City Uses Fiberglass-Reinforced CIPP to Rehab 1,900’ 16” Ductile Water Main

Track II – Waterworks

January 28, 2020

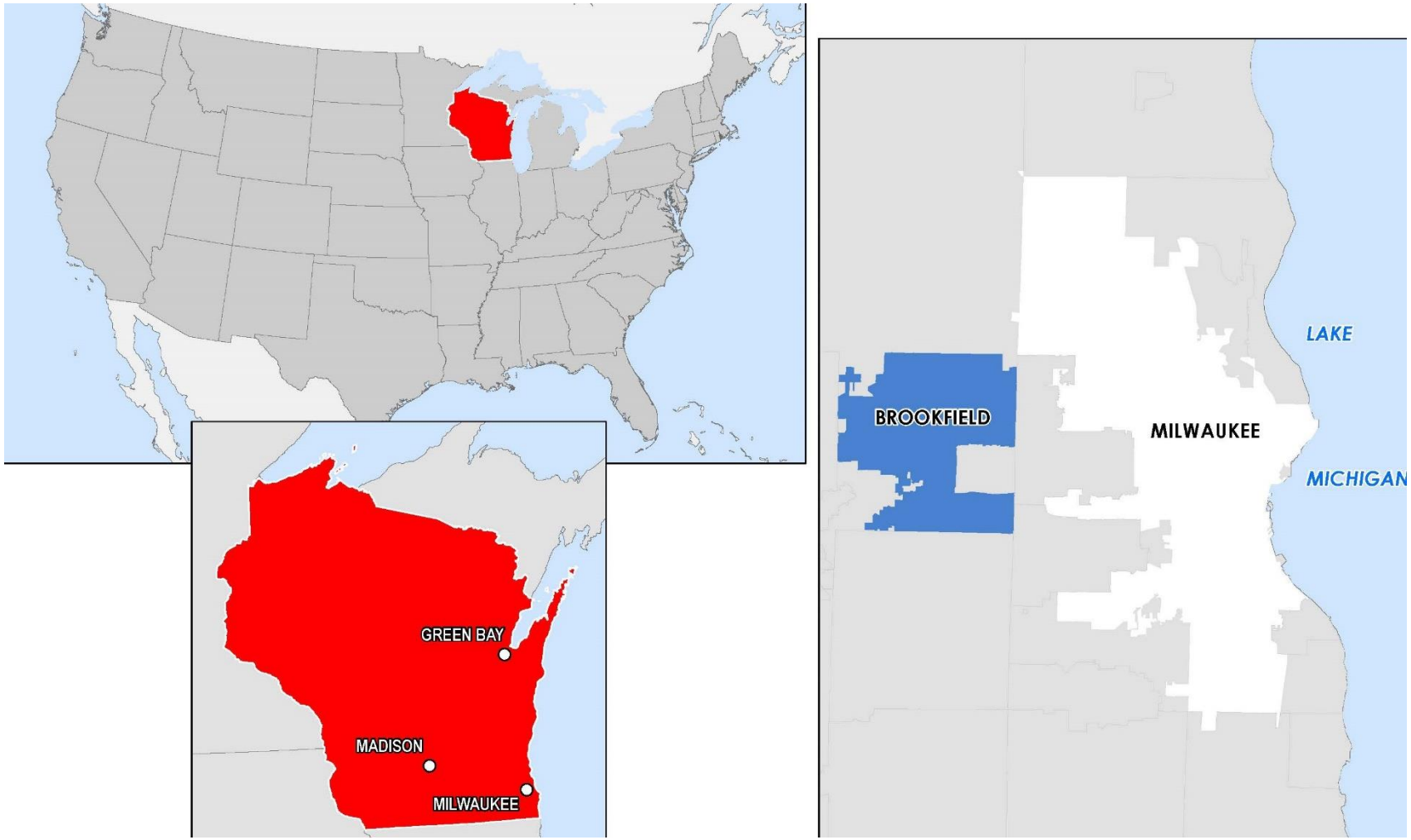
CITY OF BROOKFIELD

SEH

MICHELS®

HAMMERHEAD TRENCHLESS

The City is Brookfield – Where is Brookfield?



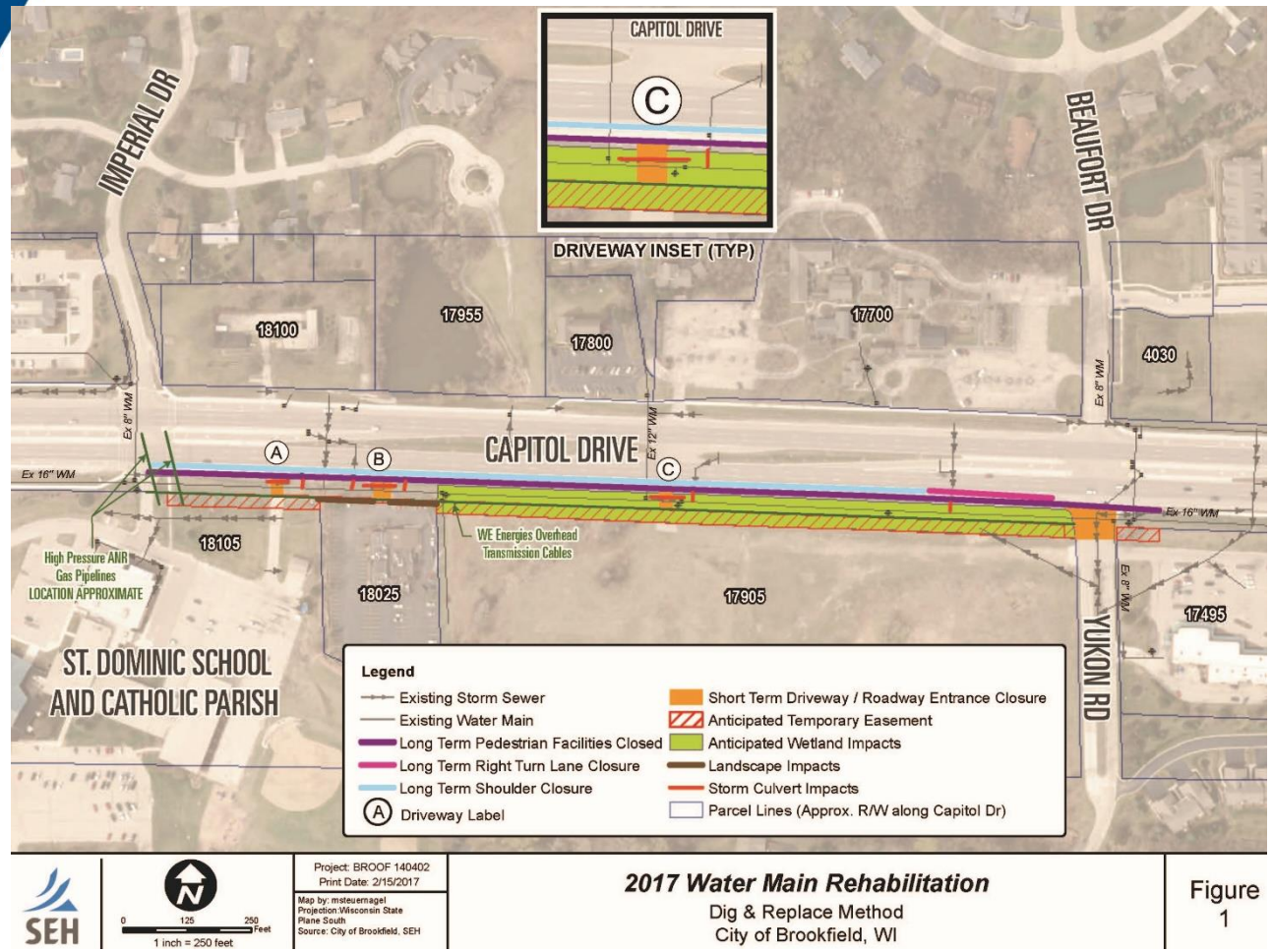
Issues

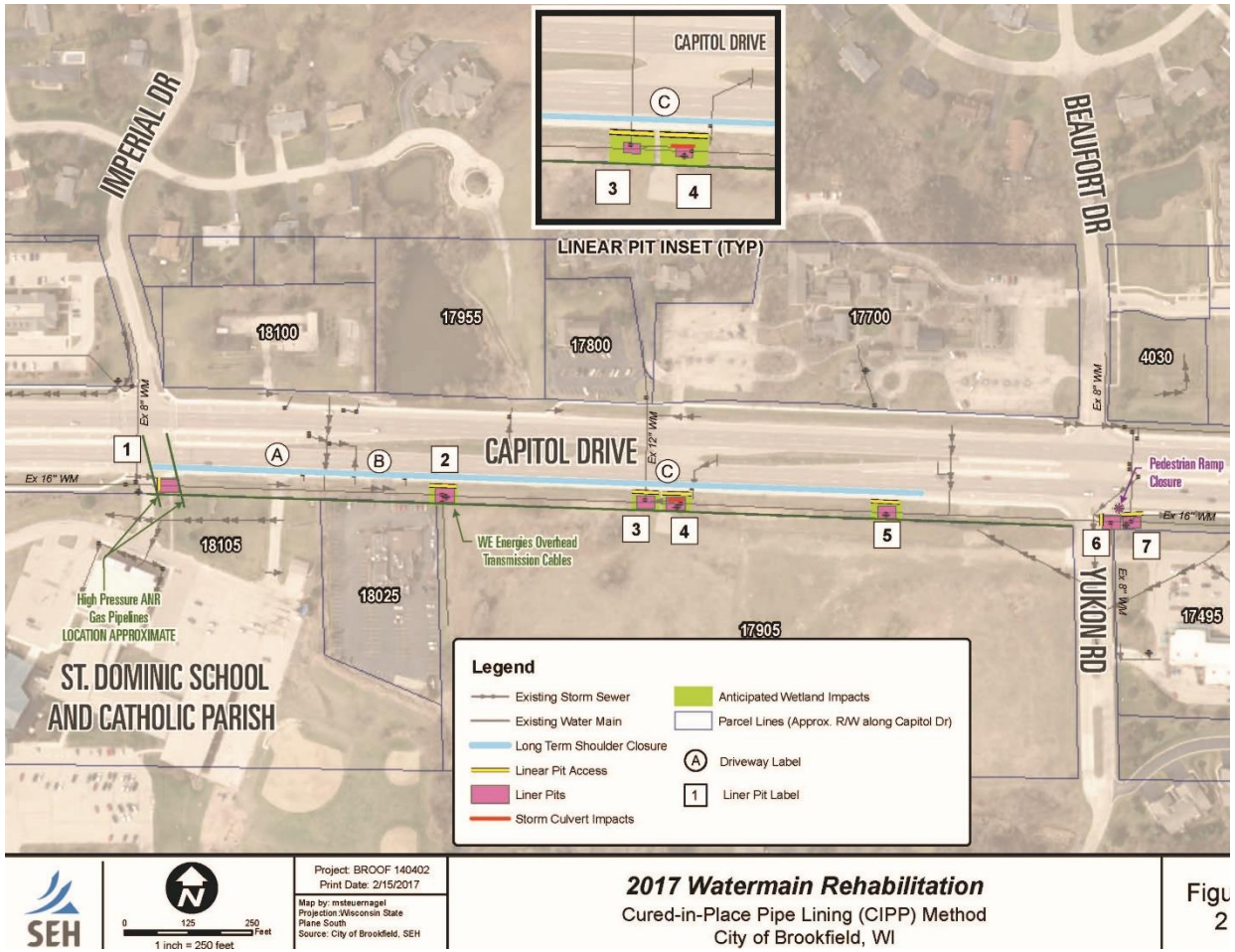
- 1987 installation
- 11 breaks since 1995, 6 breaks in last 5 years
- Wetland impacts
- Deep water main (< = 14 ft)
- Water main was located on the side slope of a deep ditch
- Power poles and transmission cables near water main alignment

Issues - continued

- High pressure Trans Canada gas crossings (ANR)
- Private property impacts due to limited right of way
- School, church, and restaurant within project limits
- Project time constraints

Forces and Issues Matrix





Forces and Issues Matrix - continued

- Wetland impacts
- Maintenance of traffic
- Property impacts
- Utility impacts
- Project duration
- Cost

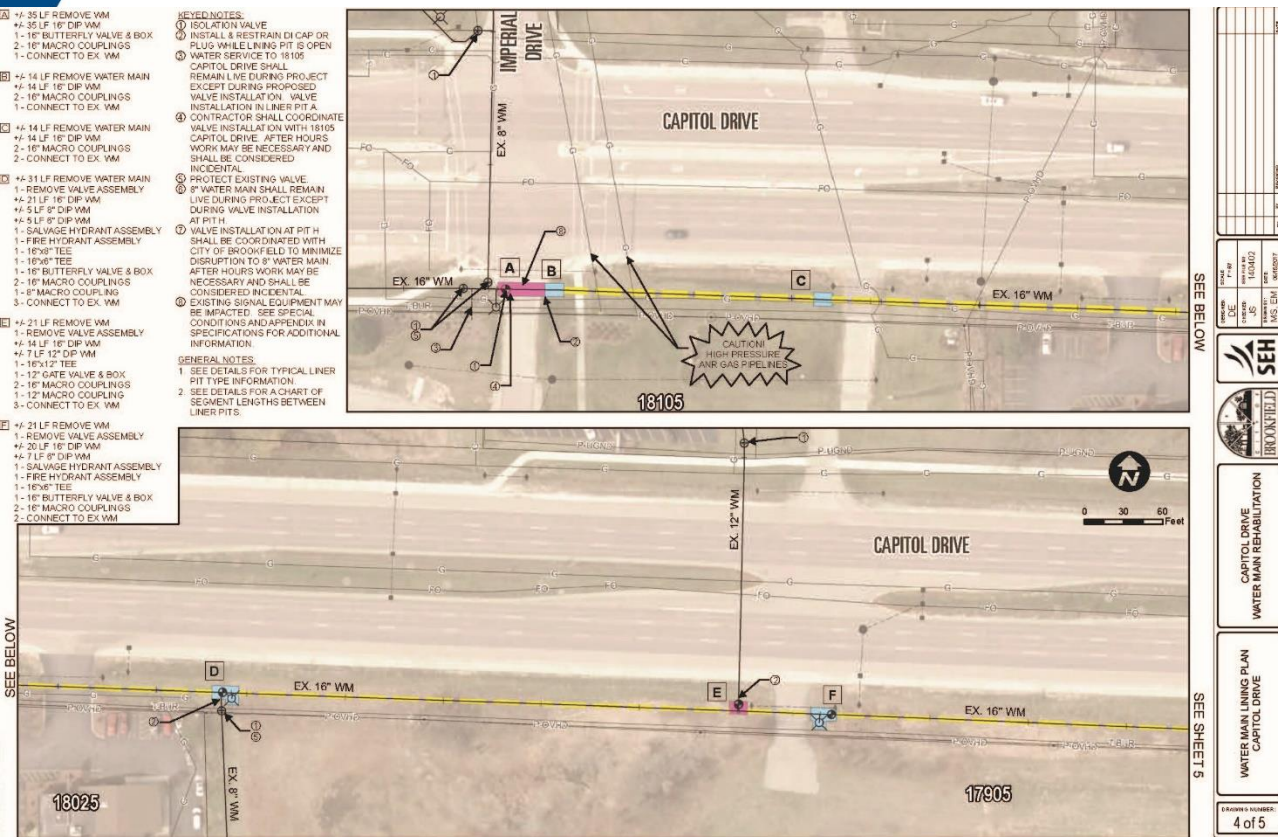
SEH

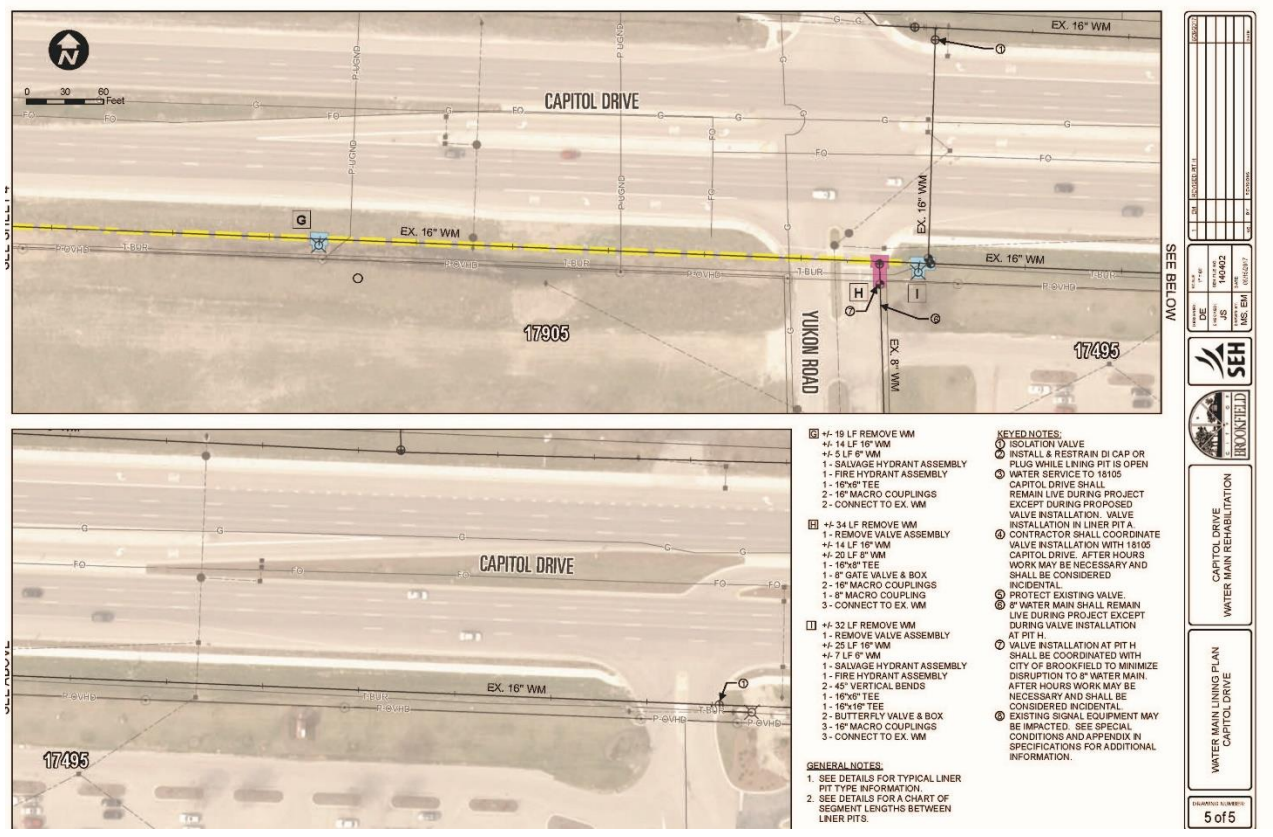
City of Brookfield
2017 Water Main Rehabilitation
Rehabilitation Method Forces and Issues Matrix
2/15/2017
D:\Paul Pasko SEH\Study\Brookfield\2017\[Forces & Issues Matrix.xlsx]Matrix

		FORCES (13)			
		Method 1 Dig & Replace (17)		Method 2 Structural Cured-In-Place Pipe Lining (CIPP) (18)	
	ISSUES	Pro	Con	Pro	Con
1	Wetland Impacts		Wetland impacts are estimated to be approximately 60,000 sf requiring mitigation of approximately $120,000 (1)	Wetland impacts are estimated to be approximately 6,000 sf not requiring mitigation. While impact is a con, we consider a pro because it is not requiring mitigation (3)	
			WI-DNR Individual wetland permit required since wetland impacts are greater than 10,000 sf. Requires an $800 permit application fee and a 6 month review process (2)	WI-DNR General wetland permit required since wetland impacts are less than 10,000 sf. Requires a $600 permit application fee and a 2 month review process. We consider this a pro because it is not a 6 month review (4)	
5	Project Duration		Construction is anticipated to take a minimum of 6-8 weeks. Construction with this option would not start until 2019 due to the wetland permitting process, securing temporary easements, and potential private utility relocations.	Construction is anticipated to take 6-8 weeks. While the duration is a con, we consider a pro because impacts to private properties, wetlands, and traffic are all minimized. Construction with this option can still occur in 2018.	
6	Cost		$515/lf		$355/lf
	Subtotal	PROS 1	CONS 14	PROS 12	CONS 3
	Est. Total Project Cost/LF (15)	$515		$355	

Notes:
(1) Assumes 1200 LF of wetland impact at an average of 50 ft. width.

Bidding Document Preparation





Bidding Document Preparation - Schedule

Task	Milestone	Comment
Bids No. 1 open	6/29/17	
Bids rejected	7/18/17	See next slide
Advertise Bid No. 2	8/16/17 to 8/31/17	
Open Bid No. 2	8/31/19	
Award Bid No. 2	9/19/17	
Fall hydrant flushing	October 2017	
Start ‘Early’ rehab period	11/1/17	Start after fall hydrant flush and be done before spring hydrant flush. Could work in winter due to NO temporary water needed
End ‘Early’ rehab period	3/31/18	
Spring hydrant flushing	April 2018	
Start ‘Late’ rehab period	5/1/18	To start after spring hydrant flush and be done before church festival (7/9/18)
End ‘Late’ rehab period	6/30/18	
Church Festival	7/9/18	Festival begins setup operations. Festival opens for business 7/12.

Bidding Results

- Bid No. 1 no award too expensive
- Bid No. 1 reveals cost savings for reduction in pits
- Bid No. 2 addressed cost savings for reduction in pits
- Bid No. 2 awarded
- Bid No. 2 general contractor had to switch lining subs across winter between award and start rehab.

Bidder	Bid No. 1 – 6/29	Bid No. 2 – 8/31
Mid-City Plumbing and Heating	**$704,057 Final**	**$699,680 Base** **$30,000 Pit Reduction** **$669,680 Final**
Michels Corporation	$789,576 Final	$698,768 Base $0 Pit Reduction $698,768 Final
Fer-Pal Construction USA, LLC	799,506 Final	$694,186 Base $0 Pit Reduction $694,186 Final
Insituform Technologies USA, LLC	NO BID	$697,518 Base $0 Pit Reduction $697,518 Final
Engineer's Estimate	$606,051 Final	$735,286 Base $0 Pit Reduction $735,286 Final

CIPP Design Requirements

WiDNR:

- Class IV Fully Structural per AWWA M28 and Fully Deteriorated Pressure Pipe Condition per ASTM F1216
- Withstand a minimum working pressure of 100 psi without a host pipe
- Have a long-term 50-yr burst strength ≥ maximum allowable operating pressure (MAOP) when tested independently of the host pipe
- Ability to survive any dynamic loads
- Minimum safety factor = 2.5
- Short-term and long-term tensile and flexural properties supported by type testing
- Design in accordance with ASTM F1216

Contract Documents:

- Host pipe ovality = 2% minimum
- Depth of cover = 8 ft or as shown on plans
- Creep reduction factor = 50% maximum
- Soil unit weight = 125 pcf
- Live loading = AASHTO HS20-44
- Factor of safety = 2.0 minimum

WiDNR Permit Approval

- RS BlueLine CIPP by HammerHead given conditional approval by WiDNR
- Diameter-specific short-term burst testing required to satisfy WiDNR design requirements
  - 16 in OD CIPP tested independent of the host pipe per ASTM D1599
  - 2.5 x MAOP = 250 psi min

CIPP Design Compliance

Property	Industry Standard	Project Requirements	Submitted	Actual
Initial flexural modulus (hoop direction)	ASTM D790	250,000 psi	500,000 psi	709,250-804,205 psi
Initial flexural strength (hoop direction)	ASTM D790	4,500 psi	10,000 psi	25,085-30,808 psi
Initial tensile strength (hoop direction)	ASTM D638	3,000 psi	13,500 psi	20,546-22,367 psi
Composite wall thickness	ASTM D5813	-	7.3 mm	7.6-8.1 mm
Hoop stress at burst	ASTM D1599	-	13,500 psi	13,426 psi
Short-term burst pressure	ASTM D1599	250 psi	516 psi	478 psi
MAOP	AWWA M28	100 psi	129 psi	120 psi
Factor of safety vs burst pressure	AWWA SCPPL*	2.5	4.0	4.0

* AWWA Committee Report: Structural Classifications of Pressure Pipe Linings, Suggested Protocol for Product Classification (2019)

AWWA Committee Report: Structural Classifications of Pressure Pipe Linings, Suggested Protocol for Product Classification (AWWA SCPPL)

- Establishes more concrete definitions, design, testing and acceptance criteria for Class I through IV pressure pipe lining systems
- Each structural classification presented as a sequential building block
- Content will be included in the next revision of AWWA M28 (2020)

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 discontinuites)		✔	✔	✔
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.*

CIPP Pressure Rating Calculations

Short-Term Type Testing

- **ASTM D1599 (Short-Term Burst)**
- **Tensile Properties – Hoop Direction**
  - ASTM D638, D2290, D3039
  - Apply reduction factor for lab-to-lab variability and field conditions (0.80 recommended for CIPP)

Long-Term Type Testing

- **ASTM D2990 (Tensile Creep)**
  - Select appropriate test levels to reflect hoop stress from short-term type testing
    - For CIPP: 20%, 30% and 40% of ultimate tensile strength recommended
  - Determine long-term retention of initial tensile properties (10,000-hr data extrapolated to 50 yrs.)

Design

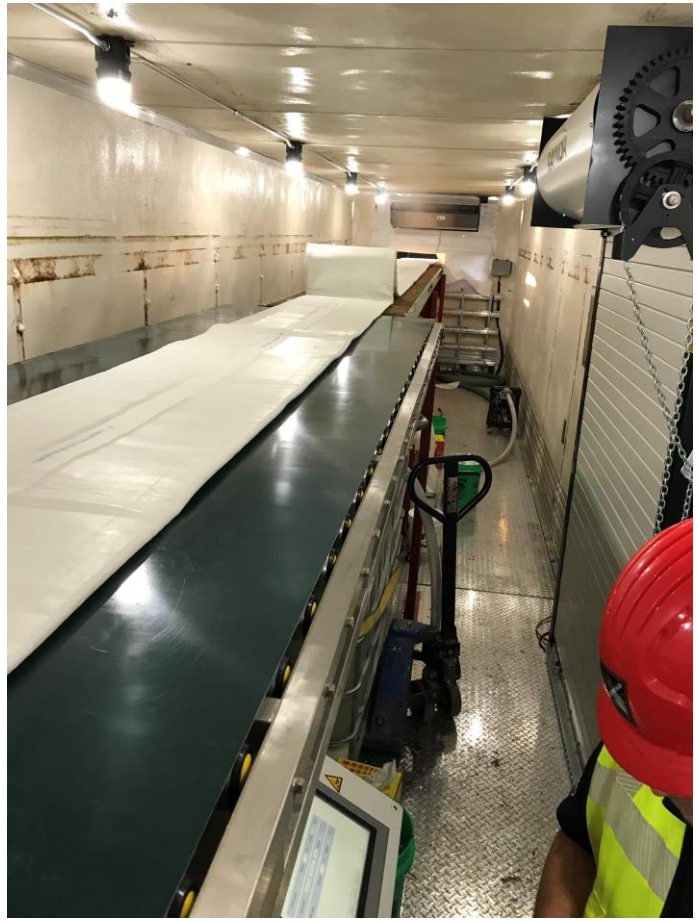
- **Estimate Pressure Rating:**
  - Barlow's Equation – using short-term tensile properties, FS = 2.0 and 50% long-term retention
  - From ASTM F1599 results; short-term burst pressure / 4
  - Consider reduction in pressure ratings for anomalies in the CIPP or when lining through bends
  - Consider other hoop and longitudinal design checks
    - AWWA SCPPL

Rehab Field Work – Prep Work for Lining

- Site walk
- Plan cleaning & lining sections
- Layout of equipment for operations
- Drag scrape pipe cleaning method used
  - Two cleaning runs – Pit to Pit of 1,029 ft and 845 ft

Rehab Field Work – Wet Out for CIPP

- Mobile wet out operation per ASTM F2994
- Self-contained in 53-ft semi trailer
  - Contains computer controlled mixing system, epoxy resin and hardener totes, pinch roller, belt conveyor, roller beds and vacuum pumps
  - Refrigerated for temp control
- Wet out liner placed into ice bath prior to installation



Rehab Field Work – CIPP Installation

- Water inversion & cure
- Liner installation lengths
  - Pit B to D = 550’
  - Pit F to D = 438’
  - Pit F to G = 396’
  - Pit H to G = 427’
- Pressure testing at 122 psi for two (2) hours
- Mechanical seals installed at CIPP ends

Rehab Field Work – CIPP Installation

Rehab Field Work – On-Site Challenges

- Work area restrictions
- Overhead power lines near water main alignment
- Ground water infiltration and storm water runoff
  - Constant dewatering of pits
- Hot outside temperatures and UV light exposure during liner wet out and installation
- Active hydrant locations for water for installation and pressure testing

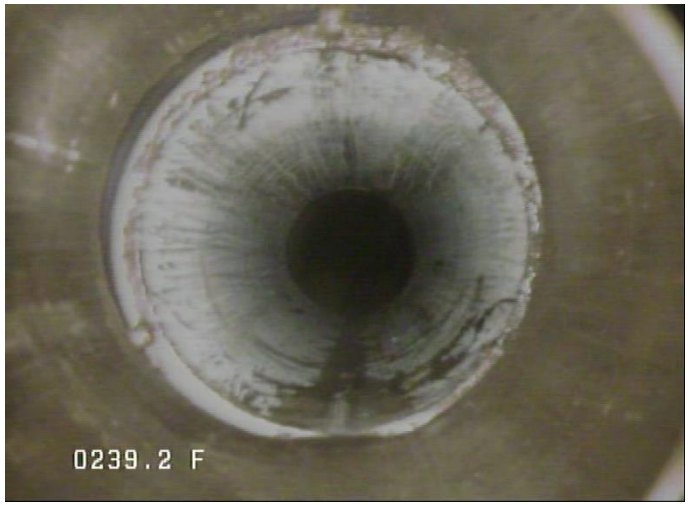
Restored Pit D 3 months after project completion

Lessons Learned

- Extend project completion dates as much as possible
- Give contractor flexibility in number of pits, distances between pits can vary between liner products
- Cost savings because of more bidding flexibility
- Be clear up front with contractor on schedule and expectations for liquidated damages
- Communication is very important – especially with the Church!

Lessons Learned - continued

- Hymax coupling repair sleeve on 16” had bolts that protruded into pipe to keep pipe from pulling out of the coupling.
  - Cured-in-place point repair installed over bolts to protect the CIPP
- Liner defects observed during QA/QC inspection prior to lining; liner was replaced and resulted in a 1 week delay



Thank You

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