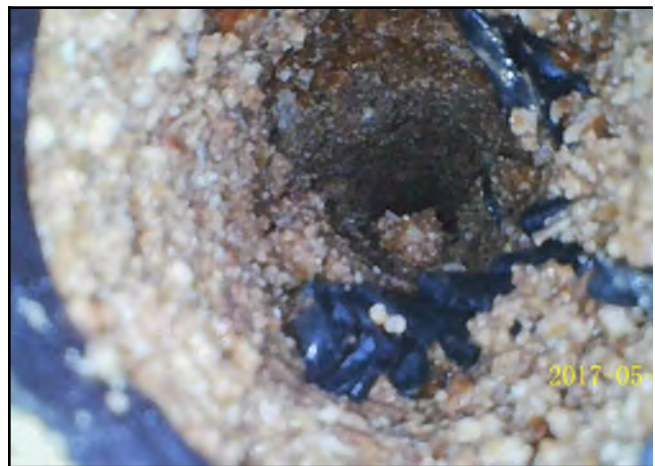


Photo 18 - V-3: Endoscope camera placed in the probe hole showing no void.



Photo 19 - V-4: Separated joint by approximately 40 mm.



Photo 20 - V-4: Separated joint by approximately 40 mm.



Photo 21 - V-5: Endoscope camera placed in the probe hole showing void.



Photo 22 - V-5: Endoscope camera placed in the probe hole showing void.



Photo 23 - V-5: Endoscope camera placed in the probe hole showing void.



Photo 24 - V-6: Separated joint by approximately 40 mm with minor localized damage evident.



Photo 25 - V-6: Separated joint by approximately 40 mm with minor localized damage evident.



Photo 26 - V-7: Endoscope camera placed in the probe hole showing no void.

The asset 71 located on Highway 17 in Algoma County, consists of a previously rehabilitated culvert by means of Sliplined High Density Polyethylene (HDPE) that has an approximate diameter of 0.91 m and length of 31.60 m. A visual inspection and inSight™ Lite assessment were performed at this site which found seven (7) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in fair condition and performing as designed, however, a few deficiencies were noted. The visual assessment identified two (2) visual indicators, V-4 and V-6, which consisted of separated joints of approximately 40 mm. Visual indicator V-2 also had minor localized damage evident.

No shape deviations were identified within the pipe barrel.

The inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. This assessment required five (5) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected area.

As noted in V-1, V-2, and V-5, visible annular voids between the existing and sliplined culverts were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at these locations. V-3 and V-7 were identified as locations of no void. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing culvert and the Sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

75

Highway 17 in Sudbury County

General Summary

The asset 75 located on Highway 17 in Sudbury County, consists of a Sliplined High Density Polyethylene (HDPE) circular culvert. The asset is located at latitude 46° 30' 5.458" N, longitude 80° 44' 14.745" W. The dimensions of the asset were found to be approximately 0.91 m in diameter and 41.40 m in length. The asset has approximately 5.30 m of cover from the obvert to the road surface and flows generally south to north.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 4 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	75
County Name	Sudbury County
GPS	46° 30' 5.458" N, 80° 44' 14.745" W
Inspection Date	July 12, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.
Approved By	Steven Godbout, B.Sc.Eng.

SoilSight™ Condition Assessment

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

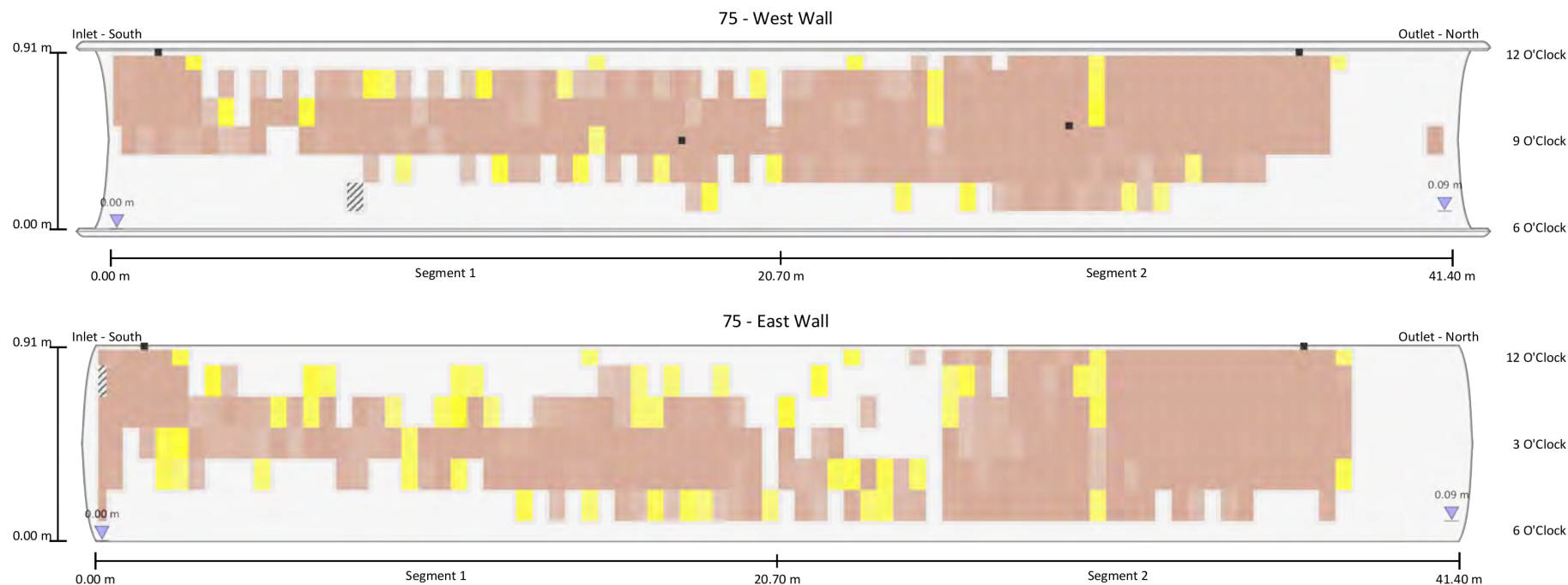
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

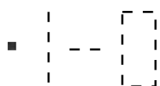
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

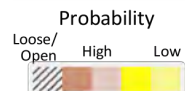
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

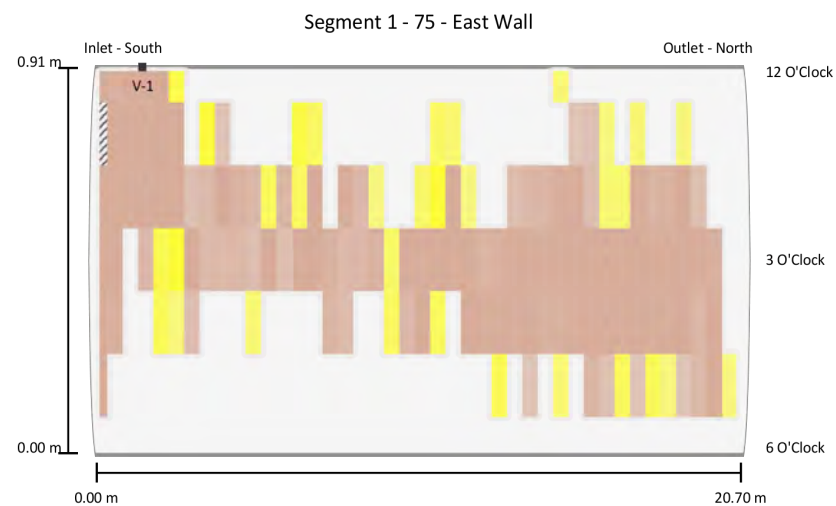
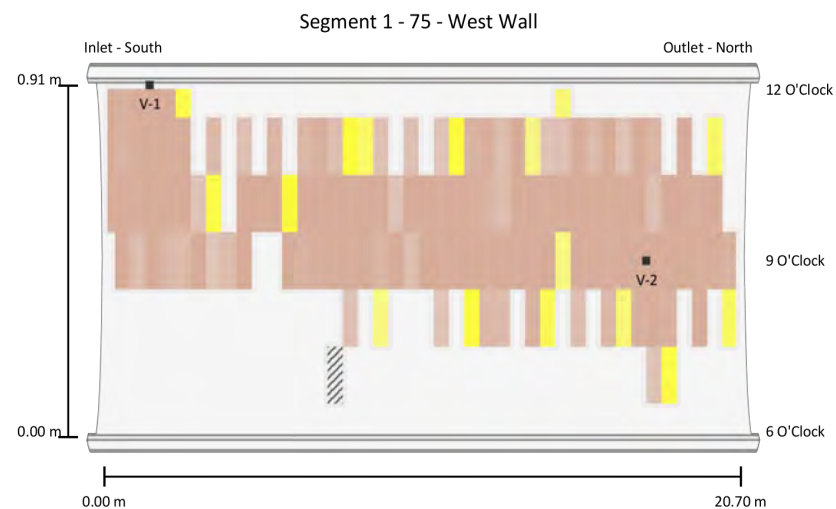


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.50 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-2	17.65 m	-	09:00	-	Endoscope camera placed in the probe hole showing void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

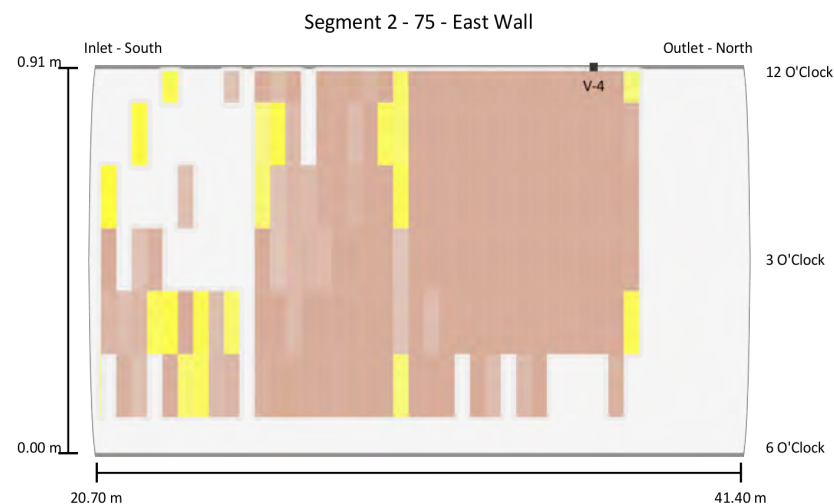
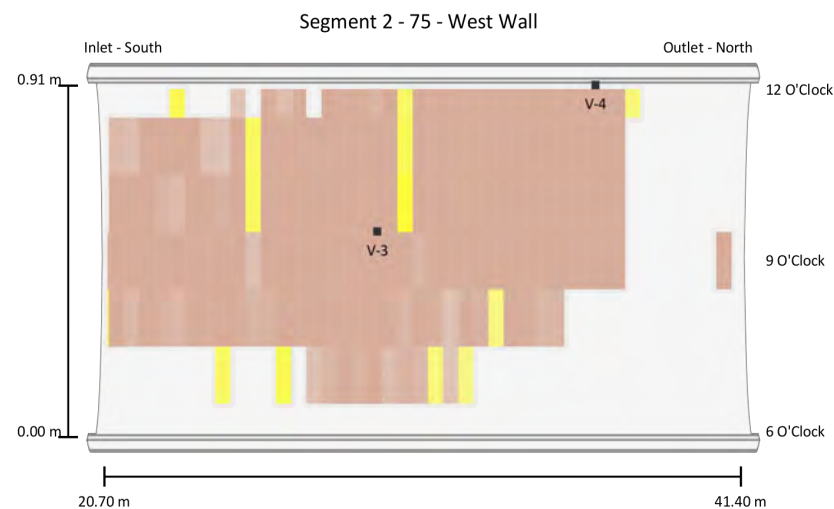
No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
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No BCT images included.

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-3	29.60 m	-	09:30	-	Endoscope camera placed in the probe hole showing void.
V-4	36.70 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.






InSight™ BCT Images

X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement		Rank 5
<ul style="list-style-type: none">Vehicle track rutting present: Severity: Severe (21 - 40 mm (0.9 - 1.6 in) Depth).		
Cracks		
<ul style="list-style-type: none">Longitudinal cracks: Frequency: Frequent (more than 5 cracks); Severity: Severe (> 15 mm (0.6 in) Width)Transverse cracks present: Frequency: Frequent (more than 5 cracks); Severity: Severe (> 15 mm (0.6 in) Width)		
Potholes		
<ul style="list-style-type: none">Pothole(s) present: Frequency: Medium (2 - 5 potholes); Severity: Very severe (> 40 mm (1.5 in) Depth)		
		
Photo 2 - Minor pothole measuring approximately 20 mm in-depth.	Photo 1 - Multiple severe transverse and longitudinal cracks directly above the pipe.	Photo 3 - Pothole measuring approximately 100 mm in-depth not directly over pipe.
		
Photo 4 - Highway 17 facing west.	Photo 5 - Highway 17 facing east.	

Guardrail

Rank 3

Both inlet and outlet guardrails have slack.

Inlet guardrail.: Present.

- Corrosion present: **Severity:** Light surface corrosion.
- Horizontal misalignment present.

Outlet guardrail.: Present.

- Corrosion present: **Severity:** Light surface corrosion.



Photo 6 - Inlet guardrail.



Photo 7 - Outlet guardrail.

Embankment

Rank 4

Inlet Embankment

- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).

Outlet Embankment

- Erosion channel(s) present: **Frequency:** > 5 channels; **Severity:** Very severe (> 300 mm (12 in) Width).
- Vegetation present: **Size:** Small vegetation present (< 3.0 m (10 ft) in height).



Photo 8 - Multiple erosion channels on the outlet, most severe measuring approximately 1500 mm in width.



Photo 9 - Poorly repaired erosion channel on the inlet embankment.



Photo 10 - Inlet embankment.



Photo 11 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 12 - Inlet overview.



Photo 13 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 14 - Upstream channel view.



Photo 15 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Pipe Alignment

Rank 2

- Vertical misalignment of terminal pipe ends present.



Photo 16 - Upstream pipe alignment and shape.



Photo 17 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 75 is 910 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	910 mm	0.0%	910 mm	0.0%
5.00 m	910 mm	0.0%	910 mm	0.0%
10.00 m	910 mm	0.0%	910 mm	0.0%
15.00 m	910 mm	0.0%	910 mm	0.0%
20.00 m	910 mm	0.0%	910 mm	0.0%
25.00 m	910 mm	0.0%	910 mm	0.0%
30.00 m	910 mm	0.0%	910 mm	0.0%
35.00 m	910 mm	0.0%	910 mm	0.0%
41.20 m	910 mm	0.0%	910 mm	0.0%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Multiple severe transverse and longitudinal cracks directly above the pipe.



Photo 2 - Minor pothole measuring approximately 20 mm in-depth.



Photo 3 - Pothole measuring approximately 100 mm in-depth not directly over pipe.



Photo 4 - Highway 17 facing west.



Photo 5 - Highway 17 facing east.



Photo 6 - Inlet guardrail.



Photo 7 - Outlet guardrail.



Photo 8 - Multiple erosion channels on the outlet, most severe measuring approximately 1500 mm in width.



Photo 9 - Poorly repaired erosion channel on the inlet embankment.



Photo 10 - Inlet embankment.



Photo 11 - Outlet embankment.



Photo 12 - Inlet overview.



Photo 13 - Outlet overview.



Photo 14 - Upstream channel view.



Photo 15 - Downstream channel view.



Photo 16 - Upstream pipe alignment and shape.



Photo 17 - Downstream pipe alignment and shape.



Photo 18 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 19 - V-1: Endoscope camera placed in the probe hole showing void.

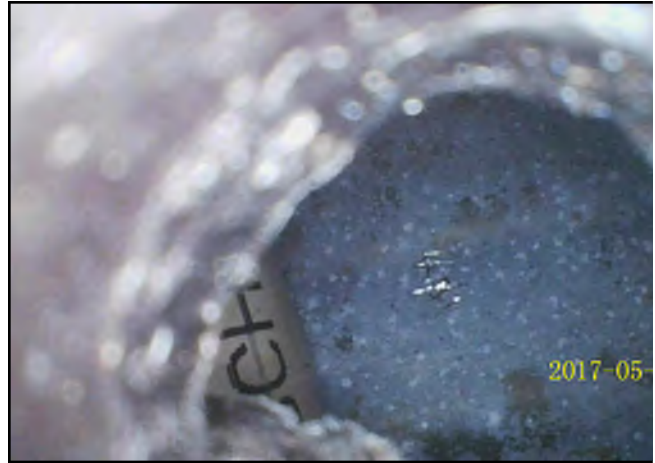


Photo 20 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 21 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 22 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 23 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 24 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 25 - V-3: Endoscope camera placed in the probe hole showing void.

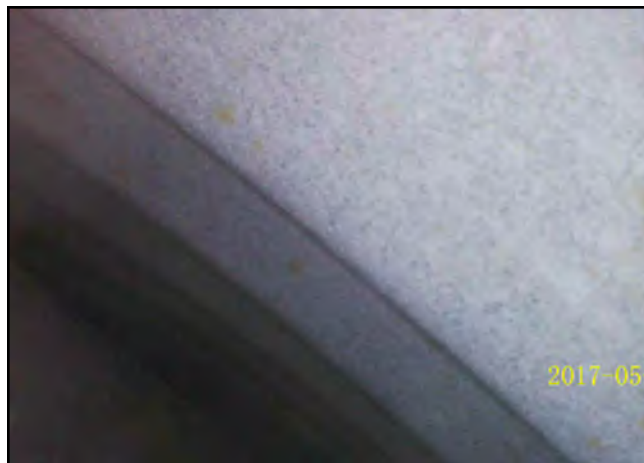


Photo 26 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 27 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 28 - V-4: Endoscope camera placed in the probe hole showing void.

The asset 75 located on Highway 17 in Sudbury County, consists of a previously rehabilitated culvert by means of Sliplined High Density Polyethylene (HDPE) that has an approximate diameter of 0.91 m and length of 41.40 m. A visual inspection and inSight™ Lite assessment were performed at this site which found four (4) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in fair condition and performing as designed, however, several deficiencies were noted. The visual inspection revealed the roadway above the asset was in poor condition with severe transverse and longitudinal cracks directly above the pipe. Additionally, two (2) potholes were identified near the asset measuring approximately 20 mm and 100 mm in-depth. Both the inlet and outlet guardrails had light surface corrosion and the inlet guardrail had visible horizontal misalignment. The outlet embankment had multiple erosion channels with the most severe measuring approximately 1500 mm in width, as shown in Photo 8.

No shape deviations were identified within the pipe barrel.

The inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and Sliplined culverts. This assessment required four (4) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected area.

As noted in V-1, V-2, V-3, and V-4, visible annular voids between the existing culvert and the sliplined HDPE were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at all locations. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended the outlet embankment be repaired and stabilized to prevent further deterioration and/or potential failure. Additionally, it is recommended that the areas with confirmed annular voids between the existing culvert and the sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

76

Reserve Road in Sudbury County

General Summary

The asset 76 located on Reserve Road in Sudbury County, consists of a Sliplined High Density Polyethylene (HDPE) circular culvert. The asset is located at latitude 46° 12' 11.899" N, longitude 82° 4' 30.905" W. The dimensions of the asset were found to be approximately 0.91 m in diameter and 24.80 m in length. The asset has approximately 3.70 m of cover from the obvert to the road surface and flows generally south to north.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 4 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	76
County Name	Sudbury County
GPS	46° 12' 11.899" N, 82° 4' 30.905" W
Inspection Date	July 13, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

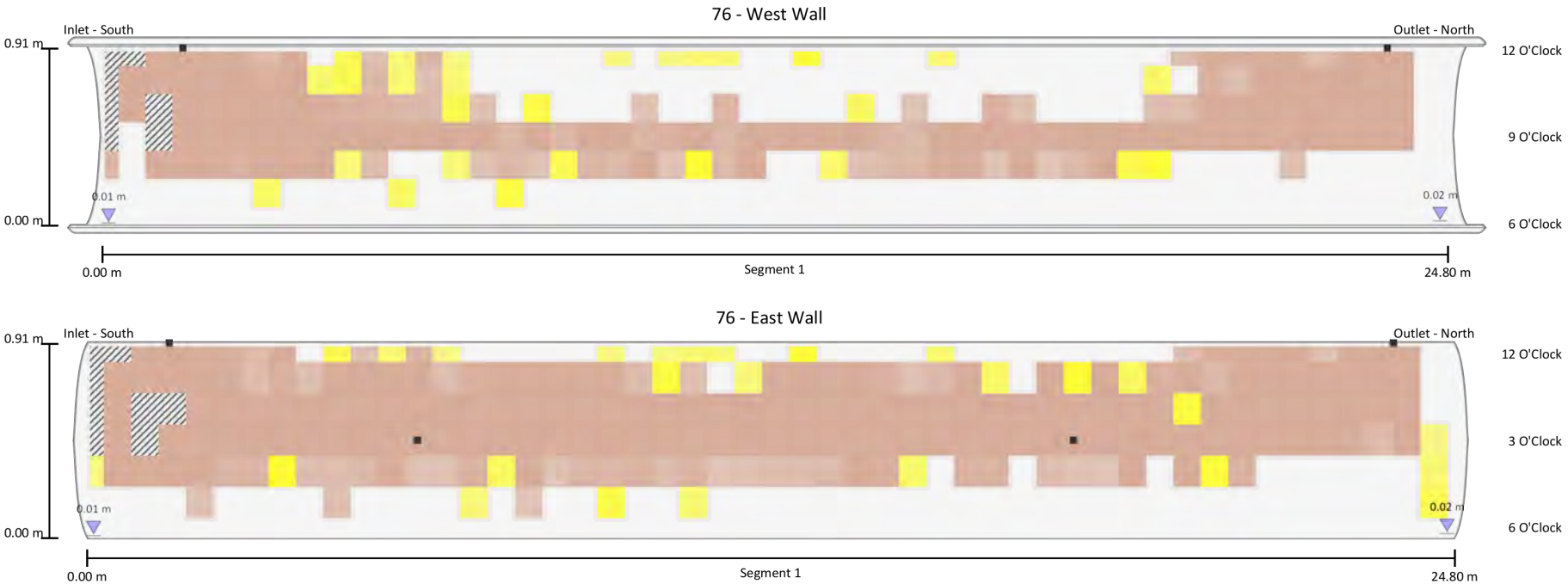
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

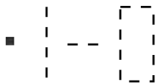
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

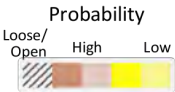
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

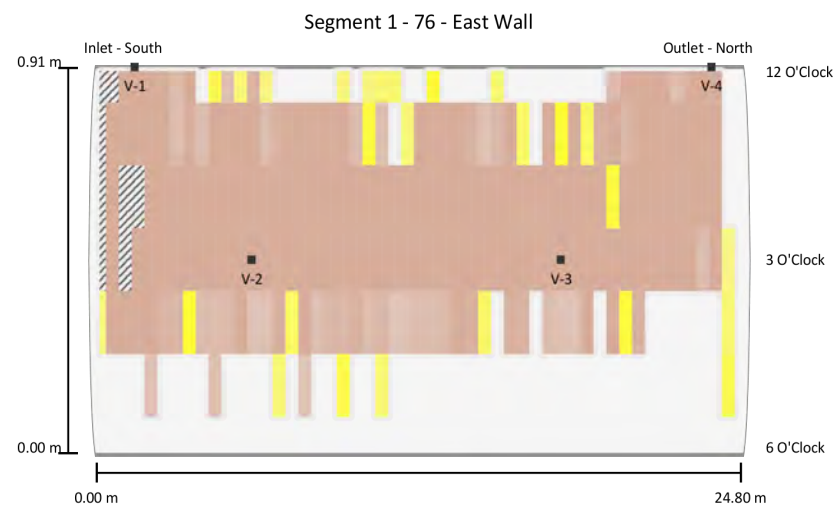
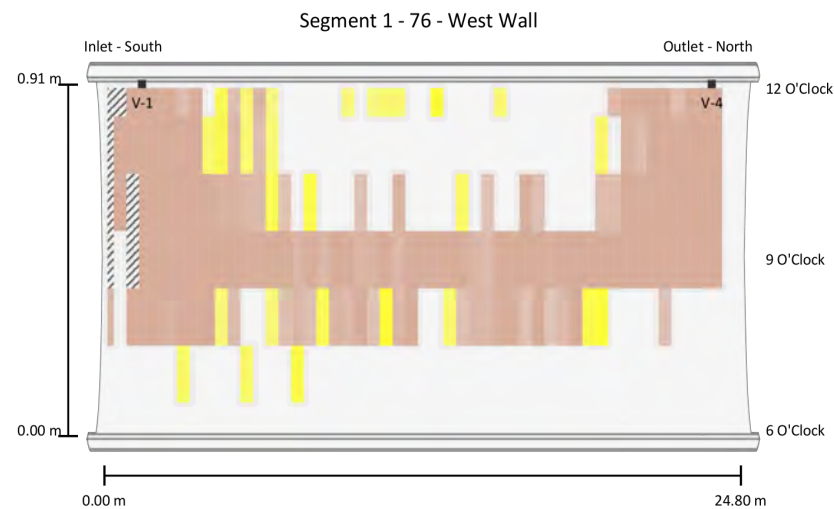


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.50 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-2	6.00 m	-	03:00	-	Endoscope camera placed in the probe hole showing void.
V-3	17.90 m	-	03:00	-	Endoscope camera placed in the probe hole showing void.
V-4	23.70 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.

InSight™ BCT Images


X	Clock	Scan ID	Verdict
---	-------	---------	---------

No BCT images included.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement	Rank 1
Pavement in excellent condition.	
	
Photo 1 - Reserve Road facing west.	Photo 2 - Reserve Road facing east.

Guardrail	Rank 1
Guardrail in near new condition. No corrosion or missing components. No damage present. Location as designed. Structure well aligned both horizontally and vertically.	
Inlet guardrail.: Inlet guardrail not present.	
Outlet guardrail.: Present.	
	
Photo 3 - Outlet guardrail.	

Embankment

Rank 2

Inlet Embankment

- Vegetation present: **Size:** Large vegetation present (> 3.0 m (10 ft) in height).

Outlet Embankment

- Rip-Rap stabilizing embankment present.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.

Waterway Blockage

Rank 2

- Streambed material present: **Location:** Outlet end.

Extent of blockage.: Equal to or less than 20%.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank N/A

Pipe is not metal.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Pipe Alignment

Rank 1

Pipe well aligned.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 76 is 910 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	910 mm	0.0%	910 mm	0.0%
5.00 m	910 mm	0.0%	910 mm	0.0%
10.00 m	910 mm	0.0%	910 mm	0.0%
15.00 m	910 mm	0.0%	910 mm	0.0%
20.00 m	910 mm	0.0%	910 mm	0.0%
24.50 m	910 mm	0.0%	910 mm	0.0%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Reserve Road facing west.



Photo 2 - Reserve Road facing east.



Photo 3 - Outlet guardrail.



Photo 4 - Inlet embankment.



Photo 5 - Outlet embankment.



Photo 6 - Inlet overview.



Photo 7 - Outlet overview.



Photo 8 - Upstream channel view.



Photo 9 - Downstream channel view.



Photo 10 - Upstream pipe alignment and shape.



Photo 11 - Downstream pipe alignment and shape.



Photo 12 - V-1: Endoscope camera placed in the probe hole showing void.

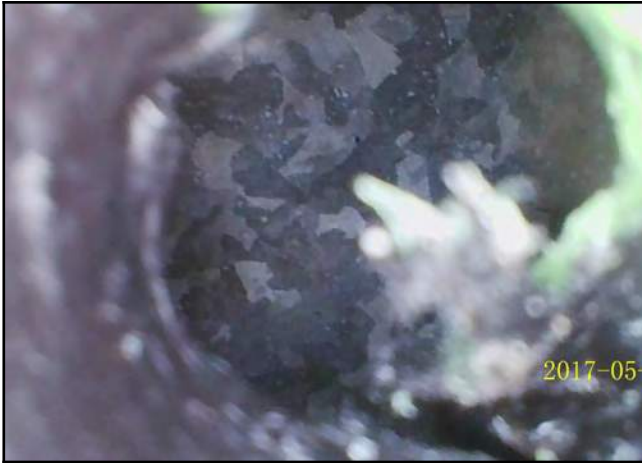


Photo 13 - V-1: Endoscope camera placed in the probe hole showing void.

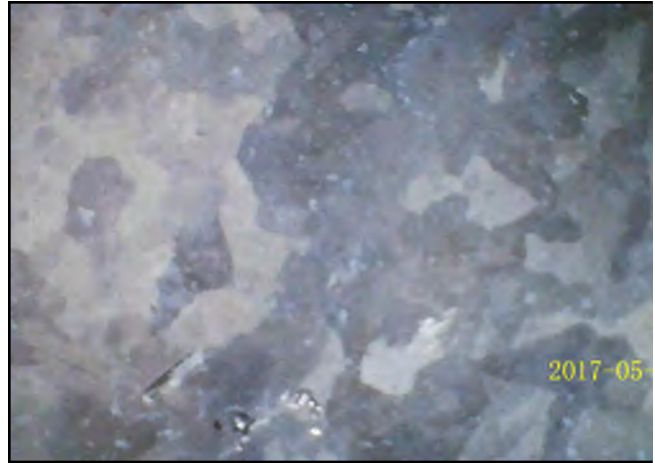


Photo 14 - V-1: Endoscope camera placed in the probe hole showing void.

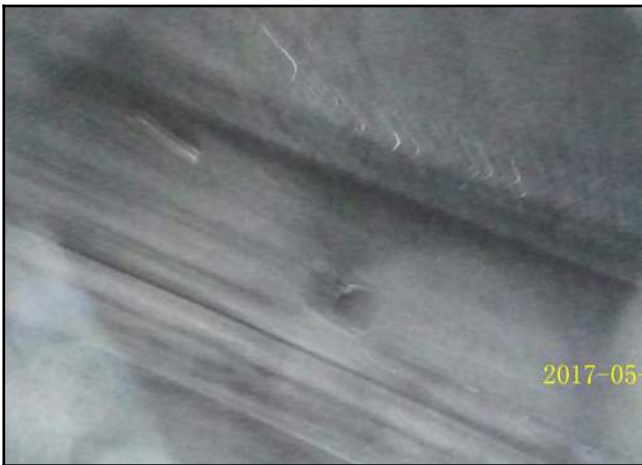


Photo 15 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 16 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 17 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 18 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 19 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 20 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 21 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 22 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 23 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 24 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 25 - V-4: Endoscope camera placed in the probe hole showing void.

The asset 76 located on Reserve Road in Sudbury County, consists of a previously rehabilitated culvert by means of Sliplined High Density Polyethylene (HDPE) that has an approximate diameter of 0.91 m and length of 24.80 m. A visual inspection and inSight™ Lite assessment were performed at this site which found four (4) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in fair condition and performing as designed with no deficiencies noted. No shape deviations were identified within the pipe barrel.

The inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. This assessment required four (4) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected area.

As noted in V-1, V-2, V-3, and V-4, visible annular voids between the existing culvert and the sliplined HDPE were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at all locations. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing culvert and the Sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

77

Highway 556 in Algoma County

General Summary

The asset 77 located on Highway 556 in Algoma County, consists of a Sliplined spiral wound circular corrugated metal pipe (CMP) culvert. The asset is located at latitude 46° 48' 53.541" N, longitude 83° 44' 18.84" W. The dimensions of the asset were found to be approximately 2.72 m in diameter and 27.10 m in length. The asset has approximately 1.20 m of cover from the obvert to the road surface and flows generally north to south.

This pipe was part of a double pipe structure where two (2) parallel culverts were found at the same location. In order to provide unique identifiers for each adjacent pipe, they were labelled as asset 77 and asset 78. Considering each pipe's proximity and interdependence with one another, these assets ideally should be considered as a whole.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 4 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	77
County Name	Algoma County
GPS	46° 48' 53.541" N, 83° 44' 18.84" W
Inspection Date	July 14, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.
Approved By	Steven Godbout, B.Sc.Eng.

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

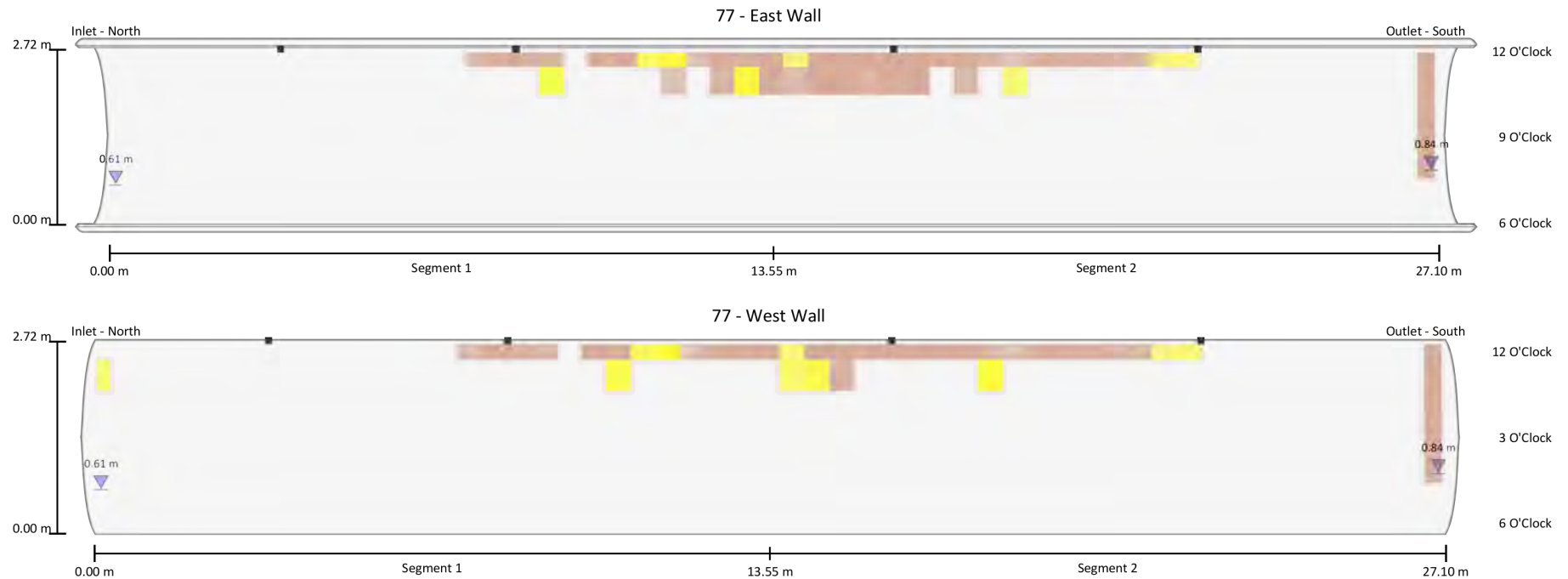
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

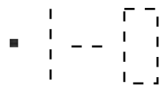
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

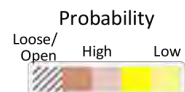
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

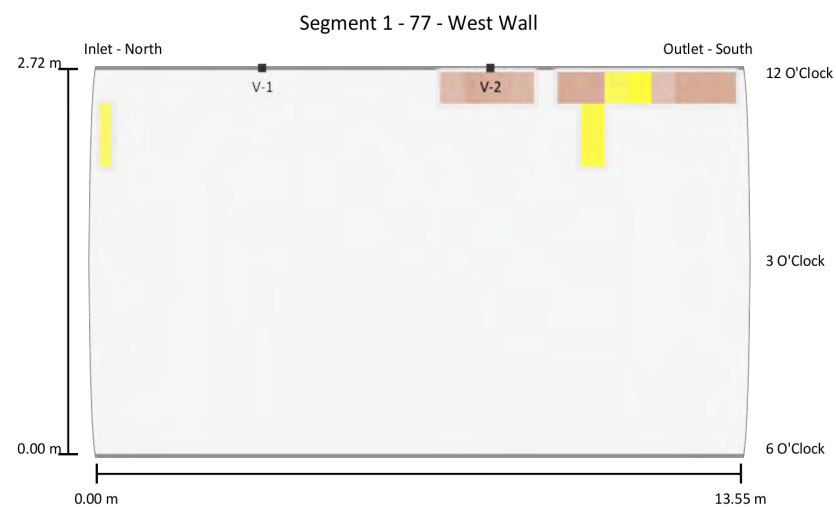
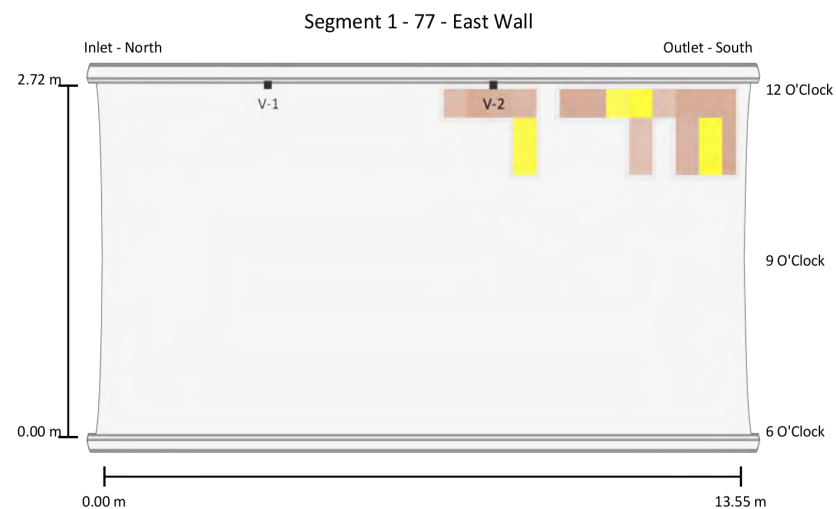


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	3.50 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.
V-2	8.30 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.

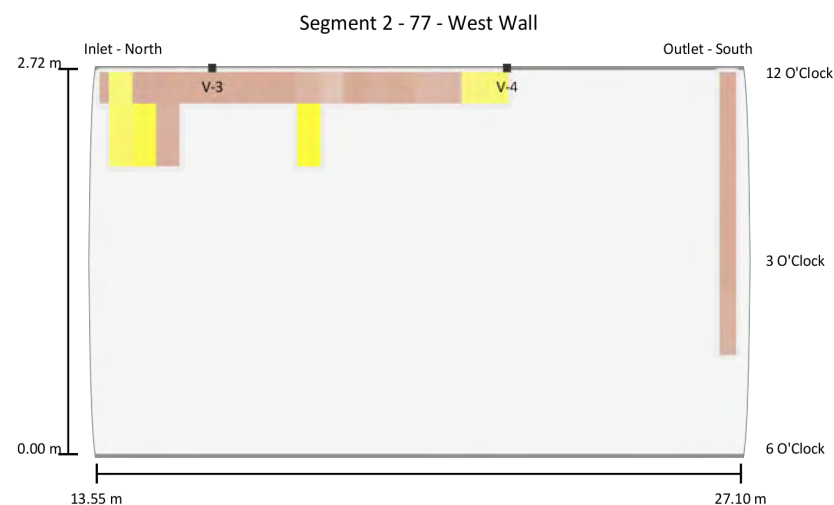
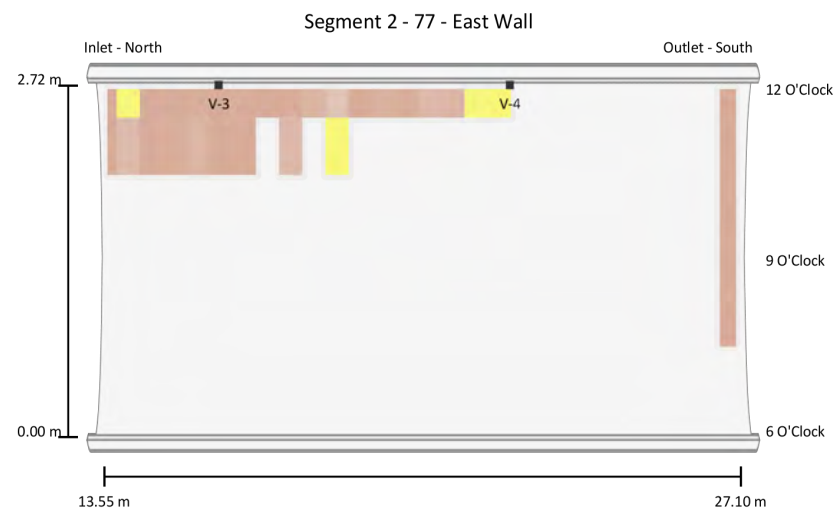
Acoustic Anomalies

X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

X	Clock	Scan ID	Verdict
No BCT images included.			

Segment 2



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-3	16.00 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-4	22.20 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
----	----	---------	---------

No acoustic anomalies found.



InSight™ BCT Images



X	Clock	Scan ID	Verdict
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No BCT images included.

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement	Rank N/A
No pavement on roadway.	
	
Photo 1 - Highway 556 facing east.	Photo 2 - Highway 556 facing west.

Guardrail	Rank 2
Inlet guardrail has minor slack in wire.	
Inlet guardrail.: Present.	
Outlet guardrail.: Present.	
	
Photo 3 - Inlet guardrail.	Photo 4 - Outlet guardrail.

Embankment

Rank 2

Inlet Embankment

- Rip-Rap stabilizing embankment present.

Outlet Embankment

- Erosion channel(s) present: **Frequency:** 1 channel; **Severity:** Very severe (> 300 mm (12 in) Width).
- Rip-Rap stabilizing embankment present.



Photo 5 - Erosion channel on the outlet embankment measuring approximately 430 mm in width.



Photo 6 - Inlet embankment.



Photo 7 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 8 - Inlet overview.



Photo 9 - Outlet overview.

Waterway Blockage

Rank 2

Some large boulders found throughout the pipe invert.

- Streambed material present: **Location:** Within pipe barrel.; X1: 5.00 m; X2: 20.00 m

Extent of blockage.: Equal to or less than 20%.



Photo 10 - Upstream channel view.



Photo 11 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank 1

No corrosion or rust evident on the pipe wall, no damage or discoloration of the coating.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Pipe Alignment

Rank 1

Pipe well aligned.



Photo 12 - Upstream pipe alignment and shape.



Photo 13 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 77 is 2720 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	2720 mm	0.0%	2720 mm	0.0%
5.00 m	2720 mm	0.0%	2720 mm	0.0%
10.00 m	2720 mm	0.0%	2720 mm	0.0%
15.00 m	2720 mm	0.0%	2720 mm	0.0%
20.00 m	2720 mm	0.0%	2720 mm	0.0%
27.00 m	-	-	-	-

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 556 facing east.



Photo 2 - Highway 556 facing west.



Photo 3 - Inlet guardrail.



Photo 4 - Outlet guardrail.



Photo 5 - Erosion channel on the outlet embankment measuring approximately 430 mm in width.



Photo 6 - Inlet embankment.



Photo 7 - Outlet embankment.



Photo 8 - Inlet overview.



Photo 9 - Outlet overview.



Photo 10 - Upstream channel view.



Photo 11 - Downstream channel view.



Photo 12 - Upstream pipe alignment and shape.

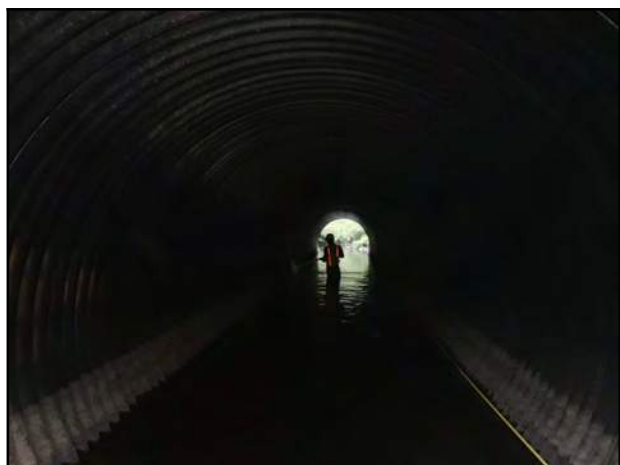


Photo 13 - Downstream pipe alignment and shape.

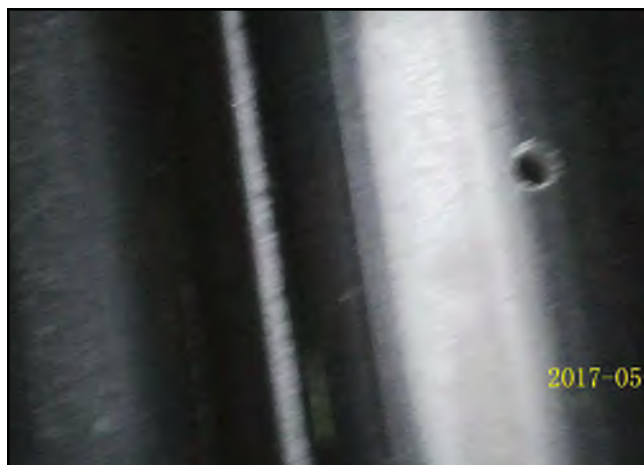


Photo 14 - V-1: Endoscope camera placed in the probe hole showing no void.



Photo 15 - V-1: Endoscope camera placed in the probe hole showing no void.

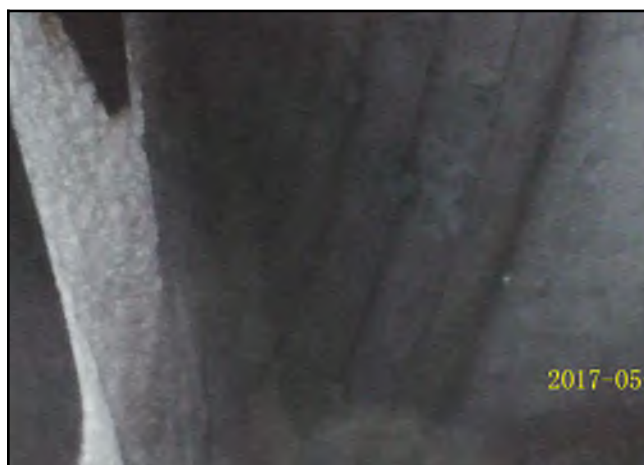


Photo 16 - V-2: Endoscope camera placed in the probe hole showing void.

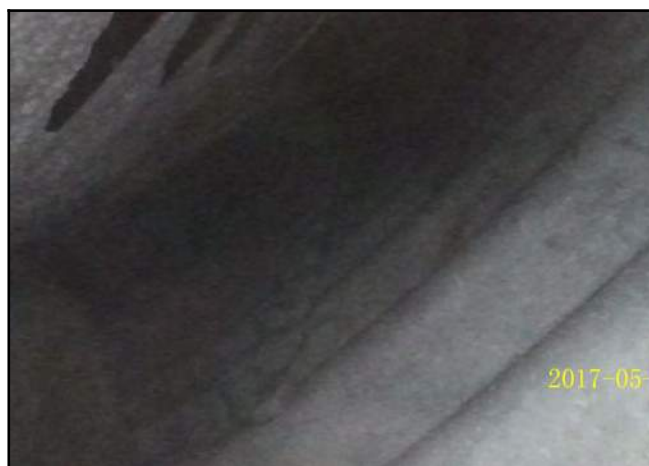


Photo 17 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 18 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 19 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 20 - V-3: Endoscope camera placed in the probe hole showing void.



Photo 21 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 22 - V-4: Endoscope camera placed in the probe hole showing void.

The asset 77 located on Highway 556 in Algoma County, consists of a previously rehabilitated culvert by means of Sliplined spiral wound circular corrugated metal pipe (CMP) that has an approximate diameter of 2.72 m and length of 27.10 m. A visual inspection and inSight™ Lite assessment were performed at this site which found four (4) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

This pipe was part of a double pipe structure where two (2) parallel culverts were found at the same location. In order to provide unique identifiers for each adjacent pipe, they were labelled as asset 77 and asset 78. Considering each pipe's proximity and interdependence with one another, these assets ideally should be considered as a whole.

The culvert was found to be in fair condition and performing as designed with no major deficiencies noted. No shape deviations were identified within the pipe barrel.

The inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. This assessment required four (4) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected area.

As noted in V-2, V-3, and V-4, visible annular voids between the existing and sliplined culverts were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at all locations. V-1 was recorded as a location of no void (control point). Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing culvert and the Sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

78

Highway 556 in Algoma County

General Summary

The asset 78 located on Highway 556 in Algoma County, consists of a Sliplined spiral wound circular corrugated metal pipe (CMP) culvert. The asset is located at latitude 46° 48' 53.588" N, longitude 83° 44' 18.105" W. The dimensions of the asset were found to be approximately 2.72 m in diameter and 27.10 m in length. The asset has approximately 1.20 m of cover from the obvert to the road surface and flows generally north to south.

This pipe was part of a double pipe structure where two (2) parallel culverts were found at the same location. In order to provide unique identifiers for each adjacent pipe, they were labelled as asset 77 and asset 78. Considering each pipe's proximity and interdependence with one another, these assets ideally should be considered as a whole.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 5 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	78
County Name	Algoma County
GPS	46° 48' 53.588" N, 83° 44' 18.105" W
Inspection Date	July 14, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.
Approved By	Steven Godbout, B.Sc.Eng.

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

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The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

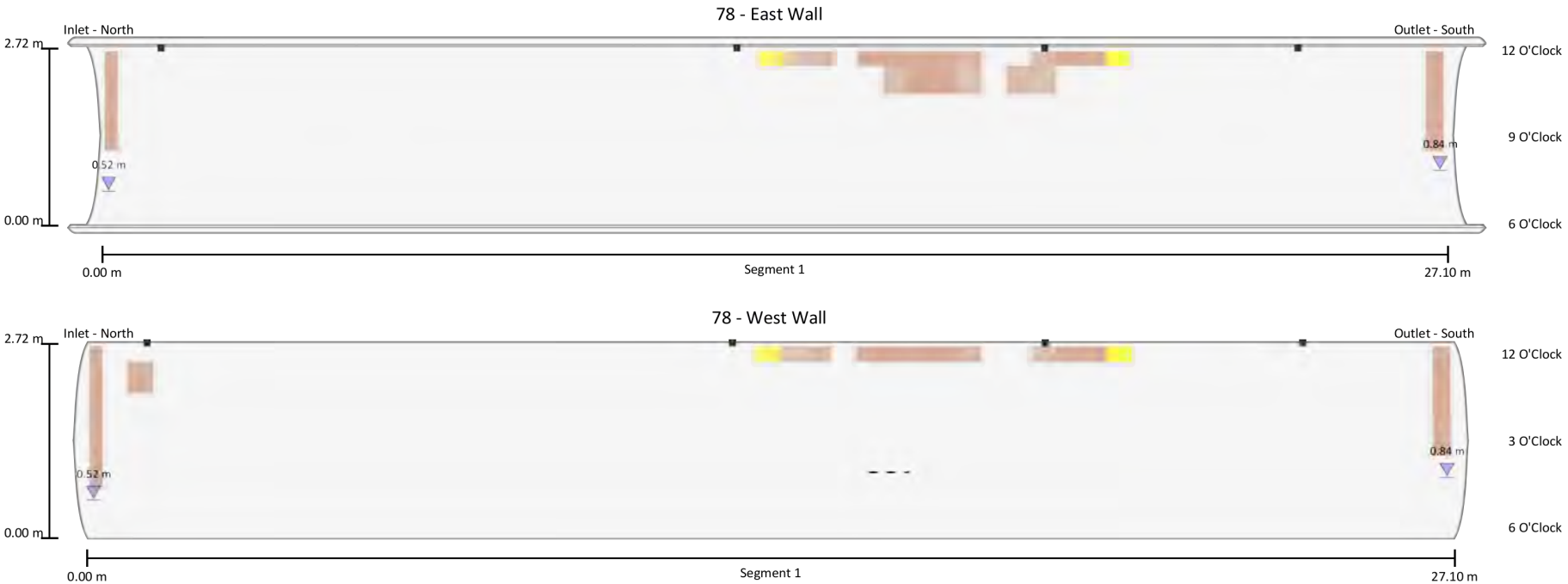
- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

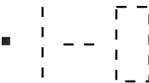
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

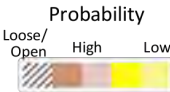
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Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

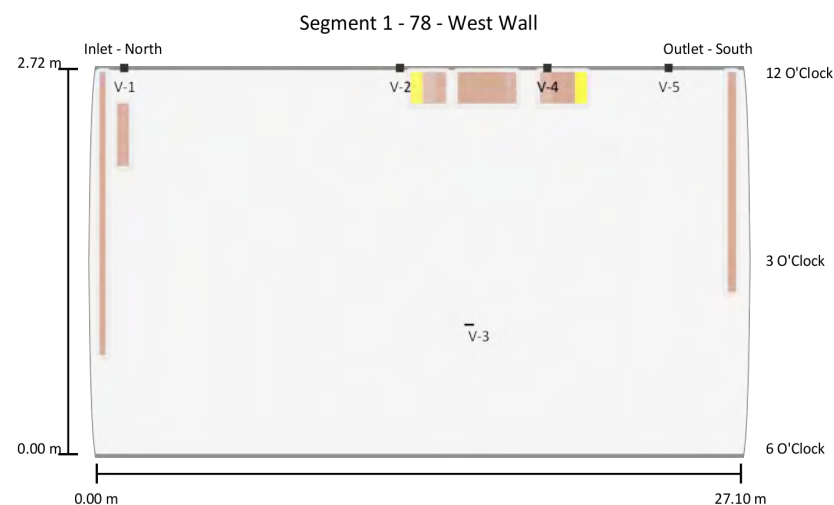
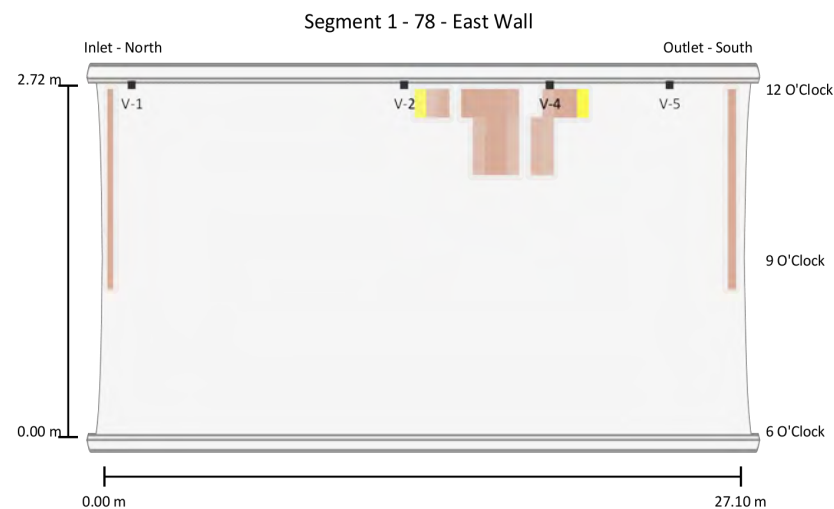


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators
InSight™ BCT Images

Acoustic Anomalies
InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.20 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-2	12.80 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-3	15.50 m	16.30 m	04:00	04:00	Minor dents protruding approximately 15 mm.
V-4	19.00 m	-	12:00	-	Endoscope camera placed in the probe hole showing void.
V-5	24.10 m	-	12:00	-	Endoscope camera placed in the probe hole showing minor void.

Acoustic Anomalies



X1	X2	Clock 1	Clock 2
No acoustic anomalies found.			

InSight™ BCT Images

X	Clock	Scan ID	Verdict
No BCT images included.			

The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement	Rank N/A
No pavement on roadway.	
	
Photo 1 - Highway 556 facing east.	Photo 2 - Highway 556 facing west.

Guardrail	Rank 2
Inlet guardrail has minor slack in wire.	
Inlet guardrail.: Present.	
Outlet guardrail.: Present.	
	
Photo 3 - Inlet guardrail.	Photo 4 - Outlet guardrail.

Embankment

Rank 2

Inlet Embankment

- Rip-Rap stabilizing embankment present.

Outlet Embankment

- Erosion channel(s) present: **Frequency:** 1 channel; **Severity:** Very severe (> 300 mm (12 in) Width).
- Rip-Rap stabilizing embankment present.



Photo 5 - Erosion channel on the outlet embankment measuring approximately 430 mm in width.



Photo 6 - Inlet embankment.



Photo 7 - Outlet embankment.

Headwall

Rank N/A

Inlet Headwall: No headwall present.

Outlet Headwall: No headwall present.



Photo 8 - Inlet overview.



Photo 9 - Outlet overview.

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 10 - Upstream channel view.



Photo 11 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank 1

No corrosion or rust evident on the pipe wall, no damage or discoloration of the coating.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

Shape, Dents, and Localized Damage

Rank 2

- Dent(s) present on the pipe wall: **Severity:** Light (< 25 mm (1 in) Depth).

Pipe Alignment

Rank 1

Pipe well aligned.



Photo 12 - Upstream pipe alignment and shape.



Photo 13 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 78 is 2720 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	2720 mm	0.0%	2720 mm	0.0%
5.00 m	2720 mm	0.0%	2720 mm	0.0%
10.00 m	2720 mm	0.0%	2720 mm	0.0%
15.00 m	2720 mm	0.0%	2720 mm	0.0%
20.00 m	2720 mm	0.0%	2720 mm	0.0%
27.00 m	2720 mm	0.0%	2720 mm	0.0%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Highway 556 facing east.



Photo 2 - Highway 556 facing west.



Photo 3 - Inlet guardrail.



Photo 4 - Outlet guardrail.



Photo 5 - Erosion channel on the outlet embankment measuring approximately 430 mm in width.



Photo 6 - Inlet embankment.



Photo 7 - Outlet embankment.



Photo 8 - Inlet overview.



Photo 9 - Outlet overview.



Photo 10 - Upstream channel view.



Photo 11 - Downstream channel view.



Photo 12 - Upstream pipe alignment and shape.



Photo 13 - Downstream pipe alignment and shape.



Photo 14 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 15 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 16 - V-1: Endoscope camera placed in the probe hole showing void.



Photo 17 - V-2: Endoscope camera placed in the probe hole showing void.

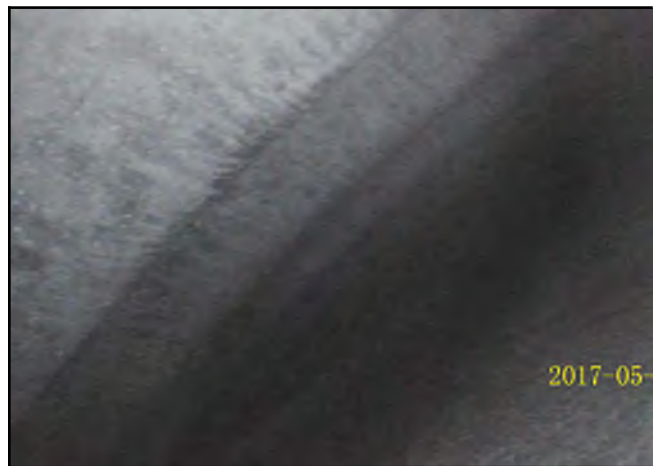


Photo 18 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 19 - V-2: Endoscope camera placed in the probe hole showing void.



Photo 20 - V-3: Minor dents protruding approximately 15 mm.

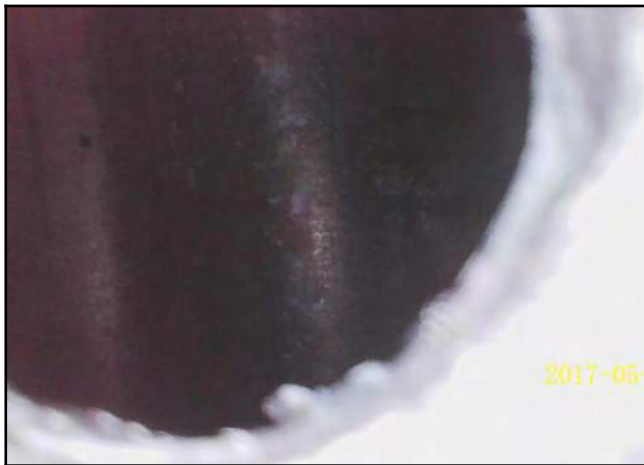


Photo 21 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 22 - V-4: Endoscope camera placed in the probe hole showing void.

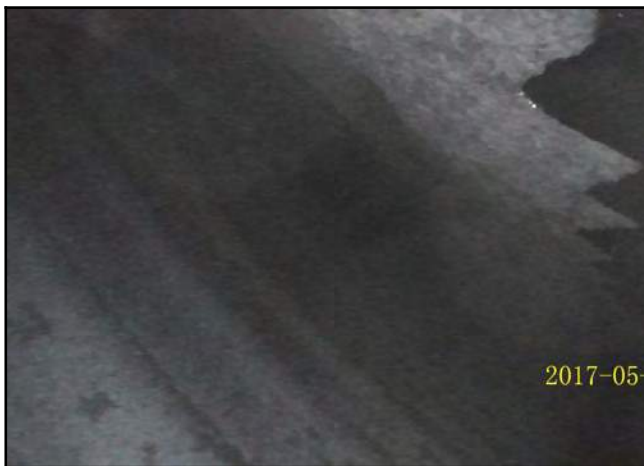


Photo 23 - V-4: Endoscope camera placed in the probe hole showing void.



Photo 24 - V-5: Endoscope camera placed in the probe hole showing minor void.

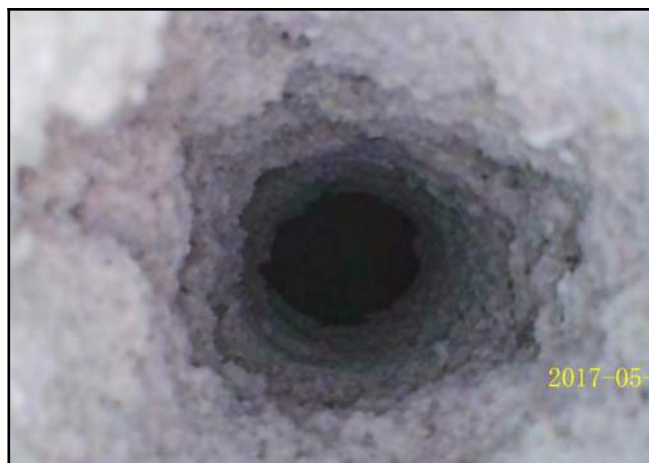


Photo 25 - V-5: Endoscope camera placed in the probe hole showing minor void.

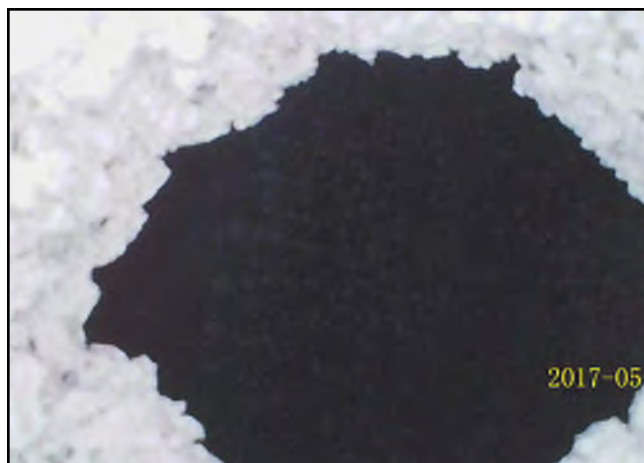


Photo 26 - V-5: Endoscope camera placed in the probe hole showing minor void.

The asset 78 located on Highway 556 in Algoma County, consists of a previously rehabilitated culvert by means of Sliplined spiral wound circular corrugated metal pipe (CMP) that has an approximate diameter of 2.72 m and length of 27.10 m. A visual inspection and inSight™ Lite assessment were performed at this site which found five (5) visual indicators and various inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

This pipe was part of a double pipe structure where two (2) parallel culverts were found at the same location. In order to provide unique identifiers for each adjacent pipe, they were labelled as asset 77 and asset 78. Considering each pipe's proximity and interdependence with one another, these assets ideally should be considered as a whole.

The culvert was found to be in fair condition and performing as designed, however, one deficiency was noted. The visual inspection identified one (1) visual indicator, V-3, which consisted of minor dents protruding approximately 15 mm.

No shape deviations were identified within the pipe barrel.

The inSight™ Lite assessment did identify numerous areas of potential void within the annular space between the existing and sliplined culverts. This assessment required four (4) probe holes at areas of high potential void. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected area.

As noted in V-1, V-2, V-4, and V-5, visible voids were recorded at each probe hole location, confirming the inSight™ Lite anomalous regions at all locations. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, it is recommended that the areas with confirmed annular voids between the existing culvert and the sliplined HDPE be injected with grouting material approved by the design engineer. This will ensure the supporting soil structure remains stable when the host culvert fully deteriorates. This can be accomplished by injecting grout directly in the center of the specific area and drilling overflow ports to ensure the product has reached the desired location. Locations of the captured probe holes are indicated by the distance from the inlet, as well as the clock position, and should be referenced during the injections. The SoilSight™ Pipe Map should also be utilized to help estimate the material volumes required to complete the repair. Please refer to the SoilSight™ Pipe Map and segment views for the exact locations of the probe holes.

Technical recommendations, as well as cost estimates, can be provided upon request.



SoilSight™ Condition Assessment

MTO 2020

80

Highway 401 in Ajax County

General Summary

The asset 80 located on Highway 401 in Ajax County, consists of a sliplined multi-plate circular corrugated metal pipe (CMP) culvert. The asset is located at latitude 43° 50' 53.525" N, longitude 79° 2' 41.803" W. The dimensions of the asset were found to be approximately 3.20 m in diameter and 97.10 m in length. The asset has approximately 4.00 m of cover from the obvert to the road surface and flows generally north to south.

Inversa Systems performed an in depth condition assessment of this asset to aid in life cycle optimization.

Details of this work are contained within this report; a summary is as follows:

- 4 visual indicators were located
- No acoustic anomalies were identified
- InSight™ Lite anomalies were identified
- No inSight™ BCT scans were taken
- Outcome: Continue Monitoring

Asset ID	80
County Name	Ajax County
GPS	43° 50' 53.525" N, 79° 2' 41.803" W
Inspection Date	July 25, 2020
Written By	Joey Stafford, Field Technician
Reviewed By	Zackarie Nowlan, Tech.
Approved By	Steven Godbout, B.Sc.Eng.

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Technical Explanation of Pipe Map Protocol

The entire culvert inspection is captured in the soilSight™ Pipe Map found in the following pages. It shows the asset in its entirety and displays the following collected data:

- Visual indicators
- Acoustic anomalies
- InSight™ BCT locations / results
- InSight™ Lite screening
- Water level
- Pipe dimensions

Sections within each asset that contain BCT image locations, inSight™ Lite screening, acoustic anomalies or visual indicators are displayed on a separate Segmented soilSight™ Pipe Map, which provides a more detailed view. The purpose of this level of detail is to define the exact location of all acoustic anomalies, visual indicators, inSight™ Lite locations, and BCT locations for future reference, deterioration trending, rehabilitation efforts and will allow detailed measurements to be used for maintenance, repairs or rehabilitation planning. The number of segments is at the discretion of the report writer and is based on the number of deficiencies discovered. If no repairs are required, measurements should be used to trend deterioration from one inspection cycle to another.

The X-coordinates are measured relative to the pipe inlet. The Y-coordinates are defined by a clock position with the invert being 6 o'clock, the obvert being 12 o'clock, the left springline being 9 o'clock and the right springline being 3 o'clock with the Inversa field inspector oriented facing downstream from the inlet to outlet (with the inlet at their back).

Acoustic Assessment

The purpose of the acoustic assessment or “knock test” is to determine possible locations (not severity) of suspected voids in the pipe's supporting soil and to aid in targeting and prioritization of anomaly imaging with BCT. A detailed knock test is performed at every second corrugation (approximately every 15-20 cm (6-8 in)) on both sides of the pipe, at five relative elevations: waterline, pipe springline, forty-five degrees above and below springline and obvert. Based on the acoustic and/or inSight™ Lite screening, the soilSight™ Pipe Map is generated to guide diagnostic imaging. Note: the terminal (unburied) ends of the pipe are considered transition zones and are not mapped unless voids are visible or extend beyond the transition zone.

Visual Inspection

The purpose of the visual inspection is to identify and locate deficiencies within the entire culvert structure. The visual inspection assesses ten (10) components of the structure, beginning from the road surface down through to the pipe barrel. Rankings are assigned a value between 1 and 5 for each component, based on pre-determined criteria.

Inspector field notes are also recorded for each of the ten (10) components. Specific visual indicators are flaws found within the pipe barrel that have a location associated with them. These visual anomalies are reflected in the soilSight™ Pipe Map in relation to the entire structure. Examples are separated joints, bolt-hole tears, through-wall corrosion, etc.

InSight™ BCT Images

BCT analysis is undertaken after the visual inspection, the acoustic and the inSight™ Lite screening only if warranted. Once an acoustic anomaly is identified, a more thorough “knock test” is performed within the anomaly to find the precise location for BCT deployment. Typically, BCT scans are captured within the acoustic anomalies and/or inSight™ Lite regions. Visual indicators can also dictate scan locations if they demonstrate evidence of soil loss in a specific area. Once all scans are captured for an asset, they are uploaded to the InSight™ portal service where the images are processed, and voids are quantified.

InSight™ Lite Screening

The purpose of the inSight™ Lite screening is to identify areas of potential low soil density / void behind the culvert wall. Once anomalous areas are identified through the inSight™ Lite screening, the asset owner can then validate and quantify these regions through inSight™ BCT imaging.

A detailed soil density measurement is collected every 0.5 m to 1.0 m (20 to 40 in) increment inside the pipe wall, taken every available clock position. Once all inSight™ Lite measurements are captured, they are uploaded to the soilSight™ portal where the measurements are processed, and potential anomalous locations are identified within the pipe map. The regions are categorized based on their probability to contain voids, from low probability being yellow to high probability being brown.

Regardless of whether inSight™ BCT imaging was completed, inSight™ Lite data sets should be used on subsequent inspections to trend soil density changes and aid in prioritization of which assets warrant further assessment, ultimately leading towards a more comprehensive asset management program.

Visual Appraisal Results

Following the inSight™ BCT Validation Results section (if applicable) is the Visual Appraisal Results, where ten components of the structure are ranked between 1 and 5. Each rank, for each component, has a precise definition associated with it, based on best practices and industry standards. The criteria are defined in Inversa’s soilSight™ Standard Operating Procedure (SOP), available upon request.

Each 1 to 5 ranking has an associated condition description, used for reporting purposes, as follows:

- Excellent (1)
- Good (2)
- Fair (3)
- Poor (4)
- High Probability of Failure (5)

Shape Deviation

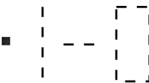
Horizontal and vertical measurements are taken in the field at even intervals along the culvert. This information is used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement. A corresponding percentage difference from expected horizontal and vertical dimensions are provided in the Shape Deviation table.

Conclusion and Recommendations

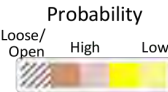
Conclusion and Recommendations are provided with any potential maintenance and/or rehabilitation recommendations including any estimated maintenance costs. The focus of the conclusion is mainly limited to components with a ranking of 3 or above unless specific concerns need to be addressed. If a detailed rehabilitation plan is warranted, a separate Asset Rehabilitation Plan is provided.



Acoustic Anomalies are designated as rectangles and are assigned an ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Visual Indicators are shown as black squares (isolated defects), dashed lines (linear defects) or rectangles with dashed lines (defects with a surface area), depending on the flaw type, and assigned a corresponding ID number. The X and Y position is recorded and displayed in the table for the corresponding pipe segment. Photos are included in the visual assessment section.



InSight™ Lite Anomalies are regions detected by the InSight™ Lite scanner which may contain voids or other low density material. The regions are categorized in terms of their probability to contain actual soil voids, from low probability being yellow to high probability being brown. The unburied ends of the culvert are represented as rectangles with black hash marks.

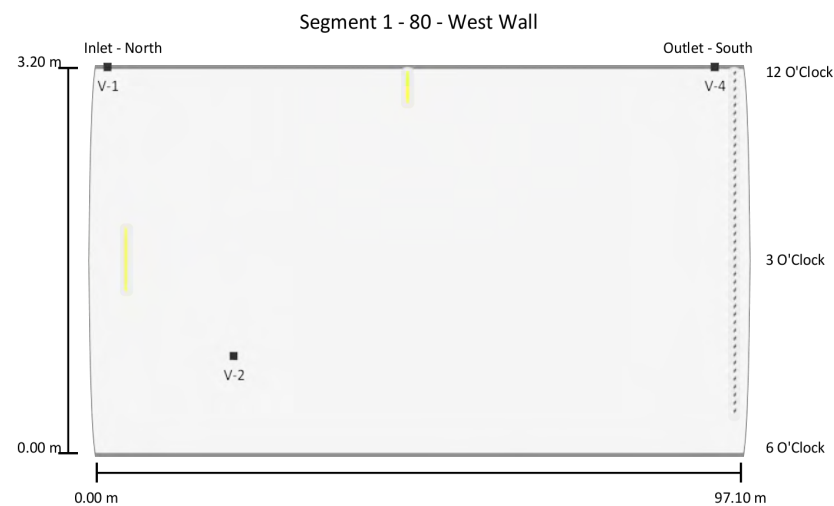
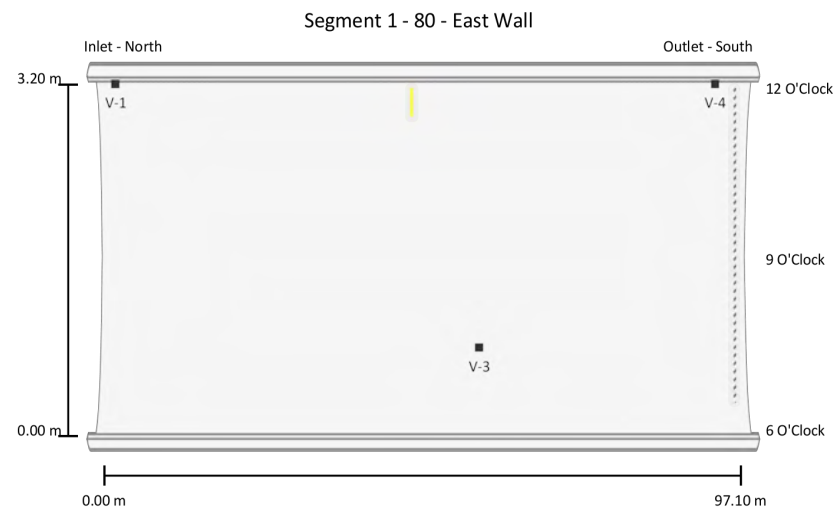


InSight™ BCT Images are assigned an ID number and are represented as red diamonds. Once a scan is captured, it is verified as void or solid backfill. The X and Y position is recorded and displayed in the table for the corresponding pipe segment.



Waterline Marks indicate the level of water in the pipe at the time of inspection.

Segment 1



Visual Indicators

InSight™ BCT Images

Acoustic Anomalies

InSight™ Lite Anomalies

Visual Indicators

	X1	X2	Clock 1	Clock 2	Comments
V-1	1.80 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.
V-2	20.80 m	-	04:30	-	Endoscope camera placed in the probe hole showing no void.
V-3	57.30 m	-	07:30	-	Endoscope camera placed in the probe hole showing no void.
V-4	93.30 m	-	12:00	-	Endoscope camera placed in the probe hole showing no void.

Acoustic Anomalies

X1	X2	Clock 1	Clock 2
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No acoustic anomalies found.

InSight™ BCT Images

X	Clock	Scan ID	Verdict
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No BCT images included.


The visual appraisal assesses ten Components.

Each "Component" is ranked 1 through 5 with 1 being "excellent" and 5 being "high probability of failure". "Ranks" are based on measurable field observations for each "Component" evaluated and based on industry standards where available. "Comments" are provided based on visual field notes as applicable.

Pavement	Rank N/A
Not included in scope of work	

Guardrail	Rank N/A
Not included in scope of work	

Embankment	Rank N/A
Not included in scope of work	

Headwall	Rank 2
<p>Inlet Headwall: Concrete Headwall.</p> <ul style="list-style-type: none"> Crack(s) present: Frequency: 2 - 5; Severity: Hair Line (< 0.1 mm (0.004 in) Width). <p>Outlet Headwall: No headwall present.</p>	
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Photo 1 - Inlet overview.</p> </div> <div style="text-align: center;">  <p>Photo 2 - Outlet overview.</p> </div> </div>	

Waterway Blockage

Rank 1

No waterway blockages found.



Photo 3 - Upstream channel view.



Photo 4 - Downstream channel view.

Scour

Rank 1

No scour evident.

Corrosion and Coatings

Rank 1

No corrosion or rust evident on the pipe wall, no damage or discoloration of the coating.

Cracks, Seams, and Joints

Rank 1

No cracks. Seams and joints intact.

- Water intrusion present.
- Water intrusion at seam(s) present.



Photo 5 - Level 1 water infiltration evident at seam bolt hole locations throughout the entire culvert.

Shape, Dents, and Localized Damage

Rank 1

No dents or localized damage found.

Maximum shape deviation of approximately -0.9%.

Pipe Alignment

Rank 1

Pipe well aligned.



Photo 6 - Upstream pipe alignment and shape.



Photo 7 - Downstream pipe alignment and shape.

Shape deviation measurements are used to examine the structure's current deformation. Deformation may be caused by construction or deterioration. This information is intended to be used to trend future changes of pipe geometry indicating possible instability, unequal loading, or soil movement.

A horizontal and vertical measurement of the pipe's dimension is taken at even intervals along the pipe. A corresponding percentage difference from the expected horizontal and vertical design dimensions is also calculated.

The expected design diameter for 80 is 3200 mm.

Distance from Inlet	Horizontal Diameter	Horizontal Deviation	Vertical Diameter	Vertical Deviation
0.00 m	3220 mm	0.6%	3200 mm	0.0%
20.00 m	3170 mm	-0.9%	3210 mm	0.3%
40.00 m	3170 mm	-0.9%	3200 mm	0.0%
60.00 m	3200 mm	0.0%	3180 mm	-0.6%
80.00 m	3220 mm	0.6%	3170 mm	-0.9%
97.00 m	3220 mm	0.6%	3220 mm	0.6%

Note: Vertical deviation measurements may be missing due to sediment or debris build up.

Pertinent photos are included below to show site conditions and features of interest.



Photo 1 - Inlet overview.



Photo 2 - Outlet overview.



Photo 3 - Upstream channel view.



Photo 4 - Downstream channel view.



Photo 5 - Level 1 water infiltration evident at seam bolt hole locations throughout the entire culvert.



Photo 6 - Upstream pipe alignment and shape.



Photo 7 - Downstream pipe alignment and shape.



Photo 8 - V-1: Endoscope camera placed in the probe hole showing no void.



Photo 9 - V-1: Endoscope camera placed in the probe hole showing no void.

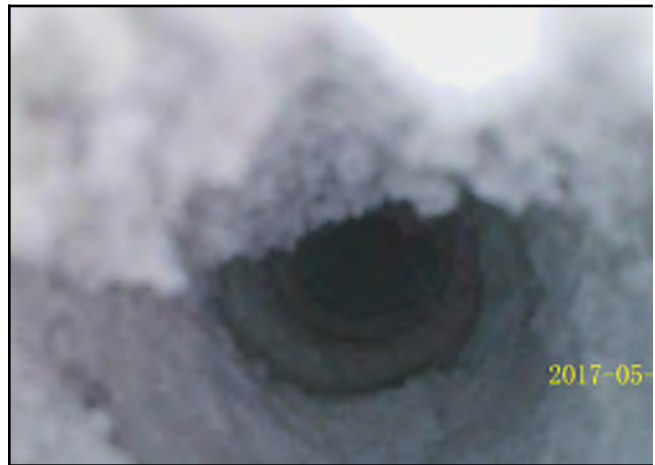


Photo 10 - V-2: Endoscope camera placed in the probe hole showing no void.



Photo 11 - V-3: Endoscope camera placed in the probe hole showing no void.



Photo 12 - V-4: Endoscope camera placed in the probe hole showing no void.

The asset 80 located on Highway 401 in Ajax County, consists of a previously rehabilitated culvert by means of sliplined multi-plate circular corrugated metal pipe (CMP) that has an approximate diameter of 3.20 m and length of 97.10 m. A visual inspection and inSight™ Lite assessment were performed at this site which found four (4) visual indicators and no inSight™ Lite anomalous regions inside the culvert. No BCT scans were completed on this asset.

The culvert was found to be in excellent condition and performing as designed with no major deficiencies identified. During the inspection, we observed level 1 water infiltration at bolt holes throughout the entire culvert, refer to Photo 5.

The deviation from expected design shape varied through the pipe with a maximum horizontal deviation of -0.9%, 20.00 m from the inlet and a maximum vertical deviation of -0.9%, 80.00 m from the inlet.

The inSight™ Lite assessment did not identify any areas of potential void within the annular space between the existing and Sliplined culverts. This assessment required four (4) probe holes at various locations within the pipe barrel. In addition to each hole being visually inspected, an endoscope inspection camera was utilized to provide images of the inspected area.

As noted in V-1, V-2, V-3 and V-4, no visible annular voids between the existing and Sliplined culverts. were recorded at each probe hole location, confirming the inSight™ Lite regions at these locations. Following the inspection, each hole was sealed with a silicone sealant.

Based on the findings, the annular space between the existing and Sliplined culverts was found to be well grouted. It is therefore recommended that the asset continues to be monitored at its current inspection intervals.



Appendix D.

Comparison of Remedial Options

Comparison of Grout-In-Place Culvert Lining Remedial Options

Option	Do Nothing	Monitoring	Supplemental Grouting
Advantages	No upfront cost.	Avoids upfront cost of supplemental grouting, but has periodic costs for monitoring.	Provides better structural support for liner. Significant reduction in risk/consequences associated with loss of soil around host pipe into voids between host pipe and liner.
Disadvantages	Decreased structural support for liner pipe. Previous studies suggest a decreased service life for ungrouted liners.	Previous studies suggest a decreased service life for ungrouted liners. Cost for monitoring. Performance issues likely not evident during monitoring until deficiencies (e.g. settlement of pavement structure) have developed.	Upfront cost to Ministry
Costs	Low	Moderate	Moderate
Risks/Consequences	Soil surrounding host pipe infiltrates void in annular space / settlement of highway and potential formation of sinkholes	Soil surrounding host pipe infiltrates void in annular space / settlement of highway and potential formation of sinkholes	None