Goulet-Doucet Feeder Main Crossing – Evaluation of Lining Options and Preliminary Design Report

The City of Winnipeg

60721829

July 2024

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July 31, 2024

Project #
60721829

Subject: Goulet-Doucet Feeder Main Crossing – Evaluation of Lining Options and Preliminary Design Report

Dear Mr. Delaurier:

AECOM is pleased to provide this Goulet-Doucet Feeder Main Crossing – Evaluation of Lining Options and Preliminary Design Final Report for the City of Winnipeg Water and Waste Department.

We trust this information meets your requirements on this matter. Should you have any queries or require further information or clarification, please do not hesitate to contact us.

Sincerely,
AECOM Canada Ltd.

Jordan Thompson, P. Eng.
Municipal Engineer
Conveyance
JAT/pab

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AECOM: 2015-04-13

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Revision History

Rev #	Revision Date	Revised By:	Revision Description
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Distribution List

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	✓	The City of Winnipeg, WWD
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1. Executive Summary

The Goulet-Doucet Feeder Main (FM) is a 400 mm steel and asbestos-cement pressure pipe that crosses the Seine River between Goulet Street and Doucet Street. The pipe was constructed in 1953 and consists of approximately 84 m of steel pipe connecting to asbestos-cement (AC) on the east and west riverbanks.

The pipeline was inspected by Pipeline Inspection & Condition Analysis Corporation (PICA) in October 2015 using Remote Field Testing (RFT) technology followed by leakage testing. The steel pipeline was found to be in good condition with no corrosion related defects identified. However, the interior coating of the steel pipe, believed to consist of coal tar, was found to be extensively disbonded from the steel pipe. The loss of internal coating exposes the steel pipe to accelerated corrosion potential over its remaining lifespan. A recommendation was made in the HRRC report to include lining of the pipeline in any future rehabilitation work programs.

AECOM has reviewed the use of three (3) technologies for the use in rehabilitation of the Goulet-Doucet Crossing:

- Cured-in-Place Pipe (CIPP),
- Flexible Fabric Reinforced Pipe (FFRP), and
- Spray-in-Place Pipe (SIPP).

AECOM's findings from the preliminary design review of the technologies are as summarized:

- CIPP is a feasible candidate for successful rehabilitation of the crossing, however, with considerable risk due to pipeline geometry, predominantly related to bends, that would require further investigation.
- FFRP is a feasible candidate for successful rehabilitation of the crossing, with minimal risk.
- SIPP is a poor candidate for rehabilitation of the crossing and would not be a recommended option due to the level of cleaning and the risks associated with not being able to achieve suitable pipe preparation to ensure proper bond of the liner.

Cost estimates have been prepared in accordance with the AACE International Cost Estimate Classification System. Based on the AACE classification system, Class 3 estimates have been developed for the two (2) feasible rehabilitation options.

- CIPP (Riverbank Access): $716,775.00
- FFRP (Street Access): $665,530.00
- FFRP (Riverbank Access): $547,750.00

AECOM recommends the use of FFRP for the rehabilitation of the Goulet-Doucet FM on the following basis:

- Low level of installation risk compared to alternatives,
- Straight forward pre-installation pipe cleaning and preparation,
- Comparable design life to alternatives,
- Recent history with installations in Winnipeg,
- Compact construction footprint and ability to complete work at street level or on the riverbank, and
- Lowest AACE Class 3 Cost Estimate.

CIPP remains a viable option for rehabilitation of river crossings, particularly for those with host pipes that are structurally deficient and require the use of a Class IV liner. However, it carries a larger risk profile, will require a larger and more disruptive construction footprint, and has a comparatively higher cost than the FFRP option.

A preliminary design drawing package (30%) is included in Appendix C.

2. Introduction

The Goulet-Doucet FM is a 400 mm steel and asbestos-cement pressure pipe that crosses the Seine River between Goulet Street and Doucet Street. The pipe was constructed in 1953 and consists of approximately 84 m of steel pipe connecting to asbestos-cement (AC) on the east and west riverbanks. The pipeline has an outside diameter of 406.40 mm (16”). The wall thickness is 9.53 mm (3/8”). The original record drawings are included in Figure 1.

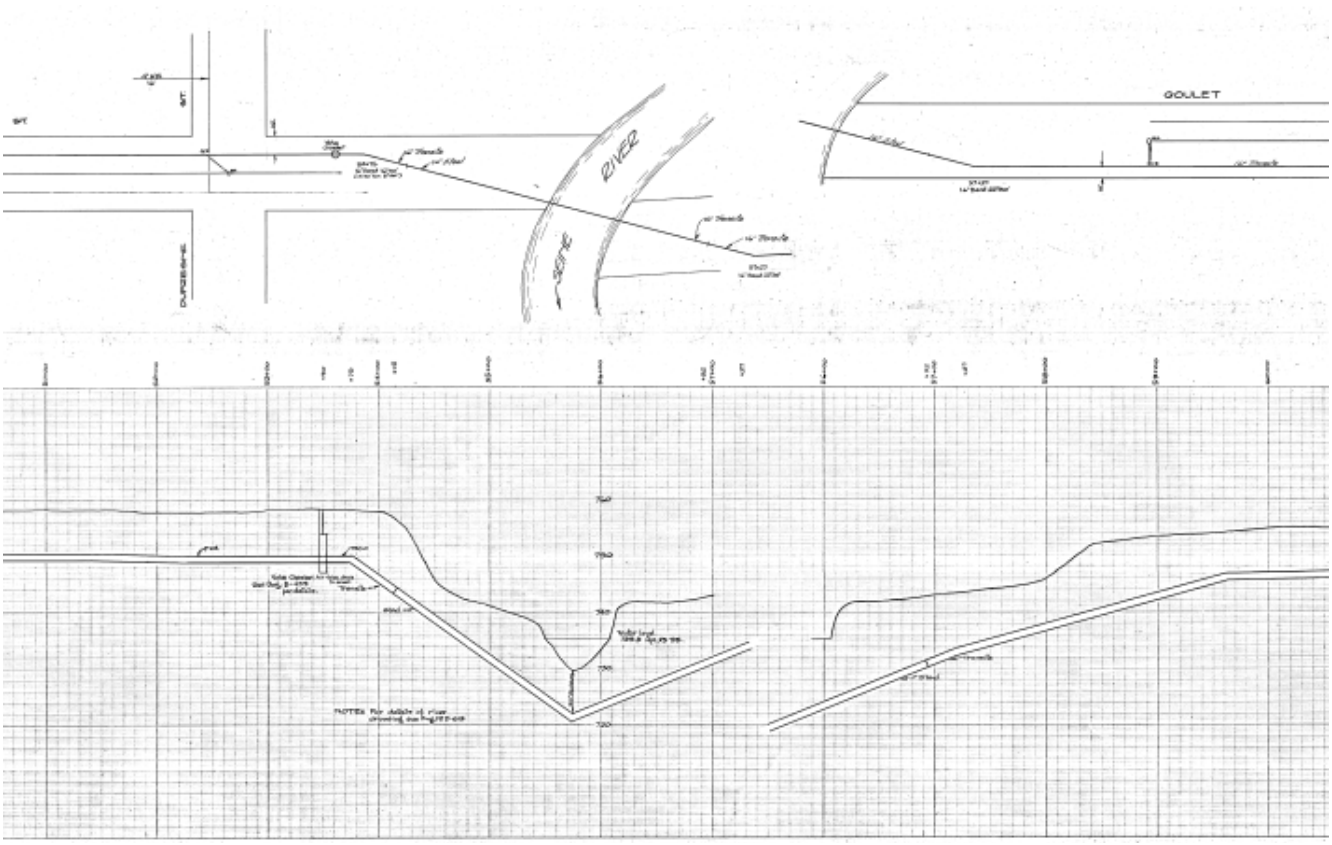


Figure 1: Original As-Built Drawings of the Goulet-Doucet FM Crossing at the Seine River

The pipeline was cleaned and modified in 2015 (Bid Opportunity 289-2015) to provide access for the deployment of condition assessment tools as part of the City of Winnipeg’s High Risk River Crossing (HRRC) program. The modifications included the installation of 400 mm wyes on each side of the crossing. The wyes served as launch and retrieval points for the inspection tools and were located on both Goulet Street and Doucet Street. A record drawing documenting the modifications is included in Appendix A.

The pipeline was inspected in October 2015 by Pipeline Inspection & Condition Analysis Corporation (PICA). The inspection program consisted of advanced electromagnetic inspection of the crossing utilizing Remote Field Testing (RFT) technology followed by leakage testing. As the AC portions of the crossing are non-ferrous in nature, RFT inspection was limited to the steel portion. The steel pipeline was found to be in good condition with no corrosion related defects identified. However, the interior coating of the steel pipe, believed to consist of coal tar, was found to be extensively disbonded from the steel pipe, evidenced by coating material found at the west launch wye during inspection operations. Disbondment of the of interior lining was further confirmed during excavation of the crossing to retrieve a cleaning pig that became stuck in the line during inspection. The loss of internal coating exposes the steel pipe to accelerated corrosion potential over its remaining lifespan. A recommendation was made in the HRRC report to include lining of the pipeline in any future rehabilitation work programs.

Geotechnical reviews completed in 2015 as a part of the HRRC project included site inspections and where required, preliminary slope stability analysis. The findings of AECOM's 2015 geotechnical site investigation of the Goulet-Doucet Crossing are summarized below:

- No existing erosion control measures in place.
- The west bank exhibited minor toe erosion at the time of inspection. No erosion was identified at the upper bank.
- The east bank did not exhibit evidence of instability.

Based on the limited concerns related to slope stability at the time, no further stability analysis was completed for the crossing.

3. Rehabilitation Options

AECOM has reviewed the use of three (3) technologies for the use in rehabilitation of the Goulet-Doucet Crossing:

- Cured-in-Place Pipe (CIPP),
- Flexible Fabric Reinforced Pipe (FFRP), and
- Spray-in-Place Pipe (SIPP).

For pressure pipe applications, the condition of the host pipe and the technical objectives for rehabilitation must be considered. AWWA's Structural Classifications of Pressure Pipe Lining[1] defines four (4) classifications for pressure pipe linings. Table 1 provides an overview of each classification for reference. The rehabilitation options and associated structural classifications will be addressed in further detail in the proceeding sections.

Table 1: AWWA Structural Classification Objectives

Lining System Characteristic	Non-Structural	Semi-Structural (Interactive)		Fully Structural
	Internal coating	Hole span	Hole span + ring stiffness	Structural resistance for all specified loads (internal & external)
	Class I	Class II	Class III	Class IV
Internal corrosion protection	✓	✓	✓	✓
Long-term adhesion to the host pipe	See Note 1 Below	✓	See Note 2 Below	See Note 2 Below
Hole span at MAOP		✓	✓	✓
Inherent ring stiffness (hydrostatic pressure or vacuum loads only)	See Note 1 Below	See Note 1 Below	✓	✓
Water tightness (positive connection to service taps and sealed at termination points or other discontinuities)		✓	✓	✓
Inherent ring stiffness (all static and dynamic external, hydrostatic, and vacuum loads)				✓
Pressure rating of lining ≥ MAOP of host pipe				✓
Lining survives anticipated host pipe failures				✓

1 The owner/engineer must specify whether vacuum loads exist. This is addressed through reliable adhesion to the host pipe, which is a characteristic of all Class II and some Class I linings, or inherent ring stiffness.
2 For Class III and IV linings, adhesion is not required to develop ring stiffness. However, it may be necessary to achieve a watertight seal (for example, at services and lining terminations). There are also situations where adhesion is not desirable, such as applications with broad temperature swings and in Class IV linings where the host pipe is anticipated to experience brittle failure modes.

3.1 Cured-in-Place Pipe (CIPP)

CIPP liners are constructed by inverting and curing a resin-impregnated felt liner within the host pipe to form a new close-fit pipe within the existing host pipe. CIPP may be designed for all deterioration states, defined by ASTM F1216 and ASCE MOP 145, as they can be designed to support both external hydrostatic pressure and overburden

[1] *Structural Classifications of Pressure Linings, Suggested Protocol for Product Classification, American Water Works Association, 2019.*

loads. CIPP liners are generally available in diameters ranging from 100 mm through to 3000 mm. Two (2) common curing methods for CIPP are steam curing and water curing, both requiring direct access to the host pipe.

For typical water main rehabilitation, the liner system can rely on achieving a localized bond with the host pipe or mechanical connectors to maintain hydrostatic integrity at service connection cut-outs. Based on a review of record drawings and the City of Winnipeg's GIS data, it is believed that there are no service connections on the feeder main. This should be confirmed in detailed design. If confirmed, the need for bond and hydrostatic integrity of the liner-to-pipe annulus is limited to the upstream and downstream ends of the liner and transition to the host pipe. This greatly simplifies host pipe preparation requirements. Cleaning of the feeder main would be focused on removing hard debris to maximize the rehabilitated pipeline bore, achieving a close fit with the host pipe, reducing wrinkling in the liner, and minimizing stress concentrations between the liner of the host pipe.

CIPP liners for potable water applications need to be NSF 61 listed systems. This typically limits potential lining systems to VOC (volatile organic compounds) free epoxy resins. Epoxy resin liners are typically wetout on site prior to inversion and cured with hot water or steam. When temperature cured, epoxy resins have a limited shelf life once wetout. This limits the installation time and consequently, the maximum inversion length.

3.1.1 Pipeline Access

Installation of CIPP requires full access to both ends of the feeder main to facilitate cleaning, liner inversion, liner terminations, and installation of end seals. The simplest form of pipeline access for the Goulet-Doucet Crossing can be achieved by removal of the existing launch wyes on each side of the crossing and utilizing the existing pipeline access for the installation of a CIPP liner. During our discussions with industry representatives, risks were identified with utilizing the wyes for access. Further details are included in Section 3.1.5.

Alternatively, new pipeline access would need to be developed on the riverbank. This would include mobilizing equipment and material to the riverbank, excavating the pipe at the transition from AC to steel, removing a section of pipe to facilitate lining, followed by closures, backfill and restoration of the riverbank. While this option would create more disturbance to the riverbank and require new access to be developed, it would reduce the length of pipeline to be rehabilitated by half when compared to access from the existing wyes.

3.1.2 Pipeline Cleaning and Dewatering

Pipeline cleaning for pressure liner applications typically requires a higher degree of effort compared to gravity liner installations. Gravity liner installations require sufficient cleaning to remove any significant geometric defects, such as build up of debris, to ensure proper installation. Generally, smaller defects such as encrustation at joints can be left in place to be lined over. Cleaning for pressure pipelines typically involves more rigorous operations, specifically in cleaning the pipe walls to avoid the development of stress concentrations on the liner. Where bond is required to the host pipe, cleaning to a recognized surface preparation standard is required to maximize bond potential. It is not anticipated that bond to the host pipe will be a requirement for the Goulet-Doucet FM Crossing, however, it is anticipated that cleaning requirements will be more onerous than for a gravity installation.

Epoxy resins typically used for pressure lining applications require the host pipe to be essentially dry prior to inversion. River crossings present additional challenges regarding dewatering due to their inherent geometry, potential for leakage, and buoyancy potential. If an active leak were to be discovered during cleaning operations, a pre-liner could be installed to restore hydrostatic integrity prior to lining. Regardless of watertightness of the pipe, a contractor may choose to install a pre-liner as a conservative measure to ensure proper installation and curing.

Buoyancy forces must be considered when dewatering river crossings. Pipe floatation was reviewed as a part of the HRRC phase one (1) inspection analysis by AECOM (2016). The report assumed a crossing with full flow, and 10 % air entrainment, with a factor of safety calculated to be 11. However, for the purposes of dewatering the

crossing for CIPP installation, AECOM completed additional analysis with the pipe under a fully dewatered state as presented in Table 2.

Table 2: Flotation Analysis of the Pipeline

Minimum Depth of Cover (m)	Operation Condition	FoS Against Flotation	Source
2.4	Full, 10% Air Entrainment	11.05	2016 HRRC1 Report Basis
2.4	Empty	10.24	2024 Analysis - Minimum depth of cover from records
1	Empty	4.68	2024 Analysis - Sensitivity to lower cover (1 m)
0.5	Empty	2.69	2024 Analysis - Sensitivity to lower cover (0.5 m)

The analysis shows that the crossing can be dewatered in its current state to facilitate the installation of a CIPP liner with sufficient factor of safety against flotation.

3.1.3 Geometrical Considerations

As the Goulet-Doucet crossing contains several moderate bends, there are considerations to be made when assessing the feasibility of CIPP lining. These considerations include:

- Inversion risk:
  - Inversion of CIPP around bends increases the overall risk associated with the inversion process both in terms of navigation of the bend, and potential for increased friction during inversion.
  - Increased pressures required to invert the liner across the crossing.
  - Potential risk of issues during inversion would be anticipated to be reflected in bid price from a potential supplier.

- Wrinkling at bends:
  - Can reduce the hydraulic capacity of the liner.
  - Can reduce the ability to withstand full hoop stress depending on design of specific liner.

The existing bends along the Goulet-Doucet FM Crossing present technology specific challenges that require careful consideration during detailed design.

3.1.4 Interface with House Services

AECOM completed a review of services that may impact the work of this project based on current GIS, construction record drawings, and UGS records. It is assumed that there are no house services directly connected to the feeder main, however, the City's GIS does not explicitly show this as shown in Figure 2. It should be confirmed that the services from houses 475 and 471 Goulet Street are connected to the water main on the south side of Goulet Street as opposed to a direct connection to the water main.

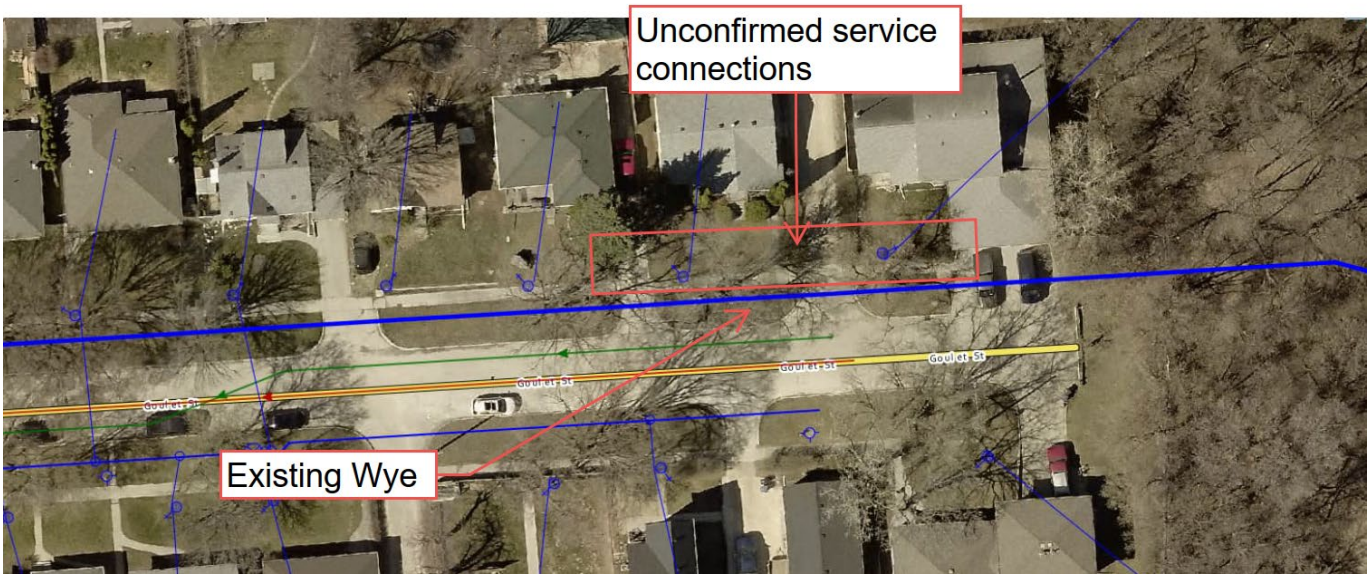


Figure 2: City of Winnipeg GIS - Water Services

3.1.5 Industry Consultation

AECOM consulted with the following CIPP lining contractors to review the project and seek feedback:

- Insituform Technologies Ltd.
- FER-PAL Construction Ltd.

Both contractors expressed that CIPP would be a feasible rehabilitation option, but not without risk. Insituform expressed several risks that were primarily related to pipeline geometry and bends, specifically a strong preference to avoid lining through the 22.5 degree horizontal bend on the west side of the crossing and the 16.5 degree bend on the east side of the crossing. This would eliminate the option of pipeline access from the existing wyes and would require the development of new pipeline access on the riverbank. Temporary construction access, clearing and grubbing of riverbank vegetation, and additional permitting and regulatory reviews would be required to facilitate access.

There was also a strong preference to limit the rehabilitation to the steel pipeline to avoid complications related to the transition between differing inside diameters of AC and steel pipe. In this case, pipeline access would be developed on the riverbank at the transition locations between AC and steel pipe.

Insituform indicated that lining would likely utilize a pre-liner and water inversion. The length of the crossing was not an issue. An inversion tower or scaffolding may be required due to the grade change and possible water inversion, which would require additional space on the riverbank.

3.1.6 Summary

AECOM's preliminary design review shows CIPP to be a feasible candidate for successful rehabilitation of the crossing, however, with considerable risk due to pipeline geometry that requires further investigation. Pipeline access would need to be developed on the riverbank to avoid the larger horizontal bends and to limit the extent of rehabilitation to the steel pipeline only.

3.2 Flexible Fabric Reinforced Pipe (FFRP)

Pulled-in-place FFRP liners are a flexible close-fit lining technology that consists of a multi-layered reinforced fabric bag which is pulled into place inside the host pipe. While originally developed by Insituform as a product called Thermopipe®, the most common form of this technology today is manufactured by Primus Line.

FFRP is a pulled in place liner, typically manufactured to the desired diameter and delivered to site on a spool. The liner is installed by pulling it through the host pipe. Once installed, the liner is inflated and unfolded inside the pipe using compressed air. Specialized end seals are installed, and the line is then pressure tested. Figure 3 shows a section view of a typical Primus Line FFRP product.

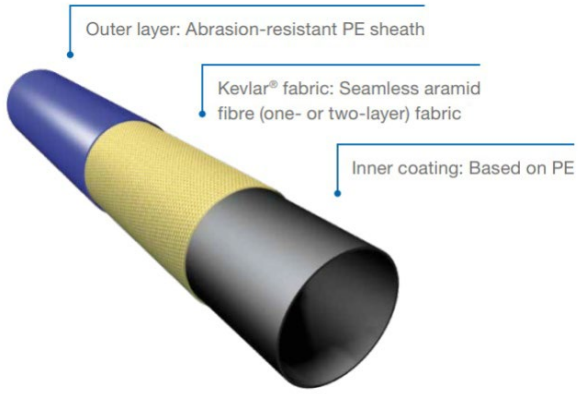


Figure 3: Typical Primus Line Cross-Section

FFRP products can be suitable for hole spanning, however, they do not have inherent ring stiffness. Therefore, it would be considered closer to a Class II liner than a Class III liner, although the product does not utilize adhesion to bond to the host pipe. The HRRC inspection results noted no significant structural deterioration of the steel host pipe, but a loss of internal coating, which could result in an acceleration of potential corrosion. Typical corrosion processes for steel pipe involve pitting corrosion. Pitting corrosion can compromise the hydrostatic integrity of the pipeline but often does not impact overall structural integrity of the pipe with respect external load resistance and its hoop stress capacity (e.g. the pipe leaks but is not at risk of collapse and can often be relined with interactive as opposed to independent lining systems). While an FFRP liner would not arrest corrosion of the host pipe, it would restore long term hydrostatic integrity of the pipe and prevent any future leaks.

FFRP liners are typically used in high pressure water supply applications such as municipal supply, process water, and fire water systems, so pressure capacity is not a limiting condition. Cleaning for the installation for FFRP liners is typically less extensive than that described above for CIPP pressure applications and focuses on minimizing the risk of damaging the liner during installation.

FFRP liners are capable of being installed through multiple vertical and horizontal bends of up to 45 degrees with minimal concern, provided they are free of or prepped to remove abrasion points such as tuberculation. The operating pressure rating of the liner will be impacted by the highest degree of bend that the liner traverses through.

Type Testing has been completed on Primus Line products to confirm compliance with a minimum design life of 50 years.

3.2.1 Access Considerations

Installation of FFRP requires full access to both ends of the feeder main to facilitate cleaning, liner installation, and installation of disassembly joints and termination couplers. The simplest access point for FFRP would be to utilize the location of the existing wyes. The wyes would be removed to facilitate the installation and the pipe would be

restored upon completion. This option requires a longer liner but simplifies installation access and restoration. Consideration could also be given to shortening the liner to include the steel portion of the pipeline only, however, based on our discussions with Prima Pipe, costs savings associated with a shorter liner may not be overly significant due to the high cost of mobilization. Further, savings could also be offset by the costs associated with developing new access. For the sake of comparison, two (2) cost estimates have been developed for the FFRP option; one (1) assuming access from the wyes and one (1) assuming access from the riverbank. These are presented in Section 3.4.

3.2.2 Cleaning Considerations

Cleaning for the installation of FFRP is less extensive than that described above for CIPP pressure applications. Since bond to the host pipe is not a requirement, cleaning and preparation works typically involve removal of hard debris, sharp points, and welds that could potentially tear the liner during pull-through. Cleaning to bare steel is not required.

3.2.3 Dewatering Considerations

Adequate host pipe preparation is key to ensuring that the liner is not damaged when it is installed. The provision of CCTV along the length to be lined should be included in the scope of work to ascertain any potential risks prior to install. Full dewatering of the pipeline would be required to achieve successful pre-installation inspections.

Buoyancy concerns related to dewatering of the Goulet-Doucet Crossing were discussed in Section 3.1.2. AECOM does not foresee any concerns with flotation as a result of dewatering the crossing.

3.2.4 Geometric Considerations

The internal pressure rating of Primus Line is derated based on the maximum bend angle anticipated that the liner would traverse. The existing horizontal 22.5 degree bend on the west side of the crossing is the largest bend that a Primus Liner would need to traverse assuming access is obtained from the existing inspection wyes. AECOM's preliminary assessment assumes the installation of a MD400 style Primus Line liner, which is typically designed with a maximum operating pressure of 261 PSI. Derating the MD400 liner for a 23 degree bend would result in a remaining maximum allowable operating pressure of approximately 200 PSI. This conclusion is based on past experience and literature available at the time of writing and should be confirmed during detailed design.

The pipeline has an inside diameter of 387.34 mm, whereas the inside diameter of the MD400 liner is 342 mm. Due to the reduced inside diameter of the pipe, AECOM requested that the City complete a hydraulic simulation of the river crossing with the reduced pipe ID. Several scenarios were reviewed with lined lengths ranging from 107.3 m to 171.5 m. The shorter length represents lining the steel pipe only, whereas the longer length represents lining the steel and AC portions of the pipeline between the existing access wyes. Matt Nikkel of WWD advised via email on January 8, 2024 that based on his modelling, he had no concerns with the downsized inside diameter. He noted that due to the expected improvement in the C-Factor for the steel portion of the lining (approximately 70 for steel vs. 130 for Primus Line), the reduced diameter has minor impact on the head loss of the lined section during expected peak flows. The 171.5 m lined length results in a head loss of less than 0.5 psi with no impact on fire flow capacity. He also noted that shorter lined lengths may actually improve hydraulic capacity of the pipeline.

3.2.5 Interface with House Services

FFRP liners are not designed to accommodate the connection of adjacent water services. AECOM completed a review of services that may impact the work of this project based on current GIS, construction record drawings, and UGS records. It is assumed that there are no house services directly connected to the feeder main, however, the City's GIS does not explicitly show this as shown in Figure 2. It should be confirmed that the services from houses

475 and 471 Goulet Street are connected to the water main on the south side of Goulet Street as opposed to a direct connection to the water main as part of detailed design.

3.2.6 Industry Consultation

AECOM consulted with the following FFRP lining contractors to review the project and seek feedback:

- Prima Pipe Solutions Ltd. (Formerly known as LV Energy Services Ltd.)
- Primus Line International

Prima Pipe Solutions has experience with the two (2) successful Primus Line installations in the City; the Maryland Water Main Crossing of the Assiniboine River (Tri-Core Projects as Prime Contractor) and the Kildonan-Redwood Feeder Main Crossing of the Red River (Nelson River Construction as Prime Contractor). AECOM provided design and contract administration for both projects. Prima Pipe Installations noted that they have also installed seven (7) successful installations in the past year in central Ontario.

Prima Pipe Solutions did not have any major concerns with the feasibility of installation provided that there are no issues with cleaning and CCTV inspection. They confirmed that they would be able to line the full length of the crossing from the inspection wye on Goulet Street to the inspection wye on Doucet Street, or vice versa. This would include portions of the AC pipeline. They anticipate that cleaning would include the use of scraper pigs and disks, similar to the previous installations completed for the City. Their preferred approach would be to dewater the pipeline and use CCTV inspection to determine risk profile and preparation requirements to allow for towing of pigs. Cleaning and installation approach would be from west (Goulet Street) to east (Doucet Street) with the intent of traversing the 22.5 degree horizontal bend on the west bank first to minimize risk. The footprint of the excavation that Prima Pipe Solutions would require for pipeline access is ideally 10 ft by 10 ft; however, could be reduced to 8 ft by 8 ft with further considerations.

The estimated lead time for procurement of a liner was 12-14 weeks shipped from Germany. Cleaning would require approximately 3 days and 4 days for installation of the liner and testing. Other civils works such as excavations and development of pipe access would be in addition to the schedule estimate provided by Prima Pipe Solutions.

3.2.7 Summary

AECOM's preliminary design review shows FFRP to be a feasible candidate for successful rehabilitation of the crossing with minimal risk. Access for installation could utilize either the existing wyes on each side of the crossing or new development could be developed on the riverbank. Geometry of the pipeline would affect the pressure rating of the liner, but in AECOM's review it appears that the liner would have sufficient capacity even with pressure deratings.

3.3 Spray-in-Place Pipe (SIPP)

Spray-in-place pipe or SIPP in this report refers to the application of a sprayed in place polymeric lining in accordance with AWWA C620. The standard refers to SIPP as an in situ polymeric lining method that utilizes a two-component epoxy resin system that is pumped under pressure through a spray head. The two (2) components are mixed at the spray head just prior to application to the pipe wall. Compared to spray applied cement mortar coatings, polymeric liners cure more rapidly, have more desirable hydraulic roughness factors, and are more resilient to chemical breakdown in most systems.

Polymeric linings are suitable for a large variety of applications and serve to protect the interior of the host pipe from corrosion and related deterioration. Compared to other lining alternatives, design of SIPP to span gaps within the host pipe presents challenges from a design perspective. While different polymeric mixes are available and the

general technology continues to evolve, there are limitations to the overall benefits SIPP compared to alternative solutions currently available.

The application techniques for SIPP range from manual applications (i.e. person-entry) to fully automated systems. SIPP products require a reliable bond to the host pipe. To achieve this, the level of cleaning and dewatering are much higher than both CIPP and FFRP systems. The existing interior coating of the pipe must be completely removed through cleaning and the pipe must be dewatered to a point where it is essentially dry, which would be difficult to achieve.

3.3.1 Access Considerations

Access for SIPP lining would require similar construction footprints to those for CIPP or FFRP products. While limiting access to the steel portion of the crossing would minimize interior preparation requirements to a degree, most concerns with cleaning and preparation remain with the steel portion of the crossing and the level of effort required to ensure that the interior coating is properly removed.

3.3.2 Cleaning Considerations

As discussed above, cleaning and preparation for SIPP lining would require much more rigorous methods when compared to CIPP or FFRP. SIPP requires bond to the host pipe and due to the existing interior coating within the steel portion of the crossing, may require the use of multiple cleaning techniques (jetting, chain flail, pigging) and CCTV to confirm the suitability of SIPP application prior to lining. Significant costs would be anticipated with these efforts, and if SIPP were found to not be a viable option after cleaning, re-design or re-tendering of the project may be required.

3.3.3 Dewatering Considerations

Application of SIPP products would require the pipe to be fully cleaned, dewatered, and allowed to dry prior to application. As discussed previously, the pipe can be safely dewatered without risk of flotation, however, achieving a dry state could be challenging in a crossing configuration.

3.3.4 Geometric Considerations

Concerns related to bends within the crossing for application of SIPP are generally minimal. Based on industry consultation, the application platforms that would be utilized are able to navigate bends.

3.3.5 Interface with House Services

SIPP liners can accommodate adjacent water services. As discussed previously, it is not anticipated that there are any service connections to the feeder main, however, this needs to be confirmed for any of the options.

3.3.6 Industry Consultation

AECOM consulted with the following SIPP lining contractors to review the project and seek feedback:

- Envirologics Engineering Inc. (Envirologics)

The major concerns that came out of our discussion were related to cleaning and pipe preparation. In EnviroLogic's experience, the existence of coal tar epoxy and the difficulty in fully removing the coating would introduce serious concerns related to achieving bond. A high level of cleaning would be required, and it would not be guaranteed that the entirety of the coating could be removed. There were also concerns with the aggressiveness of the cleaning, the potential for damage to both the AC and steel portions of the pipeline, and the handling and safe disposal of the

coal tar material. The general conclusion was that SIPP would not be an ideal candidate for rehabilitation for this crossing.

3.3.7 Summary

AECOM's preliminary design review shows SIPP to be a poor candidate for rehabilitation of the crossing and would not be a recommended option due to the level of cleaning and the risks associated with not being able to achieve suitable pipe preparation to ensure proper bond of the liner.

3.4 Cost Estimates

Cost estimates have been prepared in accordance with the AACE International Cost Estimate Classification System. Based on the AACE classification system, Class 3 estimates have been developed for the two (2) feasible rehabilitation options and are presented in Table 3.

Table 3: AACE Class 3 Cost Estimate

Rehabilitation Option	Estimate
CIPP (Riverbank Access)	$716,775.00
FFRP (Street Access)	$665,530.00
FFRP (Riverbank Access)	$547,750.00

A breakdown of the cost estimate is included in Appendix B.

The cost estimates include all identified civil works and are based on recent tender pricing in the City of Winnipeg. AECOM received separate budgetary pricing for supply and install of FFRP from Primus Line and Prima Pipe (civil works not included), which was reviewed and accounted for in the estimate. AECOM requested budgetary pricing for the CIPP option from Insituform Technologies and FER-PAL Construction. Insituform Technologies was unable to provide budgetary pricing without pursuing design of the liner to a level beyond the scope of AECOM's assignment. FER-PAL Construction provided budgetary pricing for the CIPP option; however, pricing was well below market price when compared to recent tender pricing in the City of Winnipeg and did not factor much into the Class 3 estimate.

4. Conclusions and Recommendations

Table 4 provides a comparison of differentiating factors for all three (3) rehabilitation options considered.

Table 4: Comparison of Lining Options

Criteria	Cured-in-Place Pipe (CIPP)	Flexible Fabric Reinforced Pipe (FFRP)	Spray-in-Place Pipe (SIPP)
AWWA Classification	Class III or Class IV, Semi-Structural to Fully Structural	Class I or Class II, Non-Structural or Semi-Structural	Class I, Non-Structural
Pipeline Access and Location	Full pipe access from excavation on riverbank	Full pipe access from excavation at street level or riverbank	Full pipe access from excavation on street level or riverbank (dependent on type of cleaning)
Cleaning Requirements	Hard Debris Removal	Hard Debris Removal	Cleaned to Bare Pipe
Pipeline Dewatering	Required	Required for Pre-Install CCTV Inspection	Required
Geometrical Considerations	Bends (install risk)	Bends (pressure derating)	No major issues.
House Services Accommodated (if required)	Yes	No	Yes
Environmental Risk	High (riverbank work)	Low (street level work)	High (riverbank work)
Installation Risk	High (pipeline geometry, pipeline access)	Low	High (extensive cleaning, dry pipe, pipeline access)
Industry Feedback	Feasible, with risk mitigation	Feasible, typical install	Feasible, not ideal install conditions
Effective Design Life	50+ Years	50+ Years	50+ Years
Cost	Riverbank Access: $716,775.00	Street Access: $665,530.00 Riverbank Access: $547,750.00	N/A

AECOM recommends the use of FFRP for the rehabilitation of the Goulet-Doucet FM on the following basis:

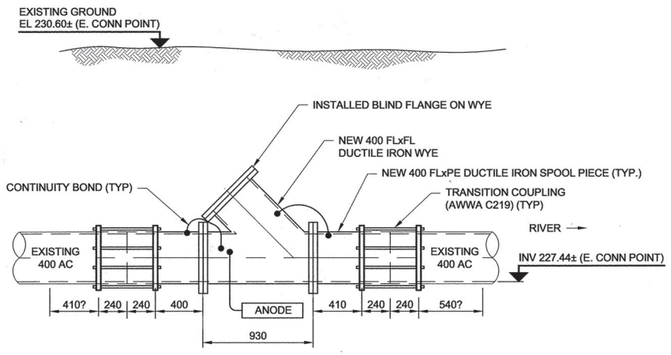
- Low level of installation risk compared to alternatives,
- Straight forward pre-installation pipe cleaning and preparation,
- Comparable design life to alternatives,
- Recent history with installations in Winnipeg,
- Compact construction footprint and ability to complete work at street level or on the riverbank, and
- Lowest AACE Class 3 Cost Estimate.

CIPP remains a viable option for rehabilitation of river crossings, particularly for those with host pipes that are structurally deficient and require the use of a Class IV liner. However, it carries a larger risk profile, will require a larger and more disruptive construction footprint, and has a comparatively higher cost than the FFRP option, even with a shorter liner installation.

A preliminary design drawing package (30%) is included in Appendix C.

Appendix A

Goulet-Doucet Feeder Main Access Modifications for HRRC – Record Drawing



DETAIL 'A'
LAUNCH WYE INSTALLATION
AT GOULET ST

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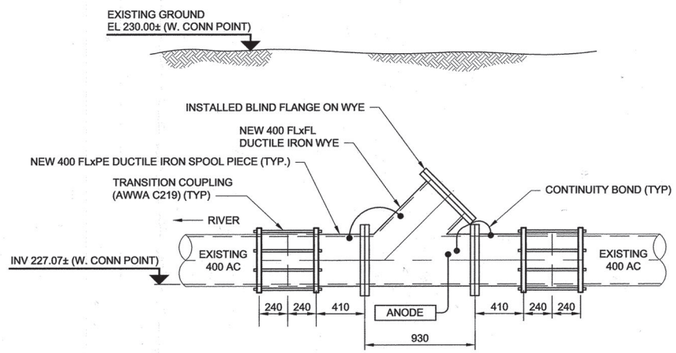
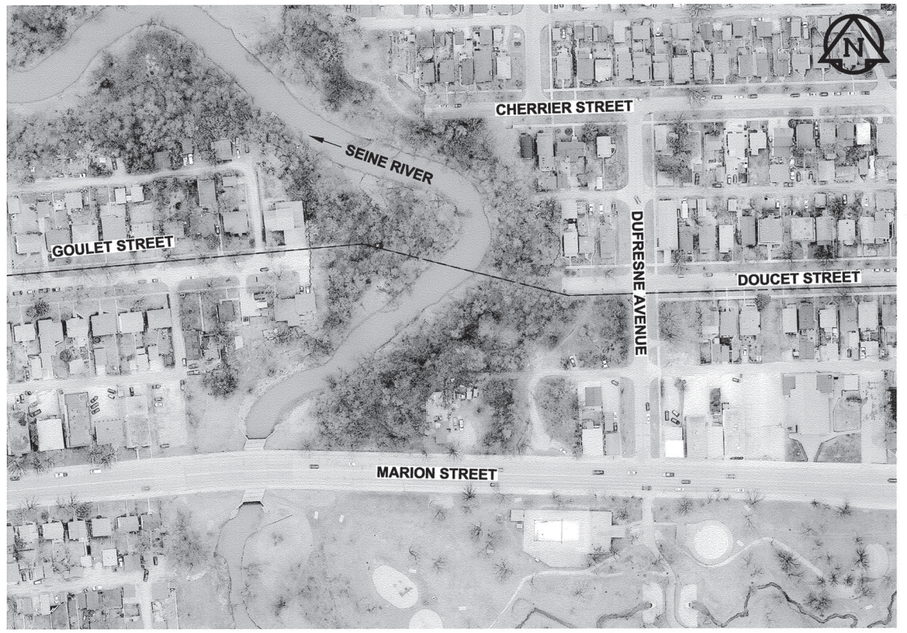
1:25



DETAIL 'B'
LAUNCH WYE INSTALLATION
AT DOUCET ST

0 625 1250 mm
1:25



SITE PLAN
Scale 1:1500
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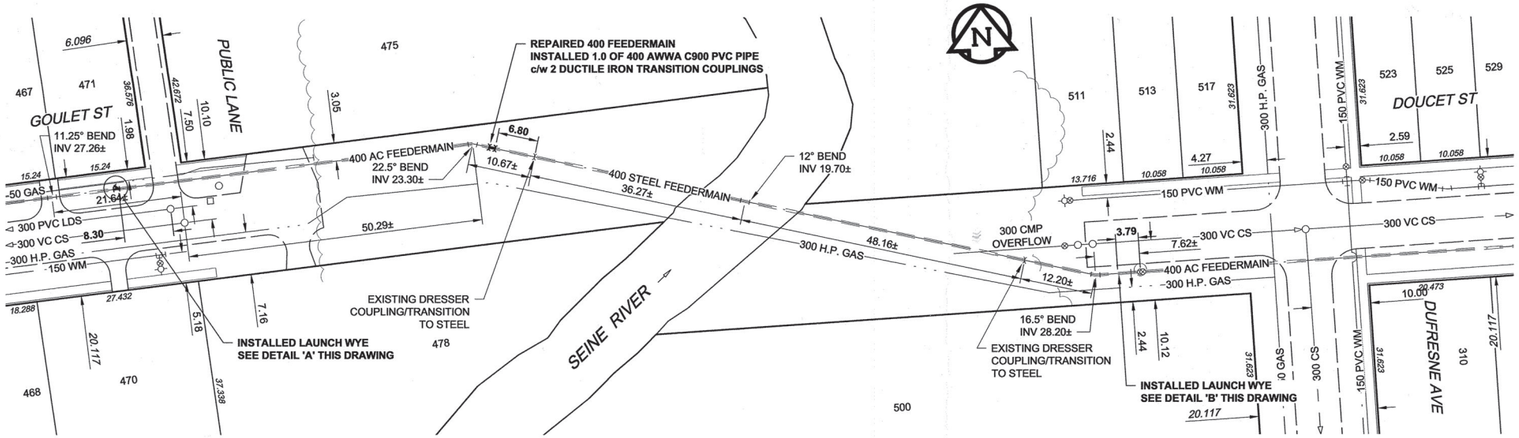


PLAN
Scale 1:500
0 12.5 25 m

MATERIAL LIST

ITEM	MANUFACTURER	MATERIAL SPECIFICATION	SPECIAL FEATURES
WATER WORKS			
400 PVC PIPE (350 to 500)	IPEX INC.	AWWA C905 CSA B137.3	"BIG BRUTE" DR-18
IRON COUPLINGS (TRANSITION) (400)	ROMAC INDUSTRIES INC.	AWWA C219 AWWA C213 ASTM A536 GRADE 65-45-12 MODEL "501"	FBE-COATED D.I. SLEEVE & END RINGS TYPE 304 S.S. NUTS, BOLTS, WASHERS AND DI-ELECTRIC WASHERS
VALVE STEM EXTENSION	W.D. VALVE BOXES LTD.	CONFORMS TO AP-002	TOP MARKED "AIL" & STENCILED "WDVB"
400 DUCTILE IRON SPOOL PIECE (FLANGE X PLAIN END)	METALFIT INC.	AWWA C115, AWWA C104, AWWA C210	EPOXY COATED CEMENT MORTAR LINED
400 DUCTILE IRON WYE (FLANGED)	METALFIT INC.	AWWA C111, AWWA C104, AWWA C210	EPOXY COATED CEMENT MORTAR LINED
400 DUCTILE IRON BLIND FLANGE	METALFIT INC.	AWWA C111, AWWA C104, AWWA C210	EPOXY COATED CEMENT MORTAR LINED
ANODES - ZINC	THE CANADA METAL (PACIFIC) LTD.	ASTM B418 - TYPE II	ZINC WEIGHT 10.9 kg
PETROLATUM TAPE CORROSION PROTECTION	DENSO NORTH AMERICA	AWWA C2017	PROFILING MASTIC PETROLATUM TAPE OUTER WRAP
CONTRACTOR:	TRI CORE PROJECTS MANITOBA LTD.		
CONSTRUCTION PERIOD:	JULY to NOVEMBER 2015		
FIELD BOOK NO.:	N/A		

APEGM
Certificate of Authorization
AECOM Canada Ltd.
No. 4671 Date: Mar 14/17

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

RECORD DRAWING

BID OPPORTUNITY NO. 289-2015

EXISTING	LEGEND - PLAN	NEW	EXISTING	LEGEND - PLAN	NEW	EXISTING	LEGEND - PROFILE	NEW
150 WM	WATERMAIN	150 WM		CURB STOP		150 WM	WATERMAIN	150 WM
	HYDRANT			REDUCER			HYDRANT	
	VALVE			COUPLING			VALVE	
300 LDS	LAND DRAINAGE SEWER	300 LDS		ANODE		300 LDS	LAND DRAINAGE SEWER	300 LDS
250 WWS	WASTE WATER SEWER	250 WWS		HYDRO		250 WWS	WASTE WATER SEWER	250 WWS
	MANHOLE			MTS			PAVEMENT CROWN	
	CATCH BASIN			GAS			N/W PROPERTY LINE	
	CURB INLET			TESTHOLE			S/E PROPERTY LINE	
	CULVERT			LAMP STANDARD			N/W GUTTER	
	PIPE ABANDONMENTS			TREE			S/E GUTTER	
	SURVEY BAR							

LOCATION APPROVED
UNDERGROUND STRUCTURES

SUPR. U/G STRUCTURES COMMITTEE — DATE

NOTE:
LOCATION OF UNDERGROUND STRUCTURES AS SHOWN ARE BASED ON THE BEST INFORMATION AVAILABLE. BUT NO GUARANTEE IS GIVEN THAT ALL EXISTING UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL SERVICES MUST BE OBTAINED FROM THE INDIVIDUAL UTILITIES BEFORE PROCEEDING WITH CONSTRUCTION.

NO.	REVISIONS	YY/MM/DD	BY
2	ISSUED FOR RECORD	17/02/24	WJd
1	ADDED TEMPORARY PLUG	15/05/05	WJd
0	ISSUED FOR CONSTRUCTION	15/04/16	ADL

AECOM

DESIGNED BY	ADB	CHECKED BY	
DRAWN BY	ADL	APPROVED BY	
HOR. SCALE	AS NOTED	RELEASED FOR CONSTRUCTION	
VERT. SCALE	N/A		
DATE		DATE	

PROFESSIONAL'S SEAL
PROVINCE OF MANITOBA
W.J.S. BRAUN
Member
24192
Mar 14/17
REGISTERED PROFESSIONAL ENGINEER

CONSULTANT DRAWING NO.
60270487-SHT-30-0000-C-1002

Winnipeg

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

PROVISION OF PIPELINE ACCESS MODIFICATIONS, CLEANING AND SUPPORT SERVICES FOR WATER MAIN RIVER CROSSING INSPECTIONS

SITE 10

GOULET - DOUCET WATER MAIN

SHEET 1 OF 3

CITY DRAWING NUMBER

D-13302 REV 2

AECOM REVIEW | DRFT CHK 4B

AECOM

Appendix B

Cost Estimates

Goulet-Doucet Feeder Main Rehabilitation - Preliminary Cost Estimate
Cured-in-Place Pipe - Pipeline Access on Riverbank

UNIT PRICES

Item	Description	Spec. Ref	Unit	Approximate Quantity	Unit Price	Amount
1.	**Mobilization and Demobilization**		L.S.	1	100,000.00	100,000.00
2.	**Pipeline Access**					
(a)	East Access - On Riverbank		L.S.	1	50,000.00	50,000.00
(b)	West Access - On Riverbank		L.S.	1	60,000.00	60,000.00
3.	**Feeder Main Cleaning and Lining Preparation Work**					
(a)	Daily Cleaning Rate, up to 10 Hours		Day	5	35,000.00	175,000.00
(b)	Overtime Rate (in excess of 10 hours per day)		Hour	8	4,000.00	32,000.00
4.	**Pipeline Inspection - 400 mm**					
(a)	Pre-Cleaning		m	85.00	225.00	19,125.00
(b)	Pre-Lining		m	85.00	225.00	19,125.00
(c)	Post-Lining		m	85.00	225.00	19,125.00
5.	**Supply and Install 400 mm CIPP Liner**		m	85.00	2,640.00	224,400.00
6.	**Restoration**					
(a)	Supply and Placement of Sod using Imported Topsoil		m^2	600.00	30.00	18,000.00

TOTAL BID PRICE (GST and MRST extra) (in numbers) $716,775.00

Name of Bidder

Name of Bidder

Goulet-Doucet Feeder Main Rehabilitation - Preliminary Cost Estimate
Flexible Fabric Reinforced Liner - Pipeline Access on Street

UNIT PRICES

Item	Description	Spec. Ref	Unit	Approximate Quantity	Unit Price	Amount
1.	**Mobilization and Demobilization**		L.S.	1	100,000.00	100,000.00
2.	**Pipeline Access**					
(a)	East Access - On Street/Boulevard		L.S.	1	20,000.00	20,000.00
(b)	West Access - On Street/Boulevard		L.S.	1	20,000.00	20,000.00
3.	**Feeder Main Cleaning and Lining Preparation Work**					
(a)	Daily Cleaning Rate, up to 10 Hours		Day	3	35,000.00	105,000.00
(b)	Overtime Rate (in excess of 10 hours per day)		Hour	8	4,000.00	32,000.00
4.	**Pipeline Inspection - 400 mm**					
(a)	Pre-Cleaning		m	171.30	225.00	38,542.50
(b)	Pre-Lining		m	171.30	225.00	38,542.50
5.	**Supply and Install 400 mm FFRP Liner**		m	171.30	1,650.00	282,645.00
6.	**Restoration**					
(a)	Supply and Placement of Sod using Imported Topsoil		m^2	60.00	30.00	1,800.00
(b)	Concrete Barrier Curb Renewal		m	10.00	200.00	2,000.00
(c)	Partial Slab Patches - 150 Reinforced Concrete Pavement		m^2	100.00	250.00	25,000.00

TOTAL BID PRICE (GST and MRST extra) (in numbers) $665,530.00

Name of Bidder

Name of Bidder

Goulet-Doucet Feeder Main Rehabilitation - Preliminary Cost Estimate
Flexible Fabric Reinforced Liner - Pipeline Access on Riverbank

UNIT PRICES

Item	Description	Spec. Ref	Unit	Approximate Quantity	Unit Price	Amount
1.	**Mobilization and Demobilization**		L.S.	1	100,000.00	100,000.00
2.	**Pipeline Access**					
(a)	East Access - On Riverbank		L.S.	1	50,000.00	50,000.00
(b)	West Access - On Riverbank		L.S.	1	60,000.00	60,000.00
3.	**Feeder Main Cleaning and Lining Preparation Work**					
(a)	Daily Cleaning Rate, up to 10 Hours		Day	3	35,000.00	105,000.00
(b)	Overtime Rate (in excess of 10 hours per day)		Hour	8	4,000.00	32,000.00
4.	**Pipeline Inspection - 400 mm**					
(a)	Pre-Cleaning		m	85.00	225.00	19,125.00
(b)	Pre-Lining		m	85.00	225.00	19,125.00
5.	**Supply and Install 400 mm FFRP Liner**		m	85.00	1,700.00	144,500.00
6.	**Restoration**					
(a)	Supply and Placement of Sod using Imported Topsoil		m^2	600.00	30.00	18,000.00

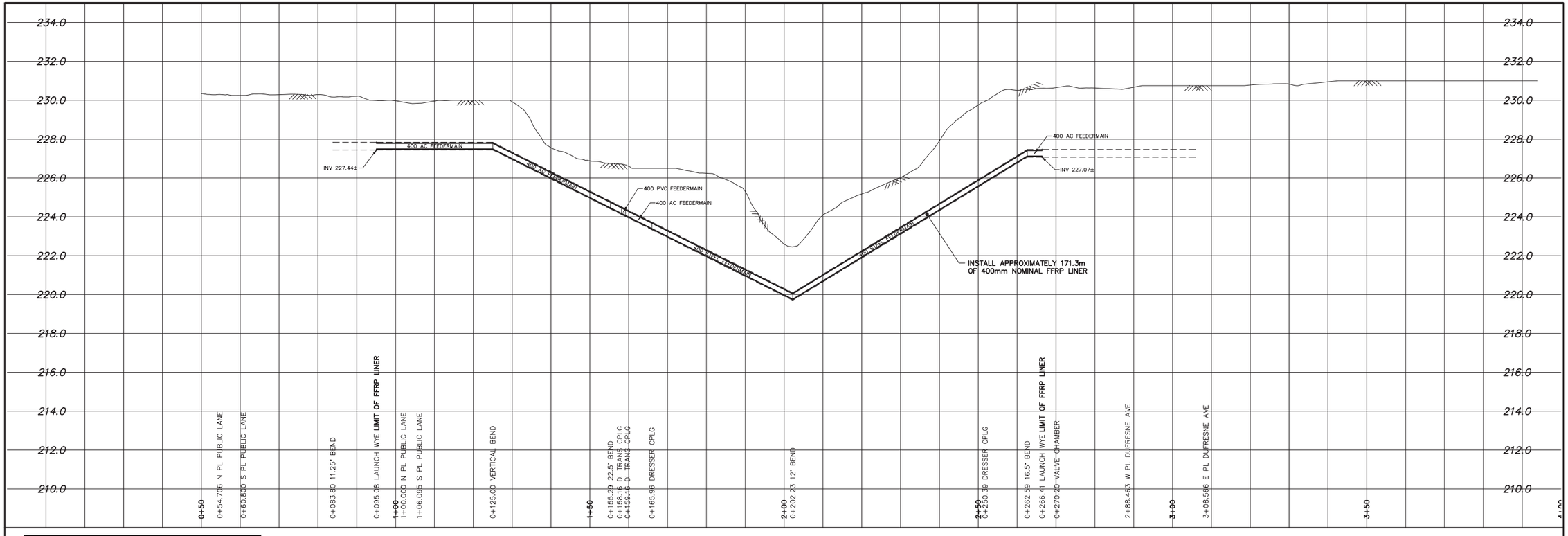
TOTAL BID PRICE (GST and MRST extra) (in numbers) $547,750.00

Name of Bidder

Name of Bidder

Appendix C

30% Design Drawings



NOTE: CHAINAGES SHOWN ARE ALONG ℄ OF 400 FEEDERMAIN

N

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

0.0 10.0 20.0 30.0 40.0 50.0

WARNING

IF POWER EQUIPMENT OR EXPLOSIVES ARE TO BE USED FOR EXCAVATION ON THIS PROJECT THE CONTRACTOR MUST:

1) NOTIFY THE GAS COMPANY OF THE PROPOSED LOCATION OF EXCAVATION.

2) TAKE PRECAUTION TO AVOID DAMAGE TO GAS COMPANY INSTALLATIONS.

SEE PROVINCIAL REGULATION 210/72 FOR DETAILS

LOCATION APPROVED
UNDERGROUND STRUCTURES

SUPV. U/G STRUCTURES COMMITTEE — DATE

NOTE:
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B.M.
ELEV.

CONSTRUCTION COMPLETION DATE: YYYY MM DD

NO.	REVISIONS	DATE	BY
A	ISSUED FOR 30% REVIEW	24/03/20	ADL

AECOM

DESIGNED BY	JAT	CHECKED BY	MGM
DRAWN BY	ADL	APPROVED BY	
SCALE: HORIZONTAL 1:500 VERTICAL 1:100		RELEASED FOR CONSTRUCTION	
DATE 2024 03 20		DATE	

PLOT DATE: 2024 03 20

ENGINEER'S SEAL

CONSULTANT DRAWING NUMBER
C-1001

BID OPPORTUNITY: XXX-2024
CONTRACT NUMBER: X

E3 ENGINEERS GEOSCIENTISTS MANITOBA
Certificate of Authorization
AECOM Canada Ltd.
No. 4671 Date:_____

Winnipeg

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT
ENGINEERING DIVISION

GOULET–DOUCET FEEDERMAIN CROSSING REHABILITATION

SHEET 01 OF 01
CITY DRAWING NUMBER
—

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