City of Winnipeg – 8” & 12” Steel lines

Condition Assessment Report, Standard Analysis

PICA – Pipeline Inspection & Condition Analysis Corporation
(a subsidiary of Russell NDT Holdings Ltd.)

RFT ILI Tool

8-in Steel Assiniboine Park Siphon (Assiniboine Park-Conway St)

12-in Steel Munroe-Polson Siphon (Munroe Ave to Polson Ave)

Winnipeg, MB

PICA Project:
WPG 12-8007

Inspection Date:	December 3-9, 2012
Report Submission:	April 27, 2016 (Rev 1.3), March 4, 2013 (Rev 1.1)
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Report Revision:	1.3

The City of Winnipeg Pipelines

8-in Assiniboine Park Siphon (Assiniboine Park to Conway St)
12-in Munroe-Polson Siphon (Munroe Ave to Polson Ave)

Condition Assessment Report, Standard Analysis

Executive Summary

PICA Corporation (PICA), under contract with AECOM to inspect various pipelines for the City of Winnipeg, mobilized between December 3 and December 9, 2012. Successful inspections were performed on the 8-in Assiniboine Park Siphon (between Assiniboine Park and Conway Street) and on the 12-in Munroe-Polson Siphon between Munroe and Polson Avenues. There were two other planned inspections that did not take place due to technical difficulties: the 24-in North Kildonan Feedermain and the 24-in St. James Interceptor Sewer Siphon. The North Kildonan Feedermain was not inspected due to restrictions in the pipeline and a buckled section of line not being supported by bedding, while the St. James Interceptor Sewer Siphon was not inspected due to safety concerns resulting from high night time flow rates.

This report documents PICA's RFT condition assessment results for the 8-in and 12-in inspections. The RFT analysis indicates the lines are in generally good condition –over half of the pipes in each line have a minimum wall thickness greater than 75% of nominal.

In the 8-in line, no pipes were found with a remaining wall thinner than 50% of nominal. The identified wall loss regions in the 8-in line were measured to have local remaining wall thicknesses ranging from 55% to 77% of nominal.

In the 12-in Munroe-Polson Siphon, a total of 22 wall loss regions were identified in 10 of 23 analyzed pipe sections. The wall loss regions have a local remaining wall thickness ranging from 24% to 85%. Eight (8) pipes (out of 23) were found with localized areas where the minimum wall is thinner than 50% of nominal.

As a supplement to this report, dig sheets were provided for two areas with the most severe wall loss regions, which are both located in the 12-in line. These regions span between Pipes 0030 to 0070 and Pipes 0150 to 0190.

A verification dig on the 12-in Munroe-Polson results was performed by AECOM on February 16, 2016 (*details can be found in AECOM's verification report that was issued on February 17, 2016*). The verification involved two defects in Pipe 0030, which were originally reported as 3% and 43% remaining wall at 31.48m and 31.27m respectively. The actual depths of these two defects were discovered to be 25% and 58% remaining wall respectively. While the reported longitudinal location of these two defects were found to be accurate in the field, the reported clock positions were discovered to be misreported by 90 degrees. As a result, PICA has revised its previously issued results for the 12-in line to account for this new information. The previously reported wall loss depths have been reduced by a scaling factor derived from the verification and all previously reported clock positions have been rotated by 90 degrees.

Figures 1 & 2 illustrate the distribution of localized wall loss expressed in percentage of remaining wall (Figure 1) and circumferential location (Figure 2) along the 8-in Assiniboine Park Siphon.

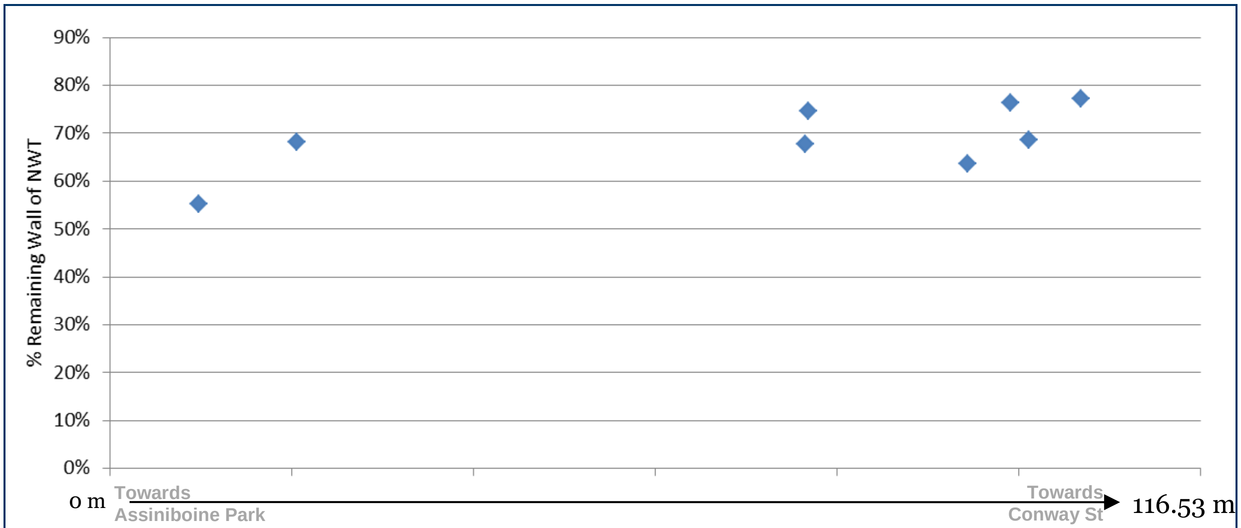


Figure 1: Distribution of local wall loss indications expressed in [%remaining wall of NWT] in pitting regions along the 8-in Assiniboine Park Siphon.

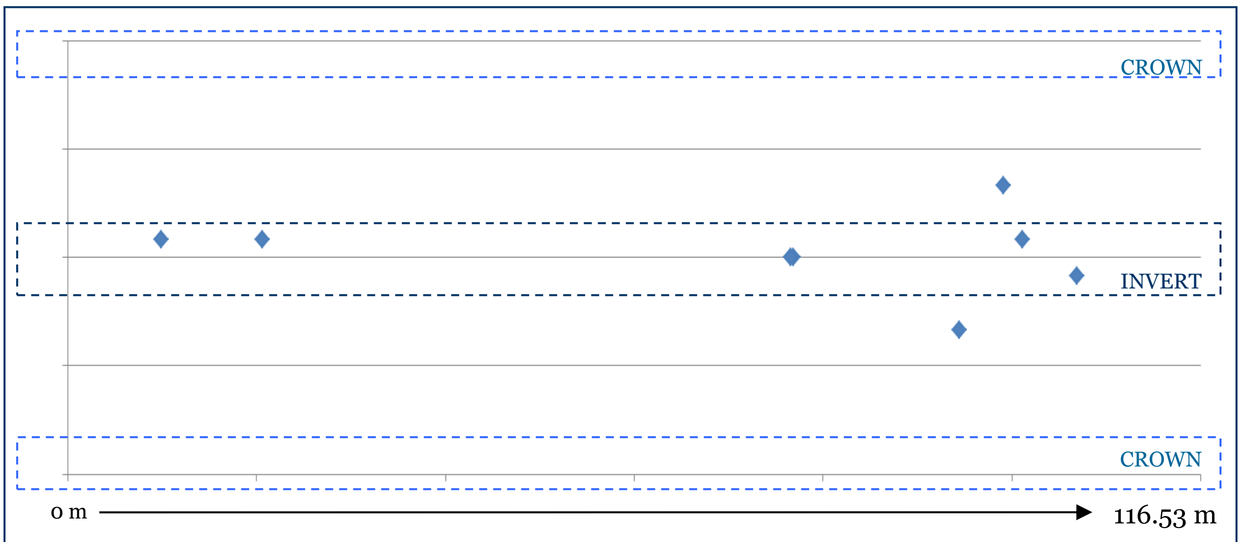


Figure 2: Circumferential distribution of pitting regions along the 8-in Assiniboine Park Siphon.

Figures 3 & 4 illustrate the distribution of localized wall loss expressed in percentage of remaining wall (Figure 3) and circumferential location (Figure 4) along the 12-in Munroe-Polson Siphon.

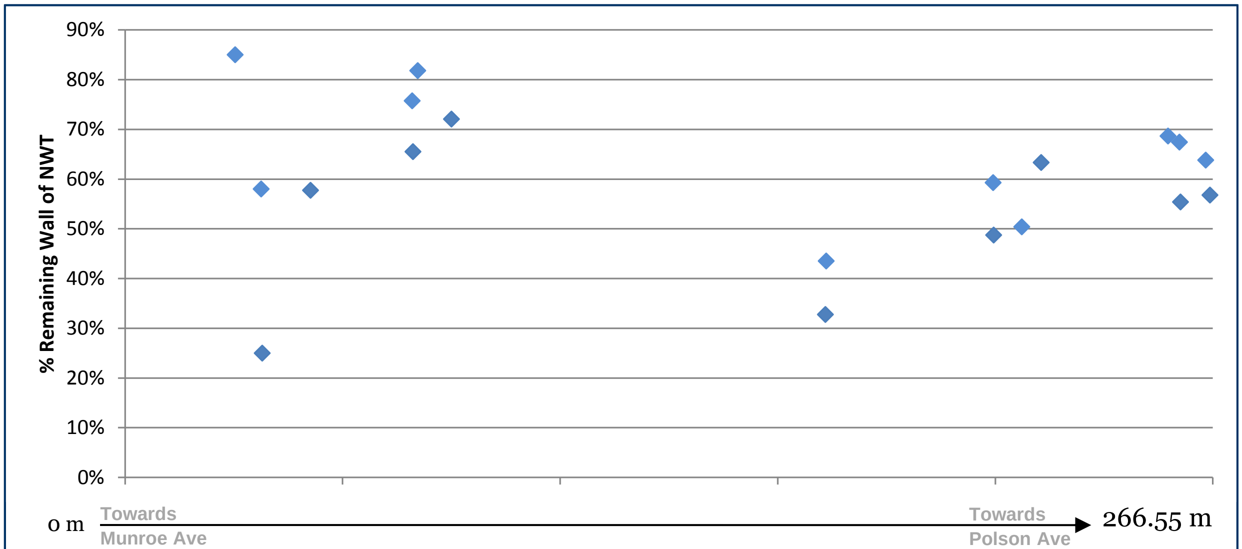


Figure 3: Distribution of local wall loss indications expressed in [%remaining wall of NWT] in pitting regions along the 12-in Munroe-Polson Siphon.

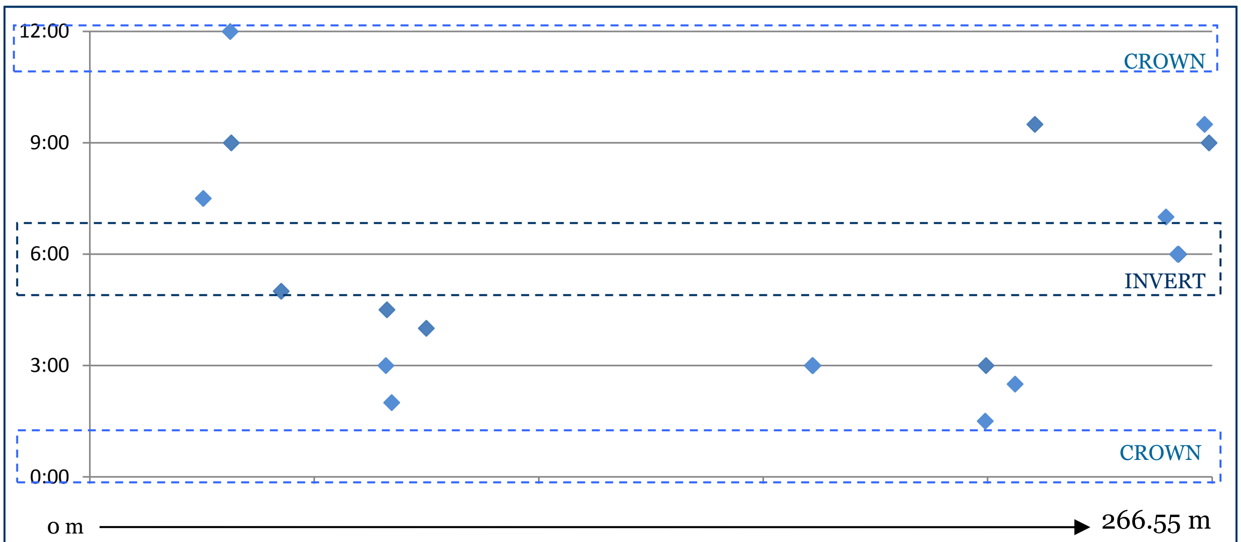


Figure 4: Circumferential distribution of pitting regions along the 12-in Munroe-Polson Siphon.

Table 1 summarizes the RFT inspection results for the 8-in Assiniboine Park Siphon and 12-in Munroe-Polson Siphon.

Table 1: Feature Indication Summary		
	8-in	**12-in**
Logged length (m)	107.90	248.45
***Scaled Inspected length (m)**	116.53	266.55
Number of pipe sections:	11	23
Number of analyzed pipe sections:	10	23
Average Wall Thickness (%NWT):	92%	97%
Number of pipes without localized wall loss indications:	5	13
Number of pipes with localized wall loss indications:	5	10
Number of wall loss indications	8	22
Number of pipes with Through Hole (TH) indications:	0	0

**Scaled Inspected lengths were based on distances obtained from the Plan and Profile drawings.*

Pipeline Background

The City of Winnipeg operates all of the pipelines presented in this report. Four sections namely, 8-in Assiniboine Park Siphon, 12-in Munroe-Polson Siphon, 24-in North Kildonan Feedermain and 24-St. James Interceptor Siphon were all selected for cleaning and inspection. PICA's See Snake technology was used to inspect the 8-in and 12-in sections. The remaining two sections were not inspected for reasons explained in the next section.

Table 2 provides basic details for each inspected line.

Table 2: Pipeline Information	
Client:	City of Winnipeg
Location:	Winnipeg, MB
Pipe Diameter:	8-in & 12-in
Year Installed:	8-in: 1965 12-in: 1964
Nominal Wall Thickness (NWT):	8-in: 6.35mm 12-in: 9.525mm
Material:	Steel (grade unknown)
Access:	8-in: Chambers near Assiniboine Park and Conway St 12-in: Chambers near Munroe Ave and Polson Ave
Internal Liner:	N/A
External Coatings:	N/A
CP:	None
Inspected Length:	8-in: 116.53 m 12-in: 266.55m
Break History:	N/A

NOTE: All information in these tables was provided by the client. Inspected Length represents the scaled distances based on the Plan and Profile drawings.

Inspection Details

See Snake Tool Description

PICA Corp's See Snake line of RFT tools are highly flexible tools that employ Remote Field Testing (RFT) technology for measuring pipe wall thickness. RFT technology works by detecting changes in an AC electromagnetic field generated by the tool that interacts with the metal in the encompassing pipe, becoming stronger in areas of metal loss. Refer to Appendix B for a more detailed explanation of RFT technology.

The tethered See Snake tools used in the inspection of the 8-in Assiniboine Park and 12-in Munroe-Polson Siphons (Figure 5) employ an articulated mechanical design that gives it flexibility to negotiate 90-degree short radius elbows. The hard diameter of the tool is significantly smaller than the ID of the pipe to allow for protrusions, lining and scale. Centralizers maintain a uniform annulus between the tool and the pipe.

The tool detects wall thinning caused by corrosion or erosion (both internal and external), as well as line features such as joint couplings, branches and elbows. The range is limited by the length of the wireline for tethered runs, and battery power for free swimming runs.

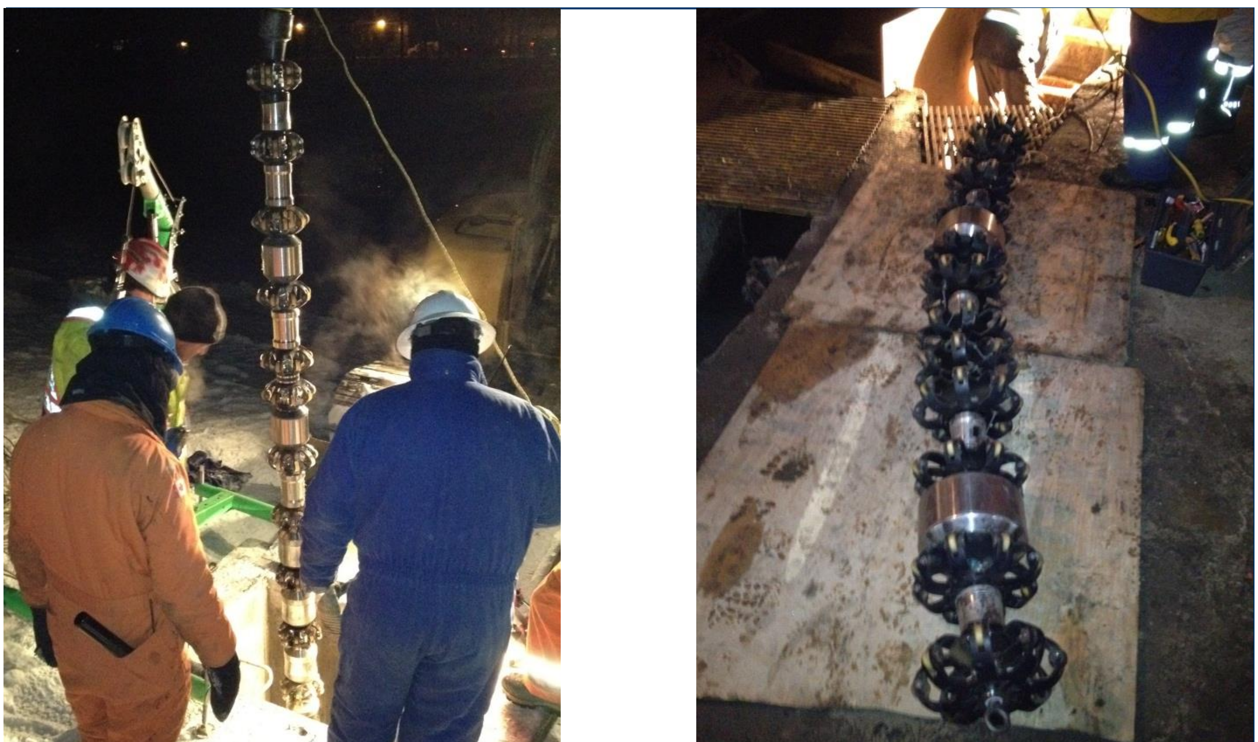


Figure 5: PICA's 8-in See Snake at the Conway St site (left) and the 12-in See Snake at the Polson Ave site (right)

Inspection Details

8-in Assiniboine Park

The 8-in Assiniboine Park Siphon that was inspected runs in a north/south direction. To provide access for the 8-in See Snake inspection tool, existing chambers located at the start and end of the siphon were used for the tethered inspection.

Two attempts were made to inspect the 8-in line. On December 4, the 8-in See Snake tool was launched on the north end of the siphon (near Conway St), and pulled with the cable-tugger equipment situated on the south end of the siphon (near Assiniboine Park). The inspection proceeded smoothly until a restriction was encountered at ~87m. It is suspected that a mitered 30 degree bend caused the restriction at this location. Numerous attempts were made to pull the See Snake past the restriction with no further progress. As a result, the first attempt concluded with an incomplete coverage of the target distance of 108m. On December 5, the 8-in line was re-inspected, this time launching the See Snake tool from Assiniboine Park. This second run was conducted successfully, with full coverage of the target distance.

12-in Munroe-Polson Siphon

The 12-in Munroe-Polson Siphon runs in an East/West direction. To provide access for the 12-in See Snake inspection tool, existing chambers located at the start and end of the siphon were used for the tethered inspection.

Prior to the 12-in See Snake launch, a gauge run was performed to confirm safe and clear passage for the tool. On December 3rd, the gauge pig was launched from the west end of the siphon, near Polson Ave, and pulled towards Munroe Avenue. At the end of gauge run, only minor deflections were observed indicating a relatively clear bore for the 12-in See Snake tool. During the RFT inspection, the 12-in See Snake tool was launched on the west end of the siphon (near Polson Ave) with the tether cable being pulled at the east end of the siphon (near Munroe Ave). The inspection proceeded smoothly with full coverage of the target distance achieved. Preliminary review of this first run data revealed substandard signal characteristics not fit for condition analysis. It was found that the initial run utilized a frequency setting that was unsuitable for the actual pipe specification and/or configuration, possibly relating to wall thickness, grade, pipe casing or close proximity of the neighboring 18-in line. It was suspected that the actual 12-in pipe specification and/or configuration may be different than what was provided to the PICA technicians. To resolve this situation, a second run utilizing an alternate inspection frequency was performed on December 4th. The RFT data collected during the second run was of significantly improved quality, and found to be suitable for analysis.

24-in North Kildonan & St. James Interceptor

Two other sections were planned for inspection: 24-in North Kildonan Feedermain and 24-in St. James Interceptor Sewer Siphon. These sections were not inspected due to various challenges encountered during the mobilizations.

On December 6 and 7, PICA attempted to inspect the 24-in North Kildonan Feedermain. On December 6, a proving foam pig equipped with a video camera was sent through the line from the East bank. Upon further review of the video recording obtained during the proving run, tubercles were discovered at girth welds and seam welds (Figure 6a). One recovered tubercle specimen sized 1.5”x1.0” (Figure 6b).

Figure 6a: A sample image of the tuberculation extent captured during PICA's foam pig proving run. The image was extracted from PICA's video recording footage of the proving run.

Figure 6b: Tubercle samples collected during the PICA's foam pig proving run.

The extent of tuberculation, in PICA's experience is not unusual and not necessarily indicative of poor line condition. Since the video showed that the liner in between the joints was generally in good shape, it was decided to continue the inspection effort. However, it was first necessary to remove the tuberculated rings and a lodged swab section from a Uni-Jet cleaning pig. Following the request of the City to retrieve the lodged Uni-Jet swab, several recovery efforts were made using customized PICA pigs to remove the lodged foam pig as well a lost PICA pen light camera. Unfortunately, none of the recovery runs were successful due in part to the requirement of not deploying any hard contact equipment that could damage the liner while keeping the (pull) forces on the wirelines low, so as not to further buckle the existing failure point. The City eventually decided to cancel inspection of this line, and replace it with a substitute line.

On December 9, an attempt was made to inspect the 24-in St. James Interceptor Sewer Siphon. This inspection also did not occur as the PICA crew found the working space within the launch chamber to be highly restrictive. In addition, fast flowing, knee-deep water within the chamber, made the area dangerous and challenging to work in.

Table 5 summarizes the details of the 8-in and 12-in line inspections.

Table 5: PICA Field Notes			
Lead Technician:	P. Ryhanen	**Technician(s):**	R. Asuncion, G. Bouchard, D. Burton, B. Knudson, M. Korz
8-in Assiniboine Park Siphon			
Survey Date(s)	December 4-5, 2012		
Arrive Site:	Dec 4: 16:00 Dec 5: 08:00	**Depart Site:**	Dec 4: 21:30 Dec 5: 12:45
Target Distance:	116.53 m	**Achieved Distance:**	116.53 m
Run Direction:	South-North (Dec 4) North-South (Dec 5)	**Launch Access:**	Near Conway St (Dec 4) Near Assiniboine Park (Dec 5)
12-in Munroe-Polson Siphon			
Survey Date(s)	December 3-4, 2012		
Arrive Site:	Dec 3: 09:15 Dec 4: 08:20	**Depart Site:**	Dec 3: 18:40 Dec 4: 15:30
Target Distance:	266.55 m	**Achieved Distance:**	266.55 m
Run Direction:	East-West	**Launch Access:**	Near Polson Ave
Operational Comments: *8-in Assiniboine Park Siphon* During the Dec 4 run, the PICA team encountered a restriction at the 87m mark, south of the Conway St launch. The See Snake tool could not be pulled past the restriction. A second run was conducted successfully on Dec 5. *12-in Munroe-Polson Siphon* The initial RFT run on Dec 3 resulted in substandard data quality due to the inspection frequency setting being inappropriate due to either significant differences in the pipe specifications or the pipe configurations (compared to City records). An alternate frequency was used during a second run on Dec 4, which resulted in significantly better RFT data allowing for effective condition analysis of the line.			

Calibration

For the best possible RFT accuracy, a calibration is performed using a short section of pipe with the same nominal pipe properties (wall thickness and grade) as the pipe being inspected. Under ideal conditions, a full pipe section with a half pipe on each end (to create two full connections and eliminate any “end effect”) in good condition are provided by the client. PICA will create artificial defects of varying depth and diameter in this pipe and run the RFT tool through it several times at various frequencies. The signal produced during this process is then compared to the signal produced during the field surveys to better quantify remaining wall calculations.

In the absence of such a calibration pipe, or to confirm the accuracy of the calibration (in the case where the test sample is not representative of the majority of the pipes in the inspected line), calibration test results are supplemented by mathematical calibrations. Simply, the analyst will build a histogram of the thickest RFT phase reading per inspected pipe section and create a calibration from this histogram. This assumes that the thickest phase readings are unaffected by possible corrosion. Using this method, defect sizing accuracy is expected to be ±20% for short (local) wall loss and ±10% for long (general) wall loss for pitting above the limit of detection and sufficiently removed from major features (such as flanged, B&S or girth weld connections).

Analysis Results

Location Reporting

The logged distance data for the 8-in Assiniboine Park Siphon was 107.90m, with the zero distance datum set at the open end of the pipe near Assiniboine Park. For the 12-in Munroe-Polson Siphon, the measured distance data was 248.45m, with the zero distance datum was set at the open end of the pipe near Munroe Ave.

For location reporting, the logged distances for both sections were scaled against the total line distances obtained from the Plan and Profile drawings. The scaled distances for the 8-in and 12-lines are 116.53m and 266.55m, respectively. Therefore, all distance references in Appendices D and E are with respect to the scaled distances mentioned above.

Dig sheets were provided for two areas in the 12-in Munroe-Polson Siphon section. More specifically, the two areas span between Pipes 0030 to 0070 and Pipes 0150 to 0190. These areas are comprised of the worst set of wall loss regions in this line. No dig sheets were provided for the 8-in line.

To facilitate the most accurate locating of specific defects and pipe lengths, it is recommended that the City work closely with PICA. Contact your PICA representative to obtain additional dig maps specific to any regions of interest prior to excavating.

Pipe Lengths & Features

Pipe Lengths

Nominal pipe length details were not provided to PICA prior to the inspection. As a result, the RFT data became the only resource for determining the predominant nominal pipe length in each section. In the 8-in Assiniboine Park Siphon, the pipeline was found to be comprised predominantly with 12-14m pieces while the 12-in Munroe-Polson Siphon had mostly 12m pieces. Nominal wall thickness details for each siphon were provided to PICA as: 6.35mm for the 8-in line and 9.525mm for the 12-in line.

Pipe Section Analysis

The RFT analysis of the 8-in Assiniboine Park Siphon identified a total of eight wall loss regions in 5 of 10 analyzed pipe sections. The wall loss regions in the 8-in line have local remaining wall thickness ranging from 55% to 77%. Pipe 0020 possesses the most severe wall loss region at 55% RW. Pipe 0110 possesses the worst cluster of wall loss regions (69%, 76% and 77% RW).

In the 12-in Munroe-Polson Siphon, a total of 22 wall loss regions were identified in 10 of 23 analyzed pipe sections. The wall loss regions in the 12-in line have local remaining wall thickness ranging from 25% to 85%.

A verification dig on the 12-in Munroe-Polson results was performed by AECOM on February 16, 2016 (*details can be found in AECOM's verification report that was issued on February 17, 2016*). The verification involved two defects in Pipe 0030, which were originally reported as 3% and 43% remaining wall at 31.48m and 31.27m respectively. The actual depths of these two defects were discovered to be 25% and 58% remaining wall respectively. While the reported longitudinal location of these two defects were found to be accurate in the field, the reported clock positions were discovered to be misreported by 90 degrees. As a result, PICA has revised its previously issued results for the 12-in line to account for this new information. The previously reported wall loss depths have been reduced by a scaling factor derived from the verification and all previously reported clock positions have been rotated by 90 degrees.

General Wall Condition

Pipe sections longer than 1 m were analyzed to obtain the average wall thickness, as well as the minimum and maximum circumferential thicknesses.

The average remaining wall thickness (Tavg) calculated over the length of the section is called the "PARW" value (Pipe Average Remaining Wall). The measured average wall thickness is 92.4% of nominal for all inspected pipes in the 8-in Assiniboine Park Siphon and 97.0% of nominal in the 12-in Munroe-Polson Siphon. A plot of each pipe's individual PARW with the line's average PARW for each section is shown in Figures 7 and 8.

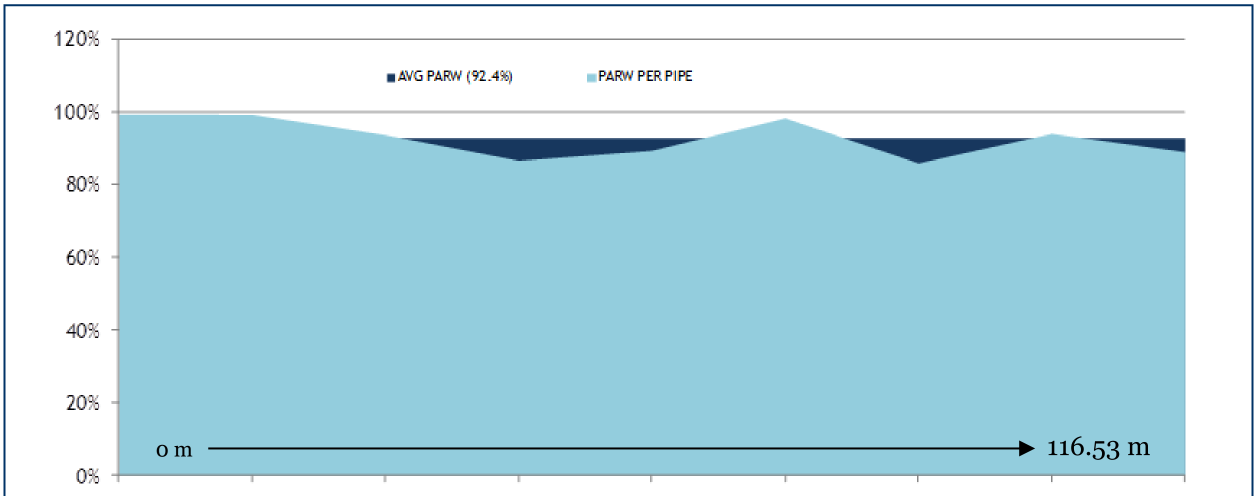


Figure 7: Pipe Average Remaining Wall (PARW) for each inspected pipe in the 8-in line.

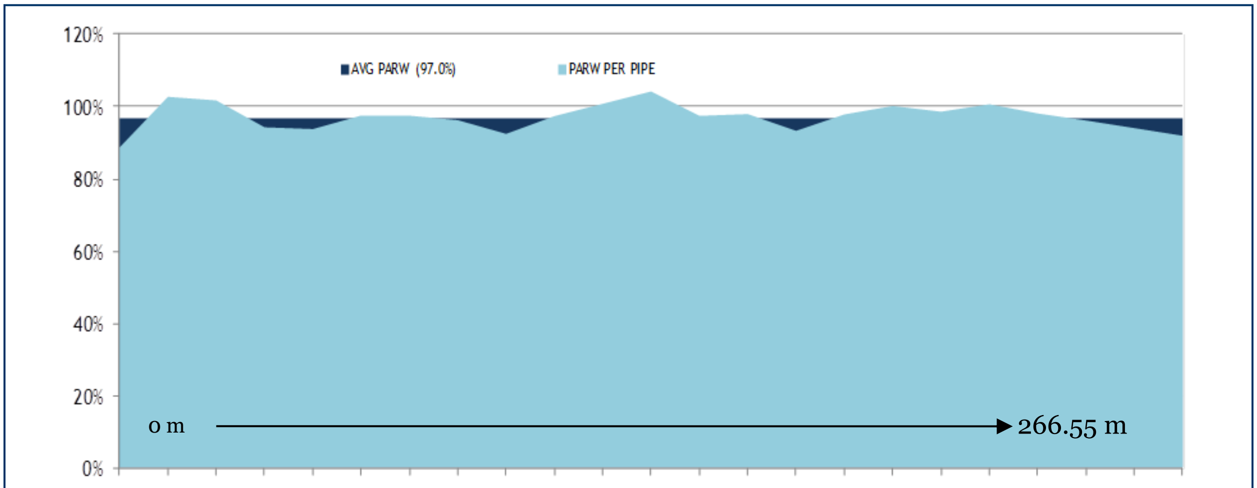


Figure 8: Pipe Average Remaining Wall (PARW) for each inspected pipe in the 12-in line.

The PARW value usually fluctuates by +15%/-10% due to tolerances in manufacturing. Variations outside this spread can be an indicator of a different nominal wall thickness or pipe type, or point towards a problem like aggregate pitting or general wall loss.

These average, minimum circumferential and maximum circumferential remaining wall values are also presented in a graphic format on pages 14-15 and in a tabular format in Appendix E.

Local Remaining Wall

The RFT analysis of the inspected portions of the 8-in Assiniboine Park and 12-in Munroe-Polson Siphons indicate the lines are in generally good condition –over half of the pipes in each line have a minimum wall thickness greater than 75% of nominal. In the 8-in line, no pipes were found with a region where the minimum wall is thinner than 50% of nominal. In the 12-line, 8 pipes (out of 23) were found with a region where the minimum wall is thinner than 50% of nominal.

More specifically, the wall loss regions in the 8-in line have local remaining wall thicknesses ranging from 55% to 77% of nominal. In the 12-in Munroe-Polson Siphon, a total of 22 wall loss regions were identified in 10 of 23 analyzed pipe sections. The breakdown below details the distribution of the pipe lengths with detected corrosion. The balance is formed by pipe sections without corrosion.

8-in Assiniboine Park Siphon:

- 30% of the pipes have 'shallow' pitting (≥65% RW)
- 20% of the pipes have 'medium' pitting (40%-64% RW)
- No pipes are found with deep or advanced pitting (<40% RW).
- 0 pipe has through-hole indications (0% RW)

12-in Munroe-Polson Siphon:

- 70% of the pipes have 'shallow' pitting (≥65% RW)
- 22% of the pipes have 'medium' pitting (40%-64% RW)
- 9% of the pipes have 'deep' pitting (20-40% RW)
- No pipes were found with 'advanced' pitting (<20% RW).

Figure 9 shows the distribution of reported pits as a function of clock position. In the 8-in line, detected pitting regions are all distributed in the lower half of the pipe with 75% at the invert (dark blue) and 25% along the mid-line (white). In the 12-in line, detected pitting regions appear to be mostly (77%) located along the mid-line (white), followed by 18% at the invert and 5% at crown.

The three thinnest pitting regions (if any) for each pipe are provided in a tabular format in Appendix E and also graphically on the following page.

If the City of Winnipeg chooses to excavate any of these wall loss locations, PICA should be contacted to provide dig maps. Additionally, sharing verification results with PICA can allow us to fine tune defect calibration and update the wall loss table in Appendix E.

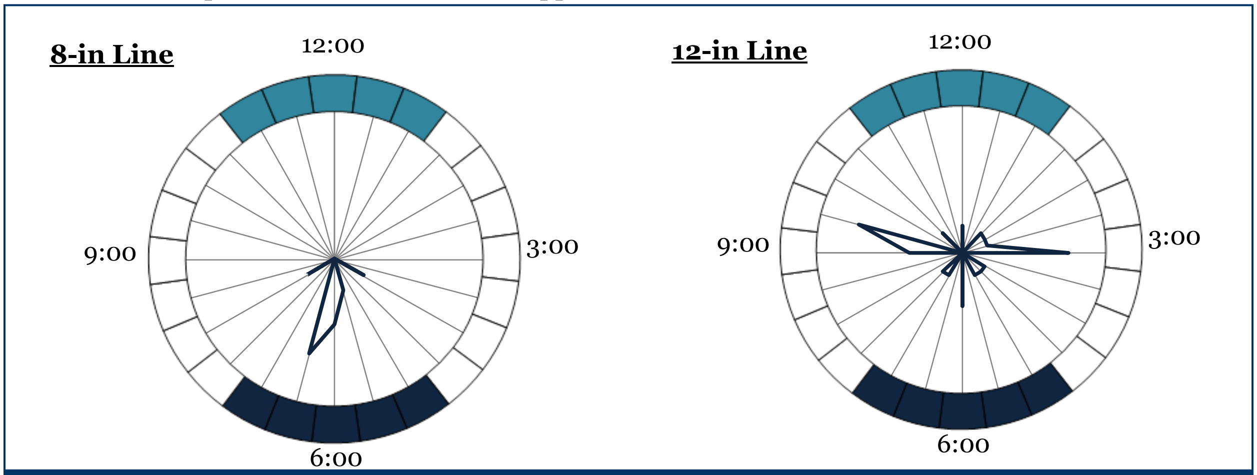
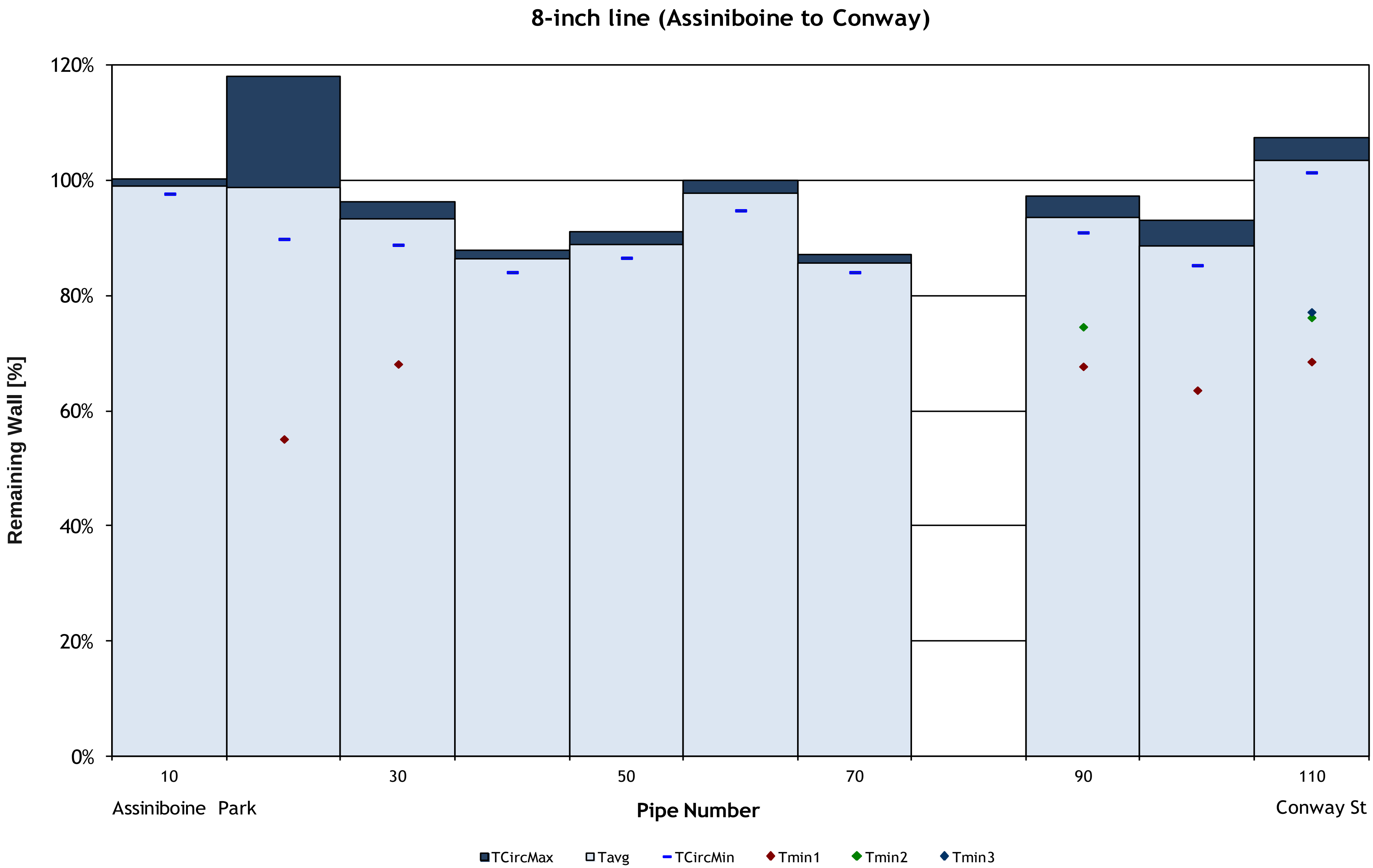
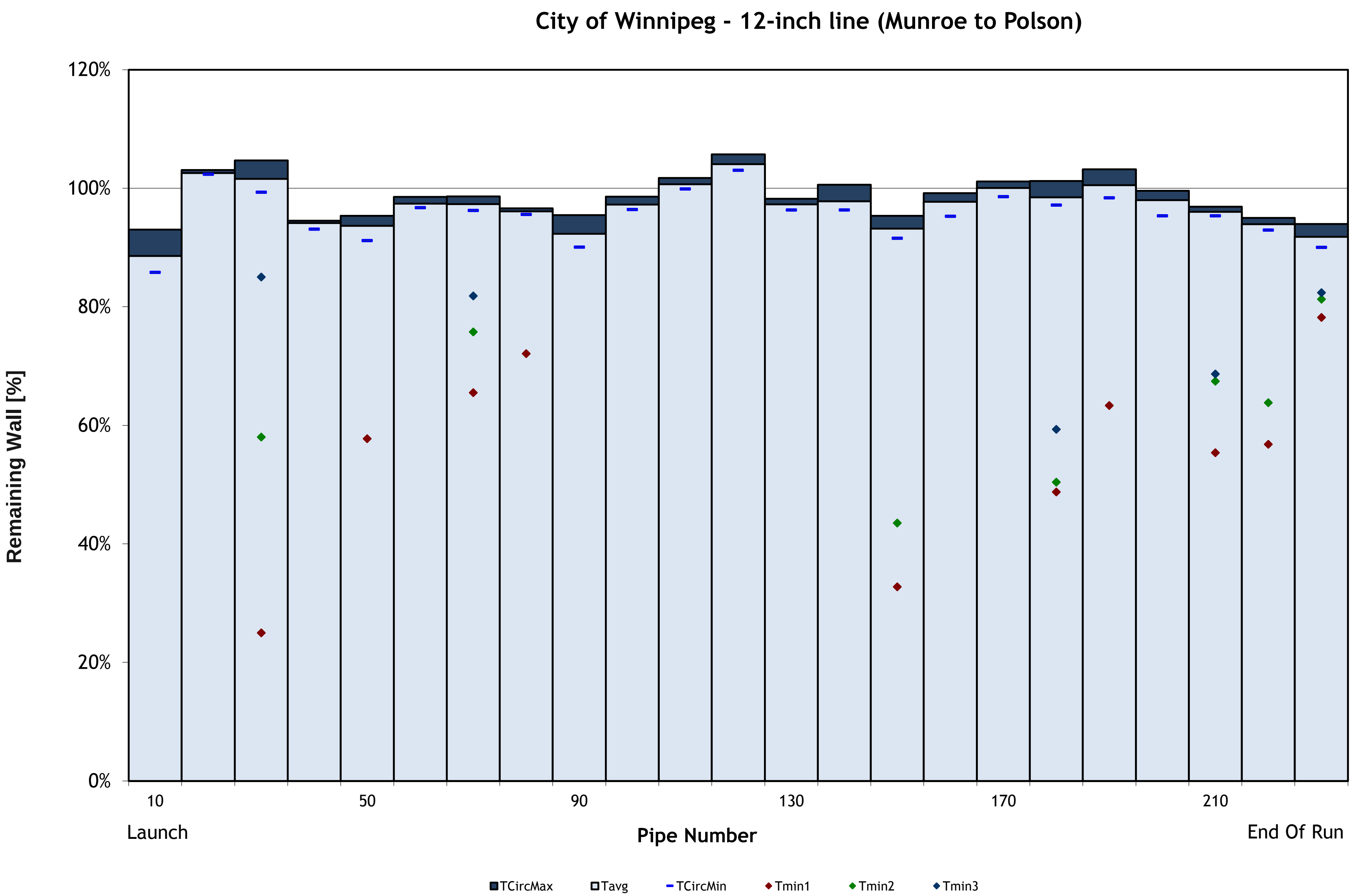


Figure 9: Circumferential distribution of pitting regions in the 8-in Assiniboine Park Siphon (left) and 12-in Munroe-Polson Siphon (right).


8-inch line (Assiniboine to Conway)
Remaining Wall [%]
120%
100%
80%
60%
40%
20%
0%
10
30
50
70
90
110
Assiniboine Park
Pipe Number
Conway St
TCircMax
Tavg
TCircMin
Tmin1
Tmin2
Tmin3


City of Winnipeg - 12-inch line (Munroe to Polson)
120%
100%
80%
60%
40%
20%
0%
Remaining Wall [%]
10
50
90
130
170
210
Launch
Pipe Number
End Of Run
TCircMax
Tavg
TCircMin
Tmin1
Tmin2
Tmin3

Disclaimer – PICA Corporation

Scope of Services

The agreement of PICA Corp to perform services extends only to those services provided for in writing. Under no circumstances shall such services extend beyond the performance of the requested services. It is expressly understood that all descriptions, comments and expressions of opinion reflect the opinions or observations of PICA Corp based on information and assumptions supplied by the owner/operator and are not intended nor can they be construed as representations or warranties. PICA Corp is not assuming any responsibilities of the owner/operator and the owner/operator retains complete responsibility for the engineering, manufacture, repair and use decisions as a result of the data or other information provided by PICA Corp. Nothing contained in this Agreement shall create a contractual relationship with or cause of action in favor of a third party against either the Line Owner or PICA Corp. In no event shall PICA Corp's liability in respect of the services referred to herein exceed the amount paid for such services.

Standard of Care

In performing the services provided, PICA Corp uses the degree, care, and skill ordinarily exercised under similar circumstances by others performing such services in the same or similar locality. No other warranty, expressed or implied, is made or intended by PICA Corp.

Compilation of Background Information for Report

PICA Corp undertakes to take every reasonable effort to generate an accurate "Condition Assessment Analysis" upon completion of the "Data Acquisition Stage" of each "Infrastructure Condition Assessment Contract". This often requires fact checking against sources of information from the client as well as third party contractors and vendors. Such information falls into the categories of Properties of the Pipe; (Material & Physical properties), Pipe Fittings; (Dimensional and Positional information), Pipeline Design; (Plan & Profile Drawings – sub-surface piping, ISO Drawings of surface infrastructure), Construction Methods for the Pipeline; (Shop Bends vs. Field Bends), Protection Infrastructure for the Pipeline; (Active or Passive Cathodic Protection, Rock Guard exterior coating, interior lining, casings, etc.), Alterations to the Pipeline; (Repairs, Changes, Additions), Corrosion/Erosion Information for the Pipeline; (Break History, Independent NDT Inspection of Dig Sites, Laboratory Analysis of Corrosion Deposits) Ancillary Services used to complete the ILI Data Acquisition; (Nitrogen, Compressed Air, Water Pumping to propel the ILI to Target distance) and any other related factors that may aid in obtaining the most accurate report results currently available.

Appendix A: Abbreviations & Terminology

Abbreviations

45H	45-deg elbow – horizontal plane
45V	45-deg elbow – vertical plane
AGM	Above-Ground Monitor
B&S:	Bell and Spigot connection
CC	Coupled or Clamped connection
DS	Downstream
F	Feature
FC	Flanged connection
FM	Force Main
ILI	In-Line Inspection
NWT	Nominal Wall Thickness
P&P	Plan & Profile drawings
PARW	Pipe Average Remaining Wall (also Tavg)
RFT	Remote Field Testing
RJ	Restrained joint
RW	Remaining Wall
Tavg	Average Wall Thickness (also PARW)
Tcircmin	Minimum Circumferential Wall Thickness
Tcircmax	Maximum Circumferential Wall Thickness
Tmin	Minimum Wall Thickness
TH	Through Hole (ie: 0% Remaining Wall)
UF	Unknown or Unidentifiable Feature
US	Upstream
VB	Bend in the vertical plane
WL	Wall Loss

Glossary

Average Wall Thickness (Tavg, PARW): The wall thickness that would occur by recasting the existing metal on the pipe barrel so that is uniform across the axial length. The average pipe wall can vary up to ±15% due to manufacturing. Variations outside the normal 15% spread can be an indicator of a different nominal wall thickness or pipe type, or a point towards a problem like aggregate pitting or general wall loss.

Circumferential Wall Thickness: Metal loss that is uniform in depth around the pipe's circumference at a given axial location. The "maximum" circumferential wall thickness (Tcircmax) indicates the thickest circumferential wall thickness for a single pipe while the "minimum" circumferential wall thickness (Tcircmin) indicates the thinnest. Figure A1 illustrates wall thickness terms.

Nominal Wall Thickness (NWT): The thickness of the pipe wall where there is assumed to be no corrosion or circumferential wall loss (ie: 100% RW). Normally, a manufacturer will designate a NWT or NWT range (in mm or inches) for a specific pipe material, diameter and class.

One-Sided Wall Loss: Metal loss that occurs predominantly on one side of the pipe – also referred to as "pitting" or "eccentric wall loss".

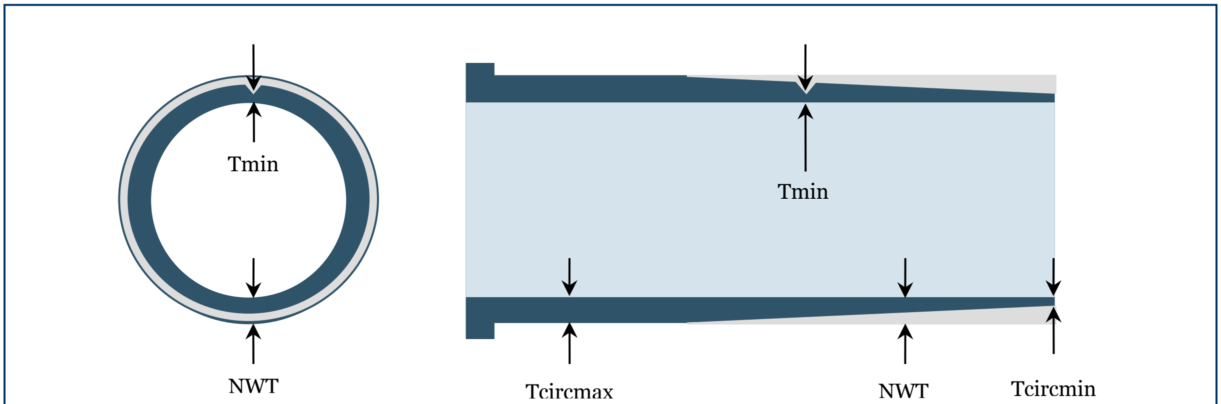


Figure A.1 Wall loss terminology

Pipe Average Wall Thickness (Tavg, PARW): The wall thickness that would occur by recasting the existing metal on the pipe barrel so that is uniform across the axial length. The average pipe wall can vary up to ±15% due to manufacturing. Variations outside the normal 15% spread can be an indicator of a different nominal wall thickness or pipe type, or a point towards a problem like aggregate pitting or general wall loss.

Pitting: Localized corrosion of a metal surface that is confined to a point or small area. Up to the three deepest pitting regions in each pipe are provided in this report as Tmin1, Tmin2, Tmin3.

Remote Field Testing (RFT): A non-destructive examination method that induces an electromagnetic field that is then detected outside the direct coupling zone (ie: in the "remote" zone) after it has passed completely through the object being examined. RFT is also called "remote field eddy current" (RFEC).

Condition Categories

In some reports, pitting is expressed as Shallow, Medium, Deep or Advanced. For example, if a pitting region has 35% remaining wall, the pitting would be classified as “Deep” pitting.

Shallow	Wall thickness at thinnest point ≥ 65% of NWT
Medium	Wall thickness at thinnest point 40%-64% of NWT
Deep	Wall thickness at thinnest point 20%-39% of NWT
Advanced	Wall thickness at thinnest point < 20% of NWT

The condition of the thinnest point on each pipe (as defined above) in conjunction with the number of corrosion indications is used to determine the overall condition of the pipeline into poor, fair or good. Loosely defined:

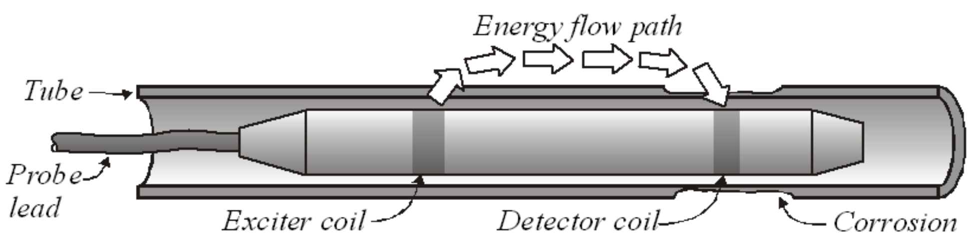
Poor	The majority of inspected pipes have corrosion deeper than 50% of NWT
Fair	The majority of inspected pipes have corrosion between 25% -50% of NWT
Good	The majority of inspected pipes have corrosion less than 25% of NWT

If you use a different condition coding system and would like that reflected in this report, please inform your PICA representative.

Appendix B: Remote Field Operation

Background Information

In the basic RFT probe shown below, there is one exciter coil and one detector coil. Both coils are wound co-axially with respect to the examined pipe and are separated by a distance greater than two times the pipe diameter. The actual separation depends on the application, but will always be a minimum of two pipe diameters. It is this separation that gives RFT its name: the detector measures the electromagnetic field remote from the exciter. Although the fields have become very small at this distance from the exciter, they contain information on the full thickness of the pipe wall.



The detector electronics include high-gain instrumentation amplifiers and steep noise filters. These are necessary in order to retrieve the remote field signals. The detector electronics output the remote field signal to an on-board storage device. The data is recalled for display, analysis and reporting purposes after the examination process is completed.

Remote Field Testing (RFT) Technology

RFT tools work by measuring the "time of flight" (phase shift) and the signal strength (amplitude) of a signal emitted by an exciter coil and detected by an array of receivers. The receivers are positioned circumferentially so that they are sensitive to the many clock locations of the pipe circumference.

For each cycle of the exciter frequency, a clock is started and the arrival time of the signal at the detector is used to re-set the clock. The time interval is a measurement of the time of flight, and indirectly, the wall thickness of the pipe.

There are many important considerations affecting in-line RFT inspection results. These can be subdivided into four categories:

- The physical quantities measured by the ILI tool. Most ILI tools indirectly measure the wall thickness and infer the wall thickness though a calibration. Ultrasonic (UT) tools measure the "time-of-flight" of sound, while Magnetic Flux Leakage (MFL) tools measure the magnetic field. RFT tools measure both the time-of-flight and the signal strength of a varying electromagnetic field.
- The design of the tool. Pipe inspection tool design is a compromise between countless design criteria. Lift-off and resolution are important considerations, but so are bend negotiation ability, battery life, pipe size range, centralization, wall thickness range, suspension, etc.

- The delivery procedure. Most tools have an optimal inspection speed and provide the best results when the speed is consistent. Going faster or slower means less than optimal results. This is an especially important consideration when tools are run in gaseous media.
- Noise and other interference sources. These can be caused by both internal sources and external sources. A major problem for many tools is the cleanliness of the pipe. A dirty pipe can cause artifacts in the data that may mask flaws.

Physical Parameters Measured by RFT Tools.

RFT technology measures three quantities:

- Wall thickness of ferromagnetic pipes
- Magnetic permeability
- Electrical conductivity

These three factors are measured simultaneously and convey different, important information. For steel pipes, the electrical conductivity remains fairly constant over the length of a pipe segment, meaning that any RFT signal changes along the length of a pipe are mainly due to wall thickness and permeability changes.

Magnetic permeability is not usually a factor of interest. However, in lines that are subjected to soil load stresses, the permeability variations can be significant. For lines known to be under external stresses (for example due to geological ground movement) the permeability variations measured by an RFT tool can be very valuable. Permeability variations produce signals that generally lie just outside the RFT wall loss reference curve that analysts use to differentiate between wall loss and permeability; while wall loss signals lie inside the reference curve.

In the data from cast and ductile iron water lines, we generally notice significant changes in wall thickness along the length of a pipe segment. This appears to be fairly typical, even for brand new pipes that come straight from the foundry. The variation is believed to be the result of the manufacturing process. To capture the spread in wall thickness, we generally report both the minimum and maximum wall thickness per pipe (measured circumferentially without local defects).

Besides wall thickness variations, we occasionally note magnetic permeability variations in the data. These are generally from two sources:

- Roller marks. These present themselves as a band of noise across all channels on the tool. The marks can be sizeable and can mask small volume wall loss defects.
- Permeability changes caused by stresses induced during installation of the line. These typically are localized indications within a couple of feet of a bell and spigot joint. They are believed to mark the points where the pipes were held when the joints were assembled.

Tool Propulsion and Delivery

A common problem encountered during tethered runs in air-filled pipe is tool surging. The surges consist of the tool being stationary one moment and surging forward the next. Speed surges are most severe when the length of the tether on the pulling winch is at its maximum, or the tether is wrapping around multiple bends. The surges are often completely missed by the field operator as the winch reels in at a constant velocity and no surging is visible from above ground. Contributors to surging are tool friction, wireline friction and wireline stretch and weight.

Interference and Noise Sources

There are three different sources of interference on the RFT data:

- Electrical sources on board the tool
- Electrical sources outside the pipe
- Mechanical vibration.

Interference from electrical sources on board the tool

There are two types of interferences caused by the tool itself: electrical noise and the exciter response to defect signals.

Electrical noise from onboard the tool will be consistently present in the data and will therefore result in a constant noise amplitude. This type of noise can be filtered out easily during the post processing stage.

When the exciter coil on an RFT tool passes an area with significant wall thickness change, the "exciter response" to this wall thickness change will be visible in the data. If the exciter response is large, it can mask the tool response to smaller defects. In the 8-in Assiniboine Park Siphon run, this means that defects that are located about 0.62m upstream from a major feature (like a Girth Weld, an Elbow, or Valve) may be lost in the exciter response to the feature – especially for smaller defects. In the 12-in Munroe-Polson Siphon, the same interference can affect defects that are located about 1.13m upstream from major features.

Noise from electrical sources outside the tool

The noise from these types of sources will increase with proximity. The closer the tool to the source, the higher the noise level will become. The noise will fade out as the tool moves away from the noise source. This type of noise can be hard to remove during post-processing and may mask flaws in the pipe. Cathodic Protection systems can induce electrical noise on the data from the pipeline and electrical cables that run parallel to the line or cross it can induce noise as well.

Vibration induced noise

Mechanical vibration can create false indications or cause the tool to miss flaws. This is called "travel noise". For example when the tool moves through a larger cross, the tool is subjected to a significant diameter change that causes the tool modules to tilt and temporarily lose concentricity with the pipe. This tilting action will create signal artifacts on the data.

Presenting RFT Data: Stripchart Display & Phase-Amplitude Diagrams

A stripchart displays the detector data as a function of time or the axial distance along the length of the pipeline. Phase and log-amplitude are the preferred quantities for the stripchart display because they are both linear indicators of overall wall thickness. The general convention for stripcharts is that deflections to the left represent metal loss and deflections to the right wall thickening (Figure B1).

A phase-amplitude diagram (Figure B2) is a two-dimensional representation of the detector output voltage with the angle representing phase with respect to a reference signal and the radius representing amplitude (ASTM E 2096). The detector signals are drawn as vector points in polar coordinates with the angle representing the phase and the radius representing the amplitude. Axial distance information is not available on phase-amplitude diagrams yet they are used for sizing flaws. By combining phase-amplitude diagrams with stripcharts, the distance information can be included.

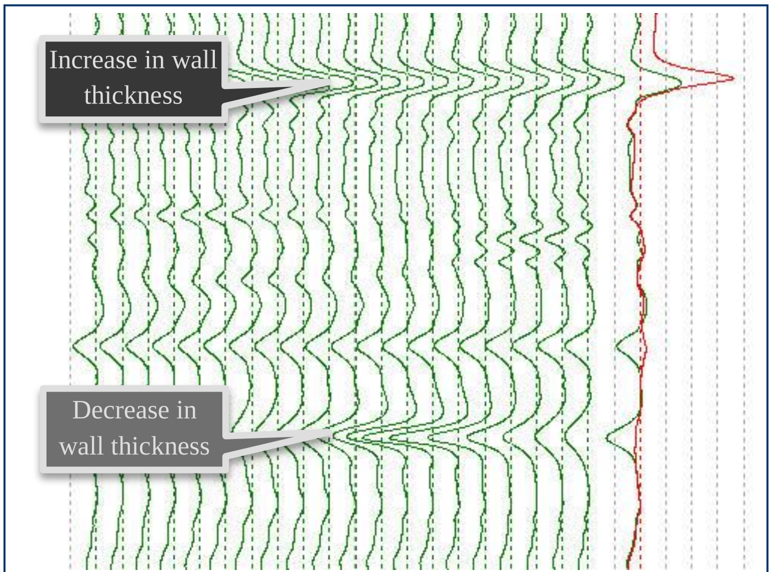


Figure B1: RFT stripchart display.

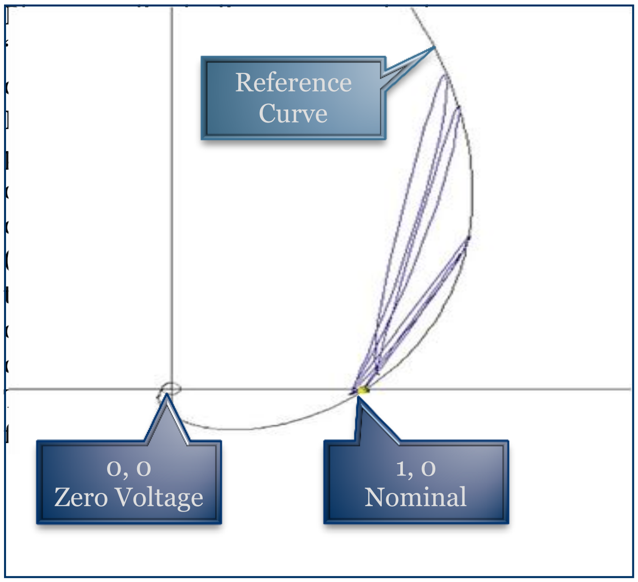
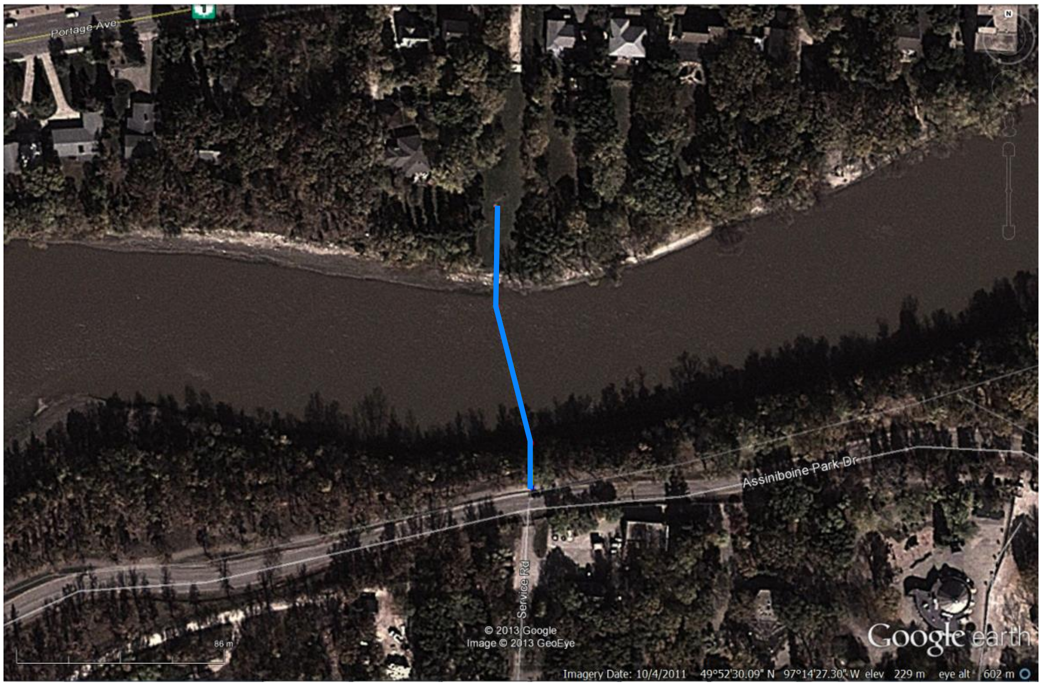


Figure B2: RFT phase-amplitude diagram.

Appendix C: Field Sketches



8" Assiniboine Park Siphon (Assiniboine Park to Conway St)

12" Munroe-Polson Siphon (Munroe Ave to Polson Ave)

Appendix D: Pipe Tally Tables

Pipe Tally – Winnipeg 8-in Assiniboine Park Siphon												
			Start Joint				**End Joint**					
Pipe Number	**Length (m)**	**NWT (mm)**	**Location (m)**	**Connection Type**	**US Reference Marker**	**US Marker Distance (m)**	**Location (m)**	**Connection Type**	**DS Reference Marker**	**DS Marker Distance (m)**	**Comments**
Towards Assiniboine Park											
0010	6.00	6.35	0.00	FC	Open end near Assiniboine Park	0.00	6.00	GW	Open end near Conway St	110.53	Start of Log
0020	14.44	6.35	6.00	GW	Open end near Assiniboine Park	6.00	20.44	GW	Open end near Conway St	96.09	Change of Grade @STA 5+70 Confirmed in RFT data.
0030	13.67	6.35	20.44	GW	Open end near Assiniboine Park	20.44	34.11	GW	Open end near Conway St	82.42	20deg bend @ STA 5+23; Unconfirmed in RFT data.
0040	14.28	6.35	34.11	GW	Open end near Assiniboine Park	34.11	48.39	GW	Open end near Conway St	68.14	
0050	13.73	6.35	48.39	GW	Open end near Assiniboine Park	48.39	62.12	GW	Open end near Conway St	54.41	
0060	13.12	6.35	62.12	GW	Open end near Assiniboine Park	62.12	75.23	GW	Open end near Conway St	41.30	
0070	3.65	6.35	75.23	GW	Open end near Assiniboine Park	75.23	78.89	GW	Open end near Conway St	37.64	20deg bend @ STA 3+47.4; STA 3+35; Change of Grade (riverbank slope to river bottom) in RFT data
0080	0.42	6.35	78.89	GW	Open end near Assiniboine Park	78.89	79.30	GW	Open end near Conway St	37.23	See above
0090	14.97	6.35	79.30	GW	Open end near Assiniboine Park	79.30	94.27	GW	Open end near Conway St	22.26	
0100	10.21	6.35	94.27	GW	Open end near Assiniboine Park	94.27	104.49	GW	Open end near Conway St	12.04	Change of Grade (riverbank slope to ground profile) in RFT data
0110	12.04	6.35	104.49	GW	Open end near Assiniboine Park	104.49	116.53	FC	Open end near Conway St	0.00	End of Log
Towards Conway St.											

GW – Girth Weld *FC – Flange Connection*

**STA numbers provided were obtained from the Plan and Profile drawings.*

Pipe Tally – Winnipeg 12-in Munroe-Polson Siphon											
			Start Joint				End Joint				
Pipe Number	Length (m)	NWT (mm)	Location (m)	Connection Type	US Reference Marker	US Marker Distance (m)	Location (m)	Connection Type	DS Reference Marker	DS Marker Distance (m)	Comments
Towards Munroe Ave.											
0010	13.75	9.525	0.00	FC	Open end near Munroe Ave	0.00	13.75	GW	Open end near Polson Ave	252.80	Start of Log
0020	8.58	9.525	13.75	GW	Open end near Munroe Ave	13.75	22.33	GW	Open end near Polson Ave	244.22	
0030	12.24	9.525	22.33	GW	Open end near Munroe Ave	22.33	34.57	GW	Open end near Polson Ave	231.98	
0040	2.19	9.525	34.57	GW	Open end near Munroe Ave	34.57	36.76	GW	Open end near Polson Ave	229.79	18deg @ STA 7+81 Vertical Bend @ STA 6+45 (ground profile-riverbank slope in RFT data
0050	13.31	9.525	36.76	GW	Open end near Munroe Ave	36.76	50.06	GW	Open end near Polson Ave	216.49	
0060	11.96	9.525	50.06	GW	Open end near Munroe Ave	50.06	62.03	GW	Open end near Polson Ave	204.52	
0070	12.11	9.525	62.03	GW	Open end near Munroe Ave	62.03	74.14	GW	Open end near Polson Ave	192.41	
0080	11.70	9.525	74.14	GW	Open end near Munroe Ave	74.14	85.84	GW	Open end near Polson Ave	180.71	
0090	13.25	9.525	85.84	GW	Open end near Munroe Ave	85.84	99.09	GW	Open end near Polson Ave	167.46	
0100	12.19	9.525	99.09	GW	Open end near Munroe Ave	99.09	111.28	GW	Open end near Polson Ave	155.27	
0110	12.40	9.525	111.28	GW	Open end near Munroe Ave	111.28	123.68	GW	Open end near Polson Ave	142.87	
0120	10.44	9.525	123.68	GW	Open end near Munroe Ave	123.68	134.12	GW	Open end near Polson Ave	132.43	
0130	12.11	9.525	134.12	GW	Open end near Munroe Ave	134.12	146.23	GW	Open end near Polson Ave	120.32	
0140	13.21	9.525	146.23	GW	Open end near Munroe Ave	146.23	159.44	GW	Open end near Polson Ave	107.11	
0150	12.57	9.525	159.44	GW	Open end near Munroe Ave	159.44	172.01	GW	Open end near Polson Ave	94.54	
0160	12.65	9.525	172.01	GW	Open end near Munroe Ave	172.01	184.66	GW	Open end near Polson Ave	81.89	

Pipe Tally – Winnipeg 12-in Munroe-Polson Siphon												
			Start Joint				End Joint					
Pipe Number	Length (m)	NWT (mm)	Location (m)	Connection Type	US Reference Marker	US Marker Distance (m)	Location (m)	Connection Type	DS Reference Marker	DS Marker Distance (m)	Comments
0170	13.10	9.525	184.66	GW	Open end near Munroe Ave	184.66	197.75	GW	Open end near Polson Ave	68.80	25deg @ STA 2+85: Unconfirmed in RFT data
0180	11.98	9.525	197.75	GW	Open end near Munroe Ave	197.75	209.74	GW	Open end near Polson Ave	56.81	
0190	12.40	9.525	209.74	GW	Open end near Munroe Ave	209.74	222.13	GW	Open end near Polson Ave	44.42	
0200	12.78	9.525	222.13	GW	Open end near Munroe Ave	222.13	234.91	GW	Open end near Polson Ave	31.64	
0210	11.90	9.525	234.91	GW	Open end near Munroe Ave	234.91	246.81	GW	Open end near Polson Ave	19.74	Change of Grade @ STA 1+60 (riverbank slope-ground profile); Unconfirmed in RFT data
0220	4.17	9.525	246.81	GW	Open end near Munroe Ave	246.81	250.98	GW	Open end near Polson Ave	15.57	
0230	15.57	9.525	250.98	GW	Open end near Munroe Ave	250.98	266.55	FC	Open end near Polson Ave	0.00	End of Log
Towards Munroe Ave.											

GW – Girth Weld *FC – Flange Connection*

**STA numbers provided were obtained from the Plan and Profile drawings.*

Appendix E: Remaining Wall (RW) Tables

Wall Thickness Readings – 8-in Assiniboine Park Siphon																
Pipe No	Pipe Location			Tavg RW (%)	Circumferential Wall Thickness		Local Wall Thickness *NOTE: Clock positions are with a North-South perspective (looking towards Conway St).*									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcirc Max RW (%)	Tcirc Min RW (%)	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
Towards Assiniboine Park																
0010	0.00	6.00	6.00	99%	100%	98%										
0020	6.00	20.44	14.44	99%	118%	90%	55%	11.37	6:30							
0030	20.44	34.11	13.67	93%	96%	89%	68%	22.91	6:30							
0040	34.11	48.39	14.28	86%	88%	84%										
0050	48.39	62.12	13.73	89%	91%	87%										
0060	62.12	75.23	13.12	98%	100%	95%										
0070	75.23	78.89	3.65	86%	87%	84%										
0080*	78.89	79.30	0.42	n/a	n/a	n/a										
0090	79.30	94.27	14.97	94%	97%	91%	68%	82.85	6:00	75%	83.10	6:00				
0100	94.27	104.49	10.21	89%	93%	85%	64%	101.93	4:00							
0110	104.49	116.53	12.04	104%	107%	101%	69%	109.09	6:30	76%	106.96	8:00	77%	115.26	5:30	
Towards Conway St.																

** Tavg RW, Tcircmax and Tcircmin details are not provided for pipes shorter than 1 meter in length.*

Wall Thickness Readings – 12-in Munroe-Polson Siphon																
Pipe No.	Pipe Location			Tavg RW (%)	Circumferential Wall Thickness		Local Wall Thickness *NOTE: Clock positions are with an East-West perspective (looking towards Polson).*									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcirc Max RW (%)	Tcirc Min RW (%)	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
Towards Munroe Ave																
0010	0.00	13.75	13.75	89%	93%	86%										
0020	13.75	22.33	8.58	103%	103%	102%										
0030	22.33	34.57	12.24	102%	105%	99%	25% Verified 3% Original	31.48	9:00 Verified 12:00 Original	58% Verified 41% Original	31.27	12:00 Verified 3:00 Original	85%	25.27	10:30	Field verification of Tmin1 and Tmin2 occurred on Feb 16, 2016. • Tmin1: 25%RW, 6mm x 6mm • Tmin2: 58%RW, 12mm x 30mm
0040	34.57	36.76	2.19	94%	95%	93%										
0050	36.76	50.06	13.31	94%	95%	91%	58%	42.60	5:00							
0060	50.06	62.03	11.96	97%	99%	97%										
0070	62.03	74.14	12.11	97%	99%	96%	66%	66.16	4:30	76%	65.96	3:00	82%	67.24	2:00	
0080	74.14	85.84	11.70	96%	97%	96%	72%	74.96	4:00							
0090	85.84	99.09	13.25	92%	95%	90%										
0100	99.09	111.28	12.19	97%	99%	96%										
0110	111.28	123.68	12.40	101%	102%	100%										
0120	123.68	134.12	10.44	104%	106%	103%										
0130	134.12	146.23	12.11	97%	98%	96%										
0140	146.23	159.44	13.21	98%	101%	96%										
0150	159.44	172.01	12.57	93%	95%	92%	33%	160.92	3:00	44%	161.09	3:00				
0160	172.01	184.66	12.65	98%	99%	95%										
0170	184.66	197.75	13.10	100%	101%	99%										
0180	197.75	209.74	11.98	98%	101%	97%	49%	199.59	3:00	50%	206.09	2:30	59%	199.45	1:30	

Wall Thickness Readings – 12-in Munroe-Polson Siphon																
Pipe No.	Pipe Location			Tavg RW (%)	Circumferential Wall Thickness		Local Wall Thickness *NOTE: Clock positions are with an East-West perspective (looking towards Polson).*									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcirc Max RW (%)	Tcirc Min RW (%)	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
0190	209.74	222.13	12.40	101%	103%	98%	63%	210.53	9:30							
0200	222.13	234.91	12.78	98%	100%	95%										
0210	234.91	246.81	11.90	96%	97%	95%	55%	242.53	6:00	67%	242.30	6:00	69%	239.68	7:00	
0220	246.81	250.98	4.17	94%	95%	93%	57%	249.31	9:00	64%	248.30	9:30				
0230	250.98	266.55	15.57	92%	94%	90%	78%	255.61	9:30	81%	253.33	10:30	82%	256.54	9:30	
Towards Polson Ave																