SUBJECT: RFQ FOR STORM SEWER REHABILITATION BY CURED-IN-PLACE PIPE (CIPP) TECHNOLOGY

BID #: RFQ-0208-19 **OPEN DATE: 2019-03-20**

GENERAL GOVERNMENT AWARDS COMMITTEE

KIND AND BASIS OF CONTRACT:
CONSTRUCTION SERVICE – FROM CONTRACT EXECUTION THROUGH SEPTEMBER 30, 2020, WITH TWO (2) TWO (2) YEAR RENEWAL OPTIONS

AGENCY: RIGHT OF WAY AND STORMWATER MAINTENANCE DIVISION

BASIS OF AWARD: PRE-QUALIFICATIONS

NUMBER OF BIDS INVITED: 7 **NUMBER OF BIDS RECEIVED:** 6 **OTHER:** 0

SUMMARY OF BIDS AND RECOMMENDED ACTIONS:
Recommend approval of award to Evans Construction Services, Inc. as the lowest responsive, responsible bidder in the total base bid amount of $291,245.00 for Sites #1 - #7 (Project 2, Bid Date 03-20-19).

Funding for this award to be encumbered by account PWGM461SW-03410 and PWGM462SW-06505-PW0072-01, to be executed by Purchase Order.

Attachments: Recommendation Memo, Tabulation Sheet, Vendor Response, Previous Award

Analyst: _____
DAVID KLAGES

RESPECTFULLY SUBMITTED: _____
GREGORY PEASE, CHIEF
PROCUREMENT DIVISION

CONCURRENCE BY: STEVE D. LONG, JR., P.E., CHIEF, RIGHT OF WAY AND STORMWATER MAINT. DIVISION

(ALL AWARD ACTIONS SUBJECT TO LAWFULLY APPROPRIATED FUNDS)
ACTION OF GGAC COMMITTEE ON RECOMMENDATIONS ABOVE

MEMBERS APPROVING _____ MEMBERS DISAPPROVING _____ DATE: _____

_____ _____ OTHER: _____

_____ _____

_____ _____

ACTION OF AWARDING AUTHORITY DATE _____

APPROVED _____ DISAPPROVED _____

OTHER _____

SIGNATURE OF AUTHENTICATION _____

City of Jacksonville, Florida

Lenny Curry, Mayor

Department of Public Works
Right of Way & Stormwater Maintenance Division
609 St. Johns Bluff Road
Jacksonville, FL 32225
(904) 255-4300
www.coj.net

ONE CITY. ONE JACKSONVILLE

March 25, 2019

MEMORANDUM

TO: Greg Pease, Chief,
Procurement Division

THRU: John P. Pappas P.E., Director of Public Works

FROM: Steven D. Long Jr., P.E. Chief
Right of Way and Stormwater Maintenance Division

RE: **RECOMMENDATION TO AWARD**
Cured-In-Place Pipe (CIPP) Bid Date 3-20-19 (Sites 1-7)

BID No.: **RFQ-0208-19**
Received Date: March 20, 2019
Award Amount: $291,245.00

Please be advised that the Right of Way and Stormwater Maintenance Division of the Department of Public Works has reviewed bids on the above-referenced contract and determined that Evans Contracting Services, Inc., 320 Foxtail Avenue, Middleburg, Fl. 32068, submitted the lowest qualified responsive bid in the amount of $291,245.00 for the above-referenced bid. There were a total of six (6) bidders.

We, therefore, recommend the subject bid in the amount of $291,245.00 be awarded to Evans Contracting Services,Inc., the lowest conforming bidder. Funding should be encumbered from Right of Way and Stormwater Maintenance Division accounts PWGM461SW-03410 and PWGM462SW-06505-PW0072-01.

If you require any additional information, you may contact Robert Young at 255-4294.

SL: ry

cc: Ann Brackin, Public Works
David Klages, Procurement
Dan Pearson, Procurement
Tammy Duggan, RoWSM
Robert Young, RowSM

ab

BID TABULATION

TITLE:	STORM SEWER REHAB. BY CIPP TECHNOLOGY		Evans Contracting Services, Inc.	Granite Ininer, LLC	Gulf Coast Underground, LLC	Insituform Technologies, LLC	Lanzo Trenchless Technologies, Inc. South	SAK Construction, LLC	Vortex Services, LLC f/k/a VueVision Environmental
BID NO.:	RFQ-0208-19 - SITES #1 - 7 (PROJECT 2)								
OPEN DATE:	MARCH 20, 2019 @ 2:00 P.M.								
BUYER:	DAVID KLAGES								
NO. INVITED:	(7) NO. RECEIVED: ( ) NO BID: ( )								
	SITE #1								
BID ITEMS	LOCATION: 5846 JIMTOM DRIVE	UNIT							
1	CURED-IN-PLACE LINER (ASTM F1216)	LS	$116,070.00	$169,405.00	No Bid	$139,237.40	$145,600.00	$171,707.00	$169,500.00
2	POINT REPAIR (under pavement)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
3	POINT REPAIR (natural ground)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
	TOTAL BASE BID FOR SITE 1:		$116,070.00	$169,407.00	No Bid	$139,239.40	$145,900.00	$171,907.00	$169,502.00
	SITE #2								
BID ITEMS	LOCATION: 204 KATHERINE ROAD	UNIT							
1	CURED-IN-PLACE LINER (ASTM F1216)	LS	$8,840.00	$16,432.00	No Bid	$8,822.80	$11,850.00	$16,224.00	$14,700.00
2	POINT REPAIR (natural ground)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
	TOTAL BASE BID FOR SITE 2:		$8,840.00	$16,433.00	No Bid	$8,823.80	$12,000.00	$16,324.00	$14,701.00
	SITE #3								
BID ITEMS	LOCATION: MONCRIEF ROAD @ 32nd STREET WEST	UNIT							
1	CURED-IN-PLACE LINER (ASTM F1216)	LS	$15,385.00	$25,526.00	No Bid	$22,876.60	$21,600.00	$26,539.50	$20,000.00
2	POINT REPAIR (under pavement)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$1,000.00	$1.00
	TOTAL BASE BID FOR SITE 3:		$15,385.00	$25,527.00	No Bid	$22,877.60	$21,750.00	$27,539.50	$20,001.00
	SITE #4								
BID ITEMS	LOCATION: MONCRIEF ROAD @ 31st STREET WEST	UNIT							
1	CURED-IN-PLACE LINER (ASTM F1216)	LS	$15,600.00	$29,520.00	No Bid	$23,371.20	$18,200.00	$27,000.00	$25,000.00
2	POINT REPAIR (under pavement)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
	TOTAL BASE BID FOR SITE 4:		$15,600.00	$29,521.00	No Bid	$23,372.20	$18,350.00	$27,100.00	$25,001.00
	SITE #5								
BID ITEMS	LOCATION: JACKSON STREET @ PARK STREET	UNIT							
2	CURED-IN-PLACE LINER (ASTM F1216)	LS	$31,005.00	$22,419.00	No Bid	$30,097.90	$25,600.00	$54,162.50	$30,000.00
3	POINT REPAIR (under pavement)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
	TOTAL BASE BID FOR SITE 5:		$31,005.00	$22,420.00	No Bid	$30,098.90	$25,750.00	$54,262.50	$30,001.00

BID TABULATION

			Evans Contracting Services, Inc.	Granite Inliner, LLC	Gulf Coast Underground, LLC	Insituform Technologies, LLC	Lanzo Trenchless Technologies, Inc. South	SAK Construction, LLC	Vortex Services, LLC f/k/a VacVision Environmental
TITLE:	STORM SEWER REHAB. BY CIPP TECHNOLOGY								
BID NO.:	RFQ-0208-19 - SITES #1 - 7 (PROJECT 2)								
OPEN DATE:	MARCH 20, 2019 @ 2:00 P.M.								
BUYER:	DAVID KLAGES								
NO. INVITED:	(7) NO. RECEIVED: ( ) NO BID: ( )								
	SITE #6								
BID ITEMS	LOCATION: 2373 CEDAR SHORES CIRCLE	UNIT							
1	CURED-IN-PLACE LINER (ASTM F1216)	LS	$21,080.00	$22,569.00	No Bid	$18,895.60	$18,000.00	$38,688.00	$22,000.00
2	POINT REPAIR (natural ground)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$1,000.00	$1.00
	TOTAL BASE BID FOR SITE 6:		$21,080.00	$22,570.00	No Bid	$18,896.60	$18,150.00	$39,688.00	$22,001.00
	SITE #7								
BID ITEMS	LOCATION: 7882 BRISTOL BAY LANE	UNIT							
1	CURED-IN-PLACE LINER (ASTM F1216)	LS	$83,265.00	$99,593.00	No Bid	$91,981.70	$110,000.00	$130,800.00	$133,100.00
2	POINT REPAIR (under pavement)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
3	POINT REPAIR (natural ground)	EA	$0.00	$1.00	No Bid	$1.00	$150.00	$100.00	$1.00
	TOTAL BASE BID FOR SITE #7		$83,265.00	$99,595.00	No Bid	$91,983.70	$110,300.00	$131,000.00	$133,102.00
	TOTAL BASE BID FOR SITES #1 - #7:		$291,245.00	$385,473.00	No Bid	$335,292.20	$352,200.00	$467,821.00	$414,309.00
	SIGNED BID ACKNOWELDGEMENT FORM:		yes	yes	No Bid	yes	yes	yes	yes
	BID FORM (All Sites):		yes	yes	No Bid	yes	yes	yes	yes
	CONFLICT OF INTEREST:		yes	yes	No Bid	yes	yes	yes	yes
	ADDENDA 1 & 2 ACKNOWLEDGED:		yes	yes	No Bid	yes	yes	yes	yes
	SITE PARAMETERS:		*yes	yes	No Bid	no	yes	yes	no

Note: Evans Contracting Services, Inc provided the site parameters upon request by the City after the Bid Opening

CURED-IN-PLACE PIPE (CIPP) LINING
JOB SITE SPECIFICATIONS, INVITATION TO BID AND BID FORM
Bid Date 03-20-2019 Site Visit Date 03-6-2019

This document is issued pursuant to those certain prequalification specifications, identified as RFQ-0037-13 for the reconstruction of existing storm drain pipe lines and conduits by the installation of cured-in-place pipe (F1216), and pursuant to those certain contracts for Storm Sewer Rehabilitation by Cured-In-Place Pipe Technology, by and between the City of Jacksonville and Insituform Technologies, LLC, Granite Inliner, Lanzo Trenchless Technologies South, SAK Construction, LLC., Gulf Coast Underground, LLC., Evans Contracting Services, Inc., and VacVision Environmental, LLC. respectively. Said Request for Qualifications (R.F.Q.) and contracts are on file in the Office of the Right of Way and Grounds Maintenance, Chief and, by this reference, are made a part hereof as if set out in their entirety.

The undersigned Bidder certifies that this proposal is made in good faith, without collusion or connection with any other entity bidding on the work.

The undersigned Bidder certifies that no officer or agent of the City will directly or indirectly benefit from this bid, as evidence by the Conflict of Interest Form attached here to.

The undersigned Bidder states that all applicable taxes are included in the lump sum bid, for each site, and that the CONTRACTOR acknowledges that the work at the job sites are not exempt from the State or Local Sales or Use taxes, and payment of such taxes is the responsibility of the Bidder.

The undersigned Bidder agrees to keep its bid in effect for 120 calendar days after the Bid Opening date to allow the CITY time to award the bid, should it be awarded. This time period begins at the time bids are opened and ends upon the issuance of Notice to Proceed (NTP) which will be in the form of a Purchase Order (PO) from the CITY. The bid prices shall remain in effect throughout the life of the Contract. Failure of the CITY to issue a PO within the specified time period shall allow Bidder to withdraw its Bid and terminate its contract without penalty. Failure of the CITY to issue a PO within the specified time period shall not entitle Bidder to an adjustment of its Bid prices, unless mutually agreeable by the CITY.

The undersigned Bidder acknowledges that included in the various items of the proposal and in the total bid price are costs for complying with the Florida Trench Safety Act and Occupational Safety and Health Administration's Safety Standards for Confined Space Entry.

The undersigned Bidder certifies, under penalty of perjury and contract rescission, that it has all required licenses to perform the work required to fulfill the terms of the contract resulting from a successful bid. Furthermore, the undersigned Bidder affirms that all subcontractors requiring to be licensed are properly licensed to perform work on their respective portions of this project.

NAME OF BIDDER (Print) Evans Contracting Svc Inc. If Corporation, affix Corporate Seal
James C Evans

ORIGINAL SIGNATURE James C Evans TITLE President
Corporate Representative

CURED-IN-PLACE PIPE (CIPP) LINING
JOB SITE SPECIFICATIONS, INVITATION TO BID AND BID FORM
Bid Date 03-20-2019 Site Visit Date 03-6-2019

SITE #1 **LOCATION:** 5846 Jimtom Drive

APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 26 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 240 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 42 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 185 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 200 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 41 (FT.)
APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP APPROXIMATE LENGTH: 17 (FT.)
APPROXIMAT SIZE (Dia): 24 (IN.) TYPE: RCP APPROXIMATE LENGTH: 17 (FT.)
APPROXIMAT SIZE (Dia): 66 (IN.) TYPE: CMP APPROXIMATE LENGTH: 63 (FT.)
APPROXIMAT SIZE (Dia): 66 (IN.) TYPE: CMP APPROXIMATE LENGTH: 63 (FT.)

SEE ATTACHED DRAWING
Note: Video provided to bidders.

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 116,070.00
POINT REPAIR (under pavement)	EA	$ N/A
POINT REPAIR (natural ground)	EA	$ N/A
TOTAL BID SITE #1		$ 116,070.00

SITE #2 **LOCATION:** 204 Katherine Rd

APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP/CMP APPROXIMATE LENGTH: 104 (FT.)
SEE ATTACHED DRAWING
Note: No Video Provided to bidders. Pipe changes material from RCP to CMP

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 8,840.00
POINT REPAIR (natural ground)	EA	$ N/A
TOTAL BID SITE #2 =		$ 8,840.00

CURED-IN-PLACE PIPE (CIPP) LINING
JOB SITE SPECIFICATIONS, INVITATION TO BID AND BID FORM
Bid Date 03-20-2019 Site Visit Date 03-6-2019

SITE #3 **LOCATION:** Moncrief Road @ 32nd St W

APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP APPROXIMATE LENGTH: 115 (FT.)
APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP APPROXIMATE LENGTH: 27 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 39 (FT.)
SEE ATTACHED DRAWING
Note: Video provided to bidders. Strong Gasoline odor detected in Structure 13.

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 15,385.00
POINT REPAIR (under pavement)	EA	$ N/A
TOTAL BID SITE #3 =		$ 15,385.00

SITE #4 **LOCATION:** Moncrief Road @ 31st St W

APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 163 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 25 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 30 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 22 (FT.)
SEE ATTACHED DRAWING
Note: Video Provided to bidders.

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 15,600.00
POINT REPAIR (under pavement)	EA	$ N/A
TOTAL BID SITE #4 =		$ 15,600.00

SITE #5 **LOCATION:** Jackson St @ Park St

APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 234 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 243 (FT.)
SEE ATTACHED DRAWING
Note: Video Provided to bidders. Segment 2-5 open top of liner in Saddle Box Structure 4.
Contractor responsible for removal of concrete in structures 5 and 7.

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 31,005.00
POINT REPAIR (under pavement)	EA	$ N/A
TOTAL BID SITE #5 =		$ 31,005.00

CURED-IN-PLACE PIPE (CIPP) LINING
JOB SITE SPECIFICATIONS, INVITATION TO BID AND BID FORM
Bid Date 03-20-2019 Site Visit Date 03-6-2019

SITE #6 **LOCATION:** 2373 Cedar Shores Cr

APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP APPROXIMATE LENGTH: 87 (FT.)
APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP APPROXIMATE LENGTH: 107 (FT.)
APPROXIMAT SIZE (Dia): 18 (IN.) TYPE: RCP APPROXIMATE LENGTH: 54 (FT.)

SEE ATTACHED DRAWING

Note: Video provided to bidders for segments 1-2 and 3-4. No ideo of segment 2-3, a point repair was made by others. Roots are present and will need to be removed. Site is Tidal.
Structure 1 has a conflict to be adjusted by others. Structure 4 is an outfall under the dock.

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 21,080.00
POINT REPAIR (natural ground)	EA	$ N/A
TOTAL BID SITE #6 =		$ 21,080.00

SITE #7 **LOCATION:** 7882 Bristol Bay Lane

APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 48 (FT.)
APPROXIMAT SIZE (Dia): 30 (IN.) TYPE: RCP APPROXIMATE LENGTH: 63 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 48 (FT.)
APPROXIMAT SIZE (Dia): 30 (IN.) TYPE: RCP APPROXIMATE LENGTH: 190 (FT.)
APPROXIMAT SIZE (Dia): 30 (IN.) TYPE: RCP APPROXIMATE LENGTH: 153 (FT.)
APPROXIMAT SIZE (Dia): 15 (IN.) TYPE: RCP APPROXIMATE LENGTH: 30 (FT.)
APPROXIMAT SIZE (Dia): 36 (IN.) TYPE: RCP APPROXIMATE LENGTH: 139 (FT.)

SEE ATTACHED DRAWING

Note: Video Provided to bidders.

BID ITEMS:

CURED-IN-PLACE LINER (ASTM F1216)	LS	$ 83,265.00
POINT REPAIR (under pavement)	EA	$ N/A
POINT REPAIR (natural ground)	EA	$ N/A
TOTAL BID SITE #7 =		$ 83,265.00

TOTAL BASE BID FOR SITES (#1- #7) $ 291,245.00

CONFLICT OF INTEREST CERTIFICATE

Bidder must execute either Section I or Section II hereunder relative to Florida Statute 112.313(12). Failure to execute either section may result in rejection of this bid proposal.

SECTION I

I hereby certify that no official or employee of the City of independent agency requiring the goods or services described in these specifications has a material financial interest in this company.

James C Evans
Signature

Evans Contracting Svc Inc.
Company Name

James C Evans
Name of Official (type or print)

320 Foxtail Ave
Business Address

Middleburg, FL 32068
City, State, Zip Code

SECTION II

I hereby certify that the following named City officials(s) and/or employee(s) having material financial interest(s) (in excess of 5%) in this company have filed Conflict of Interest Statements with the Supervisor of Elections, 105 East Monroe Street, Jacksonville, Duval County Florida, prior to bid opening.

Name	Title of Position	Date of Filing
N/A		

James C Evans
Signature

Evans Contracting Svc Inc.
Company Name

James C Evans
Name of Official (type or print)

320 Foxtail Ave
Business Address

Middleburg FL 32068
City, State, Zip Code

PUBLIC OFFICIAL DISCLOSURE

Section 126.110 of the Purchasing Code requires that a public official who has a financial interest in a bid or contract make a disclosure at the time that the bid or contract is submitted or at the time that the public official acquires a financial interest in the bid or contract. Please provide disclosure, if applicable, with bid.

Public Official _____

Position Held _____

Position or Relationship with Bidder _____

CITY OF JACKSONVILLE
PROCUREMENT DIVISION
Ed Ball Building, 8th Floor
214 N. Hogan Street
Jacksonville, Florida 32202

ADDENDUM NO	**ONE (1)**
BID NUMBER	**RFQ-0208-19**
TITLE OF BID	**STORM SEWER REHAB BY CURED-IN-PLACE PIPE LINING – SITES #1-#7**
OPENING TIME AND DATE	**MARCH 20, 2019 @ 2:00 P.M.**

THIS ADDENDUM IS ISSUED FOR THE INFORMATION OF BIDDERS ON THE ABOVE TITLED PROJECT AND WILL BE PART OF THE CONTRACT.

PURPOSE OF THIS ADDENDUM IS TO RESPOND TO QUESTION RECEIVED VIA EMAIL:

1. **QUESTION:**
   I made notes that you wanted to go ahead and line from 4 to 2 – which is that extra 27' of 15". But I didn't see that on the updated bid form. Did you want to include it? 4 to 5 – my notes say that pipe was measured at 218'. But the bid form says 234'. I just wanted to get your thoughts on what you wrote down for the LF on that one.

   ANSWER:
   The segment from Structure 4 to structure 2 is included in the notes as structure 2 to 5. Structure 4 is a saddle box so the intent is to line thru 4 and cut out the top of the liner in 4. Per my notes the measurement from 5 to 2 was 243'. The segment from 7 to 5 is 234'. Attached to the end of the addendum is an amended map.

2. **QUESTION:**
   For this site – I don't know if I wrote it down wrong – but I had from 1 to 2 was 87' long, from 2 to 3 was 88' long, from 3 to 4 was 107' and then there was from 4 to the river was 54' long. But on the bid form – there are only three lines (shots). When you get a chance, can you review your notes and let me know what you wrote down.

   ANSWER:
   There are only 3 shots 1-2 87', 2-3 107', 3-4 54', Structure 4 is the outfall at the river under the dock.

DATE March 11, 2019 **BUYER** Chelsey Fleming CF

RECEIPT ACKNOWLEDGED BY RETURN OF SIGNED COPY WITH BID.

[illegible]
Bidder's Signature

President
Title

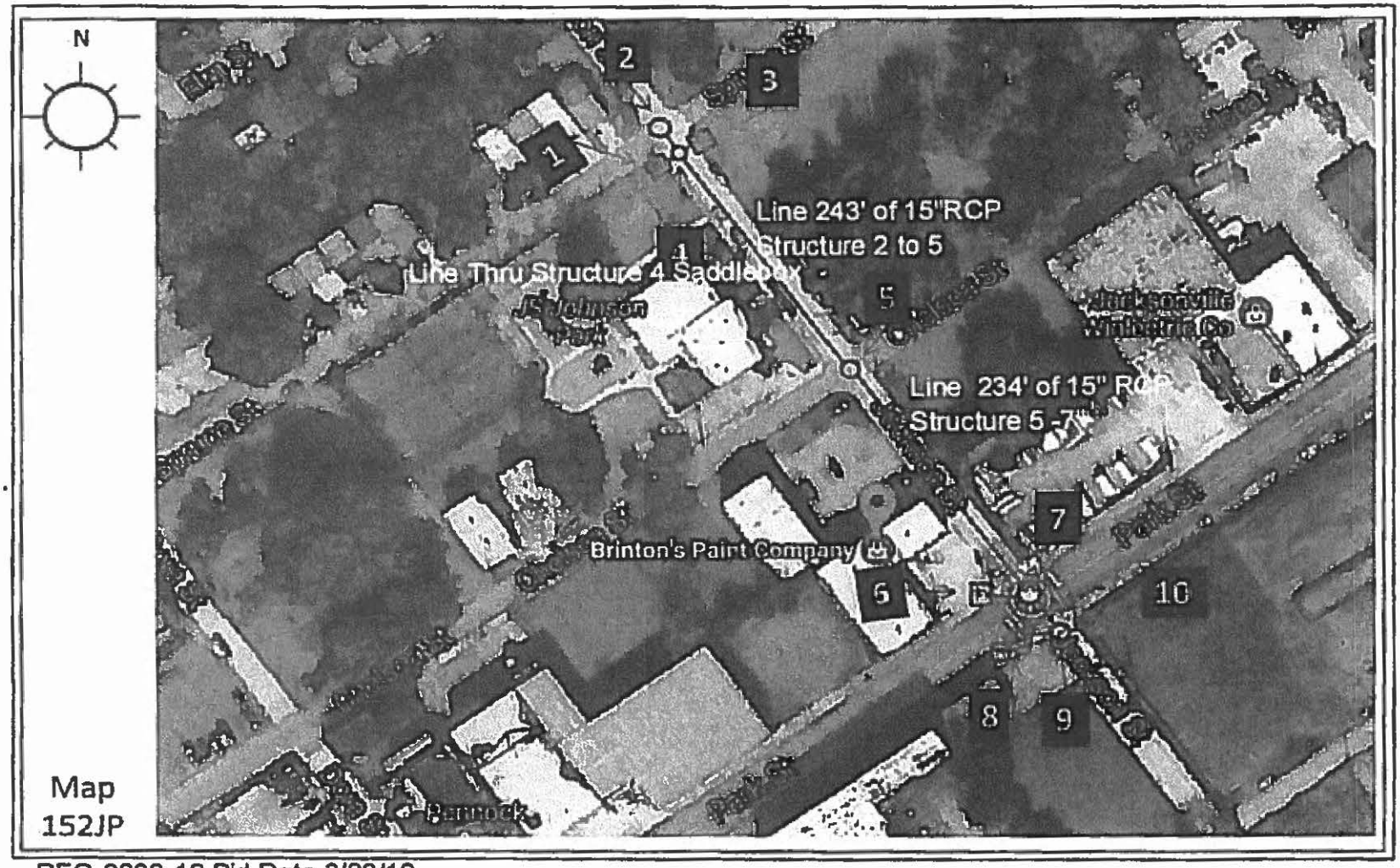
Evans Contracting Svc Inc.
Company

3/19/19
Date

Altair Environmental Group

Client City of Jacksonville Area Jackson st and park st Job No. 15221

Project Name Storm Sewer Cleaning and CCTV Inspection



RFQ-0208-19 Bid Date 3/20/19

Site # 5 Jackson St @ Park St Amended 3/11/19

CITY OF JACKSONVILLE
PROCUREMENT DIVISION
Ed Ball Building, 8th Floor
214 N. Hogan Street
Jacksonville, Florida 32202

ADDENDUM NO	**TWO (2)**
BID NUMBER	**RFQ-0208-19**
TITLE OF BID	**STORM SEWER REHAB BY CURED-IN-PLACE PIPE LINING – SITES #1-#7**
OPENING TIME AND DATE	**MARCH 20, 2019 @ 2:00 P.M.**

THIS ADDENDUM IS ISSUED FOR THE INFORMATION OF BIDDERS ON THE ABOVE TITLED PROJECT AND WILL BE PART OF THE CONTRACT.

PURPOSE OF THIS ADDENDUM IS TO RESPOND TO QUESTION RECEIVED VIA EMAIL:

1. **QUESTION:**
   Are we to assume that it is our decision (after watching the provided videos) if a point repair is necessary in order to install the CIPP liner or not?

   ANSWER:
   Yes, that would be your decision unless otherwise stated. The purpose of the item(s) for point repair on each site is to provide a price should a point repair be necessary prior to, or during, the cleaning/lining process.

DATE March 15, 2019 **BUYER** Chelsey Fleming CF

RECEIPT ACKNOWLEDGED BY RETURN OF SIGNED COPY WITH BID.

James E Evans
Bidder's Signature

President
Title

Evans Contracting Svc Inc
Company

3/19/19
Date

CURED-IN-PLACE PIPE (CIPP) LINING
JOB SITE SPECIFICATIONS, INVITATION TO BID AND BID FORM
Bid Date 03-20-2019 Site Visit Date 03-6-2019

Comments: **1) Refer to attached Site Visit(s) sign in sheet.**
2) ESTIMATED GROUNDWATER TABLE ELEVATION FOR ALL SITES IS ONE FOOT.
3) Design Parameters, specific resin system, site condition and minimum CIPP design thickness will be required for each site as part of the bid submittal.
4) All concrete or debris shall be removed from the pipes and structures to provide positive flow and a minimum of 10% reduction of ovality/ cross-sectional area shall be maintained.

TIME IS OF THE ESSENCE. It is mutually agreed among the parties that the subject work shall be completed within **120 Calendar days after the issue date of the Purchase Order.**

Award will be by total base bid for ALL sites to the lowest responsive, responsible bidder.
All awards are subject to the availability of funds and each site may be awarded on an individual basis.

It is the Contractor's responsibility to verify pipe size and length prior to manufacturing the liner. The liner will be structural unless otherwise instructed in writing by the project engineer. Point repairs are to be a contingency item, however, they will be included in the total base bid in determining the low bidder. The Contractor's Bid lump sum(LS) for the liner and lump sum(LS) for each point repair is to be sealed and submitted to the address below on the proper form. It is understood that the Contractor may perform any number of point repairs on any job site(s) at the unit price submitted.

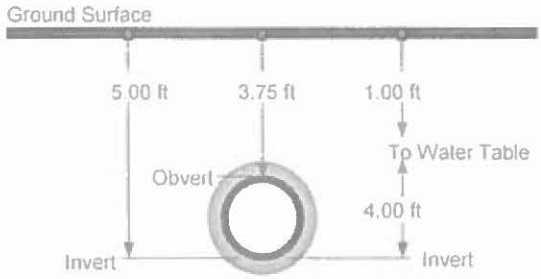
Please consider this as an invitation to submit a bid on this project. Sealed bids are to be submitted to the below-specified address on or before 2:00 p.m.on **Wednesday**, the ***20th*** Day of **March 2019** Bidders are fully responsible for delivery of bids; Reliance on mail or public carrier is at bidder's risk. **LATE BIDS WILL NOT BE CONSIDERED**

Sealed Bids submitted to: **City of Jacksonville**
Procurement Division
Ed Ball Building, 1st Floor
214 N. Hogan Street, Suite 105
Jacksonville, Fl. 32202

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#1
15" - 7.5 mil



Size: 15 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 7 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	15 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safely Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	13.50 in	At 10% ovality
Maximum Diameter for Existing Pipe	16.50 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.758	
Coeffecient of Elastic Support, B'	0.2418	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.19 psi	2.75 ft Head
Soil Pressure, Obvert	2.37 psi	3.75 ft Cover
Live Load Pressure Ws, Obvert	3.05 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.61 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation	**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater	5.3 mm	0.207 in	72.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality	5.9 mm	0.233 in	64.4
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) Governs For load at obvert due to groundwater, soil & live loads	7.0 mm	0.276 in	54.3
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	5.4 mm	0.212 in	70.8
Required In Place Liner Thickness - Fully Deteriorated	**7.0 mm**	**0.276 in**	**54.3**

t in is rounded-up to 3 decimal places. t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 7 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 7.5 mm LINER**	
Liner Thickness for flow comparision	7.5 mm	Inside Diameter before Lining	15.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	14.41 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	108% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 15/0.276 = 54.35 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(54.35-1)^3] x [0.412/2] = 4.17 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.276 in liner by X1.1= 4.17 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.276 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 54.35 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 54.3

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 54.35

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σL/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 15] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.233 in

Compare liner t to t required by Equation X1.2

Liner t:	0.276 in	t is from summary page
Required t:	0.233 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.276 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 7.5 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, Imperial units. 7.5 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 15 in = 1.25 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 14.41 in = 1.201 ft

= {[(3.142 x (1.201^2)/4] x [(1.486/0.01)] x (1.201/4)^(2/3)} / {[(3.142 x (1.25)^2)/4] x [(1.486/0.012)] x (1.25/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #1-15 inch 7.5 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_eC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2.75/3.75) = 0.758

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2418 Where H = 3.75 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.276^3)/12 = 0.00175205

D = Inside diameter of existing pipe = mean OD of liner = 15 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.758 x 0.2418 x 700 x 0.412 x (200000 x 0.00175205/15^3)]^(1/2) = 6.63 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2.75 = 1.19 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3.75 x 0.758)/144) = 2.37 psi H is soil height over top of pipe

Ws = Live load = 3.05 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.19 + 2.37 + 3.05 + 0 = 6.61 psi

Compare qa to qt

qa =	6.61 psi	Actual external pressure on liner
qt =	6.63 psi	Allowed external pressure for 0.276 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.276 in liner thickness	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.276 in = 7.0 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 15 / 0.276 = 54.35

Es / (12 x (DR^3)) = 400000/(12 x 54.35^3) = 0.2076

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.276 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

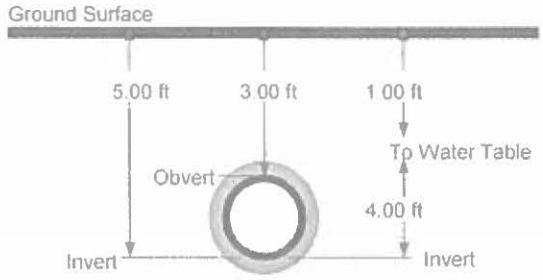
Eq X1.1	Satisfied by 0.276 in liner thickness
Eq X1.2	Satisfied by 0.276 in liner thickness
Eq X1.3	Satsified by 0.276 in liner thickness
Eq X1.4	Satisfied by 0.276 in liner thickness

Required liner thickness for fully deteriorated is: 0.276 in 7.0 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#1
24" - 12 mil



Size: 24 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 11.6 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	24 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	21.60 in	At 10% ovality
Maximum Diameter for Existing Pipe	26.40 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.78	
Coeffecient of Elastic Support, B'	0.233	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	0.87 psi	2.00 ft Head
Soil Pressure, Obvert	1.95 psi	3.00 ft Cover
Live Load Pressure Ws, Obvert	4.10 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.92 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater		8.4 mm	0.331 in	72.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		9.5 mm	0.373 in	64.3
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	11.6 mm	0.456 in	52.6
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated		8.6 mm	0.338 in	71.0
Required in Place Liner Thickness - Fully Deteriorated		**11.6 mm**	**0.456 in**	**52.6**

t in is rounded up to 3 decimal places. t mm = t in x 25.4. DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 11.6 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 12 mm LINER**	
Liner Thickness for flow comparision	12.0 mm	Inside Diameter before Lining	24.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	23.06 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	108% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.456 in = 11.6 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 24/0.456 = 52.63 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(52.63-1)^3] x [0.412/2] = 4.61 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.456 in liner by X1.1= 4.61 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.456 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 52.63 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 52.6

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.456 in = 11.6 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 52.63

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σ_L/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 24] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.373 in

Compare liner t to t required by Equation X1.2

Liner t:	0.456 in	t is from summary page
Required t:	0.373 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.456 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 12 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, Imperial units 12.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 24 in = 2 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 23.06 in = 1.921 ft

= {[(3.142 x (1.921^2)/4] x [(1.486/0.01)] x (1.921/4)^(2/3)} / {[(3.142 x (2)^2)/4] x [(1.486/0.012)] x (2/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #1-24 inch 12 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.456 in = 11.6 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2/3) = 0.78

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.233 Where H = 3 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.456^3)/12 = 0.00790157

D = Inside diameter of existing pipe = mean OD of liner = 24 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.78 x 0.233 x 700 x 0.412 x (200000 x 0.00790157/24^3)]^(1/2) = 6.92 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2 = 0.87 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3 x 0.78)/144) = 1.95 psi H is soil height over top of pipe

Ws = Live load = 4.1 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 0.87 + 1.95 + 4.1 + 0 = 6.92 psi

Compare qa to qt

qa =	6.92 psi	Actual external pressure on liner
qt =	6.92 psi	Allowed external pressure for 0.456 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.456 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.456 in = 11.6 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 24 / 0.456 = 52.63

Es / (12 x (DR^3)) = 400000/(12 x 52.63^3) = 0.2287

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.456 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

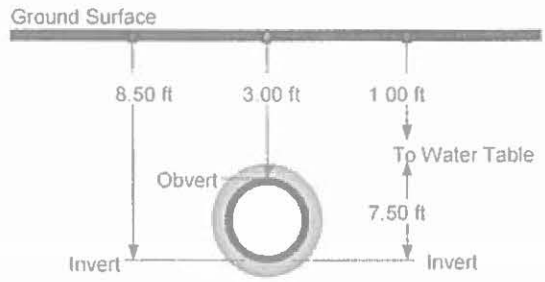
Eq X1.1	Satisfied by 0.456 in liner thickness
Eq X1.2	Satisfied by 0.456 in liner thickness
Eq X1.3	Satsified by 0.456 in liner thickness
Eq X1.4	Satisfied by 0.456 in liner thickness

Required liner thickness for fully deteriorated is: 0.456 in 11.6 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#1
66" - 36 mil



Size: 66 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 35.3 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	66 in
Depth to Invert	8.5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	59.40 in	At 10% ovality
Maximum Diameter for Existing Pipe	72.60 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.78	
Coeffecient of Elastic Support, B'	0.233	
Water Pressure, Invert	3.25 psi	7.50 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**3.25 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	0.87 psi	2.00 ft Head
Soil Pressure, Obvert	1.95 psi	3.00 ft Cover
Live Load Pressure Ws, Obvert	4.10 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.92 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation	Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater	28.4 mm	1.119 in	59.0
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality Governs	35.3 mm	1.390 in	47.5
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	31.9 mm	1.254 in	52.6
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	23.6 mm	0.930 in	71.0
Required In Place Liner Thickness - Fully Deteriorated	**35.3 mm**	**1.390 in**	**47.5**

t in is rounded up to 3 decimal places. t mm = t in x 25.4. DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 35.3 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		FLOW COMPARISON FOR 36 mm LINER	
Liner Thickness for flow comparision	36.0 mm	Inside Diameter before Lining	66.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	63.17 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	107% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 1.390 in = 35.3 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 66/1.39 = 47.48 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(47.48-1)^3] x [0.412/2] = 6.31 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 7.5 ft = 3.25 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 3.25 + 0 = 3.25 psi

Compare Pa to P

Pa, Actual external pressure on liner = 3.25 psi

P, Allowed external pressure for 1.39 in liner by X1.1= 6.31 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 1.39 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 47.48 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 47.5

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 1.390 in = 35.3 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 47.48

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 3.25 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σ_L/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 66] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(3.25 x 2 x (1+(10/100)))]}^0.5] = 1.39 in

Compare liner t to t required by Equation X1.2

Liner t:	1.390 in	t is from summary page
Required t:	1.390 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 1.39 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 36 mm LINER

Flow = Q = Area x Velocity =[(Pi x D^2)/4] x [(1.486/n) x $R^{2/3}$ x $S^{1/2}$] Manning formula, Imperial units. 36.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 66 in = 5.5 ft

Q2/Q1 = {[(Pi x (D_2^2)/4] x [(1.486/n_2)] x (D_2/4)$^{2/3}$} / {[(Pi x (D_1^2)/4] x [(1.486/n_1)] x (D_1/4)$^{2/3}$} D2 = 63.17 in = 5.264 ft

= {[(3.142 x (5.264^2)/4] x [(1.486/0.01)] x (5.264/4)^(2/3)} / {[(3.142 x (5.5)^2)/4] x [(1.486/0.012)] x (5.5/4)^(2/3) = 1.07

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 107% of before lining capacity.

CIPP-DESIGN site #1-66 inch 36 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 1.390 in = 35.3 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2/3) = 0.78

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.233 Where H = 3 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (1.39^3)/12 = 0.22380158

D = Inside diameter of existing pipe = mean OD of liner = 66 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.78 x 0.233 x 700 x 0.412 x (200000 x 0.22380158/66^3)]^(1/2) = 8.08 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2 = 0.87 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3 x 0.78)/144) = 1.95 psi H is soil height over top of pipe

Ws = Live load = 4.1 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 0.87 + 1.95 + 4.1 + 0 = 6.92 psi

Compare qa to qt

qa =	6.92 psi	Actual external pressure on liner
qt =	8.08 psi	Allowed external pressure for 1.39 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 1.39 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 1.390 in = 35.3 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 66 / 1.39 = 47.48

Es / (12 x (DR^3)) = 400000/(12 x 47.48^3) = 0.3114

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 1.39 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

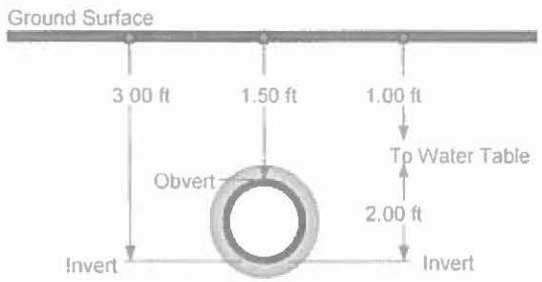
Eq X1.1	Satisfied by 1.39 in liner thickness
Eq X1.2	Satisfied by 1.39 in liner thickness
Eq X1.3	Satsified by 1.39 in liner thickness
Eq X1.4	Satisfied by 1.39 in liner thickness

Required liner thickness for fully deteriorated is: 1.390 in 35.3 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#2
18" - 7.5 mil



Size: 18 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 6.5 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	18 in
Depth to Invert	3 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	None
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	16.20 in	At 10% ovality
Maximum Diameter for Existing Pipe	19.80 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.89	
Coeffecient of Elastic Support, B'	0.2161	
Water Pressure, Invert	0.87 psi	2.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**0.87 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	0.22 psi	0.50 ft Head
Soil Pressure, Obvert	1.11 psi	1.50 ft Cover
Live Load Pressure Ws, Obvert	0.00 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**1.33 psi**	**For X1.3**

NOTES
Note 1: No live load. None selected.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater		5.0 mm	0.198 in	90.9
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		5.1 mm	0.200 in	90.0
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads		2.8 mm	0.112 in	160.7
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	Governs	6.5 mm	0.254 in	70.9
Required In Place Liner Thickness - Fully Deteriorated		**6.5 mm**	**0.254 in**	**70.9**

t in is rounded-up to 3 decimal places; t mm = t in x 25.4. DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 6.5 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON	
Liner Thickness for flow comparison	6.5 mm
Manning n used for before lining	0.0120
Manning n used for after lining	0.0100

FLOW COMPARISON FOR 6.5 mm LINER	
Inside Diameter before Lining	18.00 in
Inside Diameter after Lining	17.49 in
Flow Capacity after Lining	111% of before lining flow

COMMENTS

CIPP-DESIGN site #2 - 18 inch 7.5 mil

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.254 in = 6.5 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 18/0.254 = 70.87 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(70.87-1)^3] x [0.412/2] = 1.86 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 2 ft = 0.87 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 0.87 + 0 = 0.87 psi

Compare Pa to P

Pa, Actual external pressure on liner = 0.87 psi

P, Allowed external pressure for 0.254 in liner by X1.1= 1.86 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.254 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 70.87 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 70.9

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.254 in = 6.5 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 70.87

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 0.87 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

$t = [3 \times (\Delta/100) \times D] / [0.5 + \{0.25 + (6 \times (\Delta/100)) \times [\sigma_L/(P \times N \times (1+(\Delta/100)))]\}^{.5}]$

t = [3 x (10/100) x 18] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(0.87 x 2 x (1+(10/100)))]}^0.5] = 0.2 in

Compare liner t to t required by Equation X1.2

Liner t:	0.254 in	t is from summary page
Required t:	0.200 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.254 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 6.5 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, Imperial units. 6.5 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 18 in = 1.5 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 17.49 in = 1.458 ft

= {[(3.142 x (1.458^2)/4] x [(1.486/0.01)] x (1.458/4)^(2/3)} / {[(3.142 x (1.5)^2)/4] x [(1.486/0.012)] x (1.5/4)^(2/3) = 1.11

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 111% of before lining capacity.

CIPP-DESIGN site #2 - 18 inch 7.5 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.254 in = 6.5 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(0.5/1.5) = 0.89

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2161 Where H = 1.5 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.254^3)/12 = 0.00136559

D = Inside diameter of existing pipe = mean OD of liner = 18 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.89 x 0.2161 x 700 x 0.412 x (200000 x 0.00136559/18^3)]^(1/2) = 4.56 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 0.5 = 0.22 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 1.5 x 0.89)/144) = 1.11 psi H is soil height over top of pipe

Ws = Live load = 0 psi Note 1: No live load. None selected.

Wo = Other load = 0 psi, entered

qa = 0.22 + 1.11 + 0 + 0 = 1.33 psi

Compare qa to qt

qa =	1.33 psi	Actual external pressure on liner
qt =	4.56 psi	Allowed external pressure for 0.254 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.254 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.254 in = 6.5 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 18 / 0.254 = 70.87

Es / (12 x (DR^3)) = 400000/(12 x 70.87^3) = 0.0936

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.254 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

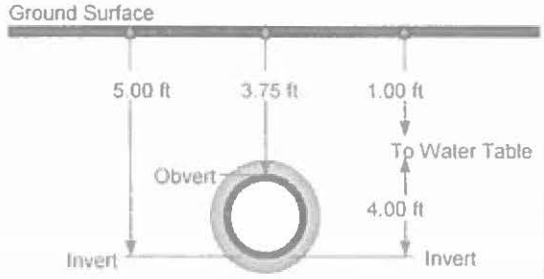
Eq X1.1	Satisfied by 0.254 in liner thickness
Eq X1.2	Satisfied by 0.254 in liner thickness
Eq X1.3	Satsified by 0.254 in liner thickness
Eq X1.4	Satisfied by 0.254 in liner thickness

Required liner thickness for fully deteriorated is: 0.254 in 6.5 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#3
15" x 7.5 mil



Size: 15 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 7 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	15 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	13.50 in	At 10% ovality
Maximum Diameter for Existing Pipe	16.50 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.758	
Coeffecient of Elastic Support, B'	0.2418	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.19 psi	2.75 ft Head
Soil Pressure, Obvert	2.37 psi	3.75 ft Cover
Live Load Pressure Ws, Obvert	3.05 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.61 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater		5.3 mm	0.207 in	72.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		5.9 mm	0.233 in	64.4
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	7.0 mm	0.276 in	54.3
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated		5.4 mm	0.212 in	70.8
Required in Place Liner Thickness - Fully Deteriorated		**7.0 mm**	**0.276 in**	**54.3**

t in is rounded up to 3 decimal places. t mm = t in x 25.4. DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 7 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 7.5 mm LINER**	
Liner Thickness for flow comparision	7.5 mm	Inside Diameter before Lining	15.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	14.41 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	108% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 15/0.276 = 54.35 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(54.35-1)^3] x [0.412/2] = 4.17 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.276 in liner by X1.1= 4.17 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.276 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 54.35 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 54.3

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 54.35

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

$t = [3 \times (\Delta/100) \times D] / [0.5 + \{0.25 + (6 \times (\Delta/100)) \times [\sigma_L/(P \times N \times (1+(\Delta/100)))]\}^{.5}]$

t = [3 x (10/100) x 15] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.233 in

Compare liner t to t required by Equation X1.2

Liner t:	0.276 in	t is from summary page
Required t:	0.233 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.276 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 7.5 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, Imperial units. 7.5 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 15 in = 1.25 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 14.41 in = 1.201 ft

= {[(3.142 x (1.201^2)/4] x [(1.486/0.01)] x (1.201/4)^(2/3)} / {[(3.142 x (1.25)^2)/4] x [(1.486/0.012)] x (1.25/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #3 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2.75/3.75) = 0.758

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2418 Where H = 3.75 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.276^3)/12 = 0.00175205

D = Inside diameter of existing pipe = mean OD of liner = 15 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.758 x 0.2418 x 700 x 0.412 x (200000 x 0.00175205/15^3)]^(1/2) = 6.63 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2.75 = 1.19 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3.75 x 0.758)/144) = 2.37 psi H is soil height over top of pipe

Ws = Live load = 3.05 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.19 + 2.37 + 3.05 + 0 = 6.61 psi

Compare qa to qt

qa =	6.61 psi	Actual external pressure on liner
qt =	6.63 psi	Allowed external pressure for 0.276 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.276 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.276 in = 7.0 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 15 / 0.276 = 54.35

Es / (12 x (DR^3)) = 400000/(12 x 54.35^3) = 0.2076

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.276 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

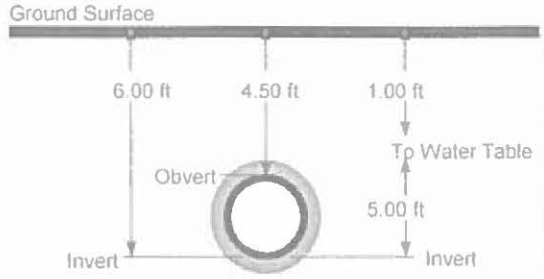
Eq X1.1	Satisfied by 0.276 in liner thickness
Eq X1.2	Satisfied by 0.276 in liner thickness
Eq X1.3	Satsified by 0.276 in liner thickness
Eq X1.4	Satisfied by 0.276 in liner thickness

Required liner thickness for fully deteriorated is: 0.276 in 7.0 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#3
18" - 9 mil



Size: 18 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 8.3 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	18 in
Depth to Invert	6 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED

Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	16.20 in	At 10% ovality
Maximum Diameter for Existing Pipe	19.80 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.743	
Coeffecient of Elastic Support, B'	0.2509	
Water Pressure, Invert	2.17 psi	5.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**2.17 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.52 psi	3.50 ft Head
Soil Pressure, Obvert	2.79 psi	4.50 ft Cover
Live Load Pressure Ws, Obvert	2.25 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.56 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater		6.8 mm	0.268 in	67.2
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		7.9 mm	0.312 in	57.7
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	8.3 mm	0.328 in	54.9
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated		6.5 mm	0.254 in	70.9
Required in Place Liner Thickness - Fully Deteriorated		**8.3 mm**	**0.328 in**	**54.9**

t in is rounded-up to 3 decimal places: t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 8.3 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 9 mm LINER**	
Liner Thickness for flow comparision	9.0 mm	Inside Diameter before Lining	18.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	17.29 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	108% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.328 in = 8.3 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 18/0.328 = 54.88 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(54.88-1)^3] x [0.412/2] = 4.05 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 5 ft = 2.17 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 2.17 + 0 = 2.17 psi

Compare Pa to P

Pa, Actual external pressure on liner = 2.17 psi

P, Allowed external pressure for 0.328 in liner by X1.1= 4.05 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.328 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 54.88 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 54.9

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.328 in = 8.3 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 54.88

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 2.17 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x {σL/(P x N x (1+(Δ/100)))}]^.5}

t = [3 x (10/100) x 18] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(2.17 x 2 x (1+(10/100)))]}^0.5] = 0.312 in

Compare liner t to t required by Equation X1.2

Liner t:	0.328 in	t is from summary page
Required t:	0.312 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.328 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 9 mm LINER

Flow = Q = Area x Velocity =$[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, Imperial units. 9.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 18 in = 1.5 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 17.29 in = 1.441 ft

= {[(3.142 x (1.441^2)/4] x [(1.486/0.01)] x (1.441/4)^(2/3)} / {[(3.142 x (1.5)^2)/4] x [(1.486/0.012)] x (1.5/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #3 - 18 inch x 9 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.328 in = 8.3 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(3.5/4.5) = 0.743

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2509 Where H = 4.5 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.328^3)/12 = 0.00294063

D = Inside diameter of existing pipe = mean OD of liner = 18 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.743 x 0.2509 x 700 x 0.412 x (200000 x 0.00294063/18^3)]^(1/2) = 6.59 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 3.5 = 1.52 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 4.5 x 0.743)/144) = 2.79 psi H is soil height over top of pipe

Ws = Live load = 2.25 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.52 + 2.79 + 2.25 + 0 = 6.56 psi

Compare qa to qt

qa =	6.56 psi	Actual external pressure on liner
qt =	6.59 psi	Allowed external pressure for 0.328 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.328 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.328 in = 8.3 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 18 / 0.328 = 54.88

Es / (12 x (DR^3)) = 400000/(12 x 54.88^3) = 0.2017

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.328 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

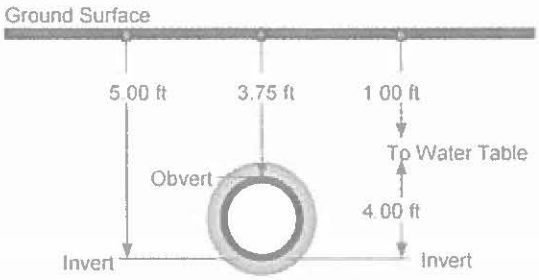
Eq X1.1	Satisfied by 0.328 in liner thickness
Eq X1.2	Satisfied by 0.328 in liner thickness
Eq X1.3	Satsified by 0.328 in liner thickness
Eq X1.4	Satisfied by 0.328 in liner thickness

Required liner thickness for fully deteriorated is: 0.328 in 8.3 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#4
15" x 7.5 mil



Size: 15 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 7 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	15 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	**ENTERED**
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	13.50 in	At 10% ovality
Maximum Diameter for Existing Pipe	16.50 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.758	
Coeffecient of Elastic Support, B'	0.2418	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.19 psi	2.75 ft Head
Soil Pressure, Obvert	2.37 psi	3.75 ft Cover
Live Load Pressure Ws, Obvert	3.05 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.61 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater		5.3 mm	0.207 in	72.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		5.9 mm	0.233 in	64.4
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	7.0 mm	0.276 in	54.3
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated		5.4 mm	0.212 in	70.8
Required in Place Liner Thickness - Fully Deteriorated		**7.0 mm**	**0.276 in**	**54.3**

t in is rounded up to 3 decimal places; t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 7 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON	
Liner Thickness for flow comparision	7.5 mm
Manning n used for before lining	0.0120
Manning n used for after lining	0.0100

FLOW COMPARISON FOR 7.5 mm LINER	
Inside Diameter before Lining	15.00 in
Inside Diameter after Lining	14.41 in
Flow Capacity after Lining	108% of before lining flow

COMMENTS

CIPP-DESIGN site #4 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 15/0.276 = 54.35 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(54.35-1)^3] x [0.412/2] = 4.17 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.276 in liner by X1.1= 4.17 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.276 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 54.35 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 54.3

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 54.35

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σ_L/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 15] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.233 in

Compare liner t to t required by Equation X1.2

Liner t:	0.276 in	t is from summary page
Required t:	0.233 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.276 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 7.5 mm LINER

Flow = Q = Area x Velocity =[(Pi x D^2)/4] x [(1.486/n) x $R^{2/3}$ x $S^{1/2}$] Manning formula, Imperial units. 7.5 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 15 in = 1.25 ft

Q2/Q1 = {[(Pi x (D_2^2)/4] x [(1.486/n_2)] x $(D_2/4)^{2/3}$} / {[(Pi x (D_1^2)/4] x [(1.486/n_1)] x $(D_1/4)^{2/3}$} D2 = 14.41 in = 1.201 ft

= {[(3.142 x (1.201^2)/4] x [(1.486/0.01)] x (1.201/4)^(2/3)} / {[(3.142 x (1.25)^2)/4] x [(1.486/0.012)] x (1.25/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #4 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2.75/3.75) = 0.758

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2418 Where H = 3.75 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.276^3)/12 = 0.00175205

D = Inside diameter of existing pipe = mean OD of liner = 15 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.758 x 0.2418 x 700 x 0.412 x (200000 x 0.00175205/15^3)]^(1/2) = 6.63 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2.75 = 1.19 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3.75 x 0.758)/144) = 2.37 psi H is soil height over top of pipe

Ws = Live load = 3.05 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.19 + 2.37 + 3.05 + 0 = 6.61 psi

Compare qa to qt

qa =	6.61 psi	Actual external pressure on liner
qt =	6.63 psi	Allowed external pressure for 0.276 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.276 in liner thickness	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.276 in = 7.0 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 15 / 0.276 = 54.35

Es / (12 x (DR^3)) = 400000/(12 x 54.35^3) = 0.2076

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.276 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

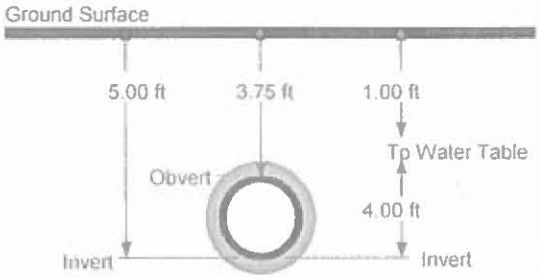
Eq X1.1	Satisfied by 0.276 in liner thickness
Eq X1.2	Satisfied by 0.276 in liner thickness
Eq X1.3	Satsified by 0.276 in liner thickness
Eq X1.4	Satisfied by 0.276 in liner thickness

Required liner thickness for fully deteriorated is: 0.276 in 7.0 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#5
15" x 7.5 mil



Size: 15 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 7 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	15 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	13.50 in	At 10% ovality
Maximum Diameter for Existing Pipe	16.50 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.758	
Coeffecient of Elastic Support, B'	0.2418	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.19 psi	2.75 ft Head
Soil Pressure, Obvert	2.37 psi	3.75 ft Cover
Live Load Pressure Ws, Obvert	3.05 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.61 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation	**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at Invert due to groundwater	5.3 mm	0.207 in	72.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality	5.9 mm	0.233 in	64.4
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) Governs For load at obvert due to groundwater, soil & live loads	7.0 mm	0.276 in	54.3
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	5.4 mm	0.212 in	70.8
Required in Place Liner Thickness - Fully Deteriorated	**7.0 mm**	**0.276 in**	**54.3**

t in is rounded-up to 3 decimal places; t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 7 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 7.5 mm LINER**	
Liner Thickness for flow comparision	7.5 mm	Inside Diameter before Lining	15.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	14.41 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	108% of before lining flow

COMMENTS

CIPP-DESIGN site #5 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 15/0.276 = 54.35 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(54.35-1)^3] x [0.412/2] = 4.17 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.276 in liner by X1.1= 4.17 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.276 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 54.35 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 54.3

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 54.35

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σ_L/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 15] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.233 in

Compare liner t to t required by Equation X1.2

Liner t:	0.276 in	t is from summary page
Required t:	0.233 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.276 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 7.5 mm LINER

Flow = Q = Area x Velocity =[(Pi x D^2)/4] x [(1.486/n) x $R^{2/3}$ x $S^{1/2}$] Manning formula, Imperial units. 7.5 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 15 in = 1.25 ft

Q2/Q1 = {[(Pi x (D_2^2)/4] x [(1.486/n_2)] x $(D_2/4)^{2/3}$} / {[(Pi x (D_1^2)/4] x [(1.486/n_1)] x $(D_1/4)^{2/3}$} D2 = 14.41 in = 1.201 ft

= {[(3.142 x (1.201^2)/4] x [(1.486/0.01)] x (1.201/4)^(2/3)} / {[(3.142 x (1.25)^2)/4] x [(1.486/0.012)] x (1.25/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #5 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2.75/3.75) = 0.758

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2418 Where H = 3.75 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.276^3)/12 = 0.00175205

D = Inside diameter of existing pipe = mean OD of liner = 15 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.758 x 0.2418 x 700 x 0.412 x (200000 x 0.00175205/15^3)]^(1/2) = 6.63 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2.75 = 1.19 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3.75 x 0.758)/144) = 2.37 psi H is soil height over top of pipe

Ws = Live load = 3.05 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.19 + 2.37 + 3.05 + 0 = 6.61 psi

Compare qa to qt

qa =	6.61 psi	Actual external pressure on liner
qt =	6.63 psi	Allowed external pressure for 0.276 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.276 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.276 in = 7.0 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 15 / 0.276 = 54.35

Es / (12 x (DR^3)) = 400000/(12 x 54.35^3) = 0.2076

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.276 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

Eq X1.1	Satisfied by 0.276 in liner thickness
Eq X1.2	Satisfied by 0.276 in liner thickness
Eq X1.3	Satsified by 0.276 in liner thickness
Eq X1.4	Satisfied by 0.276 in liner thickness

Required liner thickness for fully deteriorated is: 0.276 in 7.0 mm

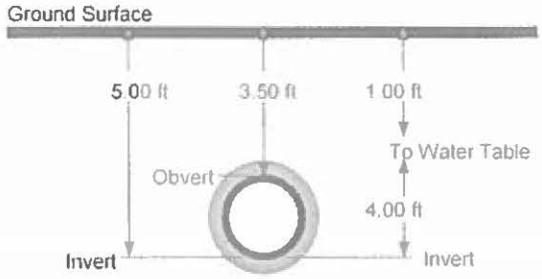
EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN

CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019

City of Jax RFQ 028-19
site#6
18" x 9 mil



Size: 18 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 8.5 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	18 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	16.20 in	At 10% ovality
Maximum Diameter for Existing Pipe	19.80 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.764	
Coeffecient of Elastic Support, B'	0.2389	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.08 psi	2.50 ft Head
Soil Pressure, Obvert	2.23 psi	3.50 ft Cover
Live Load Pressure Ws, Obvert	3.40 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.71 psi**	**For X1.3**

NOTES

Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater		6.3 mm	0.249 in	72.3
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		7.1 mm	0.280 in	64.3
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	Governs	8.5 mm	0.335 in	53.7
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated		6.5 mm	0.254 in	70.9
Required In Place Liner Thickness - Fully Deteriorated		**8.5 mm**	**0.335 in**	**53.7**

t in is rounded-up to 3 decimal places: t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 8.5 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		FLOW COMPARISON FOR 9 mm LINER	
Liner Thickness for flow comparision	9.0 mm	Inside Diameter before Lining	18.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	17.29 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	108% of before lining flow

COMMENTS

CIPP-DESIGN site #6 - 18 inch x 9 mil

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.335 in = 8.5 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 18/0.335 = 53.73 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $\{[1-\Delta/100]/[1+\Delta/100]^2\}^3$, where Δ is existing pipe % ovality Ovality = 10%

C = {[1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(53.73-1)^3] x [0.412/2] = 4.32 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.335 in liner by X1.1= 4.32 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.335 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 53.73 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 53.7

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.335 in = 8.5 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 53.73

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σL/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 18] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.28 in

Compare liner t to t required by Equation X1.2

Liner t:	0.335 in	t is from summary page
Required t:	0.280 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.335 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 9 mm LINER

Flow = Q = Area x Velocity =[(Pi x D^2)/4] x [(1.486/n) x $R^{2/3}$ x $S^{1/2}$] Manning formula, Imperial units. 9.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 18 in = 1.5 ft

Q2/Q1 = $\{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 17.29 in = 1.441 ft

= {[(3.142 x (1.441^2)/4] x [(1.486/0.01)] x (1.441/4)^(2/3)} / {[(3.142 x (1.5)^2)/4] x [(1.486/0.012)] x (1.5/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

CIPP-DESIGN site #6 - 18 inch x 9 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.335 in = 8.5 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2.5/3.5) = 0.764

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2389 Where H = 3.5 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.335^3)/12 = 0.00313295

D = Inside diameter of existing pipe = mean OD of liner = 18 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.764 x 0.2389 x 700 x 0.412 x (200000 x 0.00313295/18^3)]^(1/2) = 6.73 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2.5 = 1.08 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3.5 x 0.764)/144) = 2.23 psi H is soil height over top of pipe

Ws = Live load = 3.4 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.08 + 2.23 + 3.4 + 0 = 6.71 psi

Compare qa to qt

qa =	6.71 psi	Actual external pressure on liner
qt =	6.73 psi	Allowed external pressure for 0.335 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.335 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.335 in = 8.5 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 18 / 0.335 = 53.73

Es / (12 x (DR^3)) = 400000/(12 x 53.73^3) = 0.2149

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.335 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

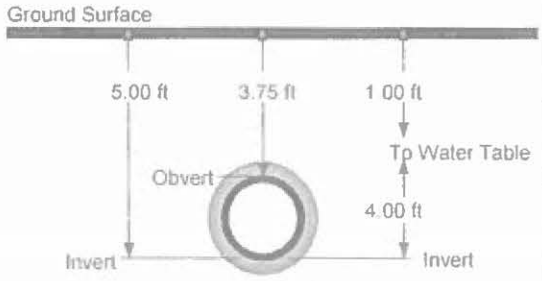
Eq X1.1	Satisfied by 0.335 in liner thickness
Eq X1.2	Satisfied by 0.335 in liner thickness
Eq X1.3	Satsified by 0.335 in liner thickness
Eq X1.4	Satisfied by 0.335 in liner thickness

Required liner thickness for fully deteriorated is: 0.335 in 8.5 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#7
15" x 7.5 mil



Size: 15 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 7 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	15 in
Depth to Invert	5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	13.50 in	At 10% ovality
Maximum Diameter for Existing Pipe	16.50 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.758	
Coeffecient of Elastic Support, B'	0.2418	
Water Pressure, Invert	1.73 psi	4.00 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.73 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.19 psi	2.75 ft Head
Soil Pressure, Obvert	2.37 psi	3.75 ft Cover
Live Load Pressure Ws, Obvert	3.05 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.61 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation	Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater	5.3 mm	0.207 in	72.5
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality	5.9 mm	0.233 in	64.4
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) Governs For load at obvert due to groundwater, soil & live loads	7.0 mm	0.276 in	54.3
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	5.4 mm	0.212 in	70.8
Required In Place Liner Thickness - Fully Deteriorated	**7.0 mm**	**0.276 in**	**54.3**

t in is rounded-up to 3 decimal places. t mm = t in x 25.4, DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 7 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		**FLOW COMPARISON FOR 9 mm LINER**	
Liner Thickness for flow comparision	9.0 mm	Inside Diameter before Lining	15.00 in
Manning n used for before lining	0.0120	Inside Diameter after Lining	14.29 in
Manning n used for after lining	0.0100	Flow Capacity after Lining	105% of before lining flow

COMMENTS

CIPP-DESIGN site #7 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 15/0.276 = 54.35 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(54.35-1)^3] x [0.412/2] = 4.17 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.73 psi

P, Allowed external pressure for 0.276 in liner by X1.1= 4.17 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.276 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 54.35 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 54.3

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 54.35

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σL/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 15] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.73 x 2 x (1+(10/100)))]}^0.5] = 0.233 in

Compare liner t to t required by Equation X1.2

Liner t:	0.276 in	t is from summary page
Required t:	0.233 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.276 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 9 mm LINER

Flow = Q = Area x Velocity = $[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, Imperial units. 9.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 15 in = 1.25 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 14.29 in = 1.191 ft

= {[(3.142 x (1.191^2)/4] x [(1.486/0.01)] x (1.191/4)^(2/3)} / {[(3.142 x (1.25)^2)/4] x [(1.486/0.012)] x (1.25/4)^(2/3) = 1.05

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 105% of before lining capacity.

CIPP-DESIGN site #7 - 15 inch x 7.5 mil

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.276 in = 7.0 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2.75/3.75) = 0.758

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2418 Where H = 3.75 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.276^3)/12 = 0.00175205

D = Inside diameter of existing pipe = mean OD of liner = 15 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.758 x 0.2418 x 700 x 0.412 x (200000 x 0.00175205/15^3)]^(1/2) = 6.63 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2.75 = 1.19 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3.75 x 0.758)/144) = 2.37 psi H is soil height over top of pipe

Ws = Live load = 3.05 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.19 + 2.37 + 3.05 + 0 = 6.61 psi

Compare qa to qt

qa =	6.61 psi	Actual external pressure on liner
qt =	6.63 psi	Allowed external pressure for 0.276 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.276 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.276 in = 7.0 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 15 / 0.276 = 54.35

Es / (12 x (DR^3)) = 400000/(12 x 54.35^3) = 0.2076

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.276 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

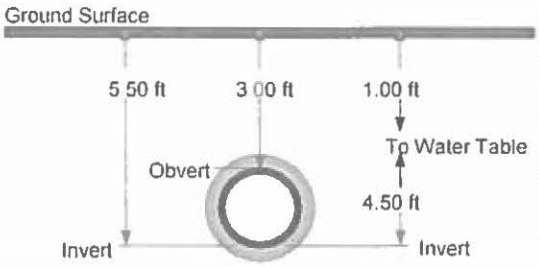
Eq X1.1	Satisfied by 0.276 in liner thickness
Eq X1.2	Satisfied by 0.276 in liner thickness
Eq X1.3	Satsified by 0.276 in liner thickness
Eq X1.4	Satisfied by 0.276 in liner thickness

Required liner thickness for fully deteriorated is: 0.276 in 7.0 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#7
30" x 15 mil



Size: 30 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 14.5 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	30 in
Depth to Invert	5.5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	ENTERED
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	27.00 in	At 10% ovality
Maximum Diameter for Existing Pipe	33.00 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.78	
Coeffecient of Elastic Support, B'	0.233	
Water Pressure, Invert	1.95 psi	4.50 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**1.95 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	0.87 psi	2.00 ft Head
Soil Pressure, Obvert	1.95 psi	3.00 ft Cover
Live Load Pressure Ws, Obvert	4.10 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.92 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation	**Required t mm**	**Required t in**	**Required DR**
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater	10.9 mm	0.431 in	69.6
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality	12.5 mm	0.494 in	60.7
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) Governs For load at obvert due to groundwater, soil & live loads	14.5 mm	0.570 in	52.6
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	10.7 mm	0.423 in	70.9
Required in Place Liner Thickness - Fully Deteriorated	**14.5 mm**	**0.570 in**	**52.6**

t in is rounded-up to 3 decimal places: t mm = t in x 25.4, DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 14.5 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON	
Liner Thickness for flow comparision	15.0 mm
Manning n used for before lining	0.0120
Manning n used for after lining	0.0100

FLOW COMPARISON FOR 15 mm LINER	
Inside Diameter before Lining	30.00 in
Inside Diameter after Lining	28.82 in
Flow Capacity after Lining	108% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.570 in = 14.5 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 30/0.57 = 52.63 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(52.63-1)^3] x [0.412/2] = 4.61 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 4.5 ft = 1.95 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 1.95 + 0 = 1.95 psi

Compare Pa to P

Pa, Actual external pressure on liner = 1.95 psi

P, Allowed external pressure for 0.57 in liner by X1.1= 4.61 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.57 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 52.63 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 52.6

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.570 in = 14.5 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 52.63

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.95 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σ_L/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 30] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(1.95 x 2 x (1+(10/100)))]}^0.5] = 0.494 in

Compare liner t to t required by Equation X1.2

Liner t:	0.570 in	t is from summary page
Required t:	0.494 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.57 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 15 mm LINER

Flow = Q = Area x Velocity =[(Pi x D^2)/4] x [(1.486/n) x $R^{2/3}$ x $S^{1/2}$] Manning formula, Imperial units. 15.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 30 in = 2.5 ft

Q2/Q1 = {[(Pi x (D_2^2)/4] x [(1.486/n_2)] x $(D_2/4)^{2/3}$} / {[(Pi x (D_1^2)/4] x [(1.486/n_1)] x $(D_1/4)^{2/3}$} D2 = 28.82 in = 2.402 ft

= {[(3.142 x (2.402^2)/4] x [(1.486/0.01)] x (2.402/4)^(2/3)} / {[(3.142 x (2.5)^2)/4] x [(1.486/0.012)] x (2.5/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.570 in = 14.5 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(2/3) = 0.78

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.233 Where H = 3 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.57^3)/12 = 0.01543275

D = Inside diameter of existing pipe = mean OD of liner = 30 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.78 x 0.233 x 700 x 0.412 x (200000 x 0.01543275/30^3)]^(1/2) = 6.92 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 2 = 0.87 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 3 x 0.78)/144) = 1.95 psi H is soil height over top of pipe

Ws = Live load = 4.1 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 0.87 + 1.95 + 4.1 + 0 = 6.92 psi

Compare qa to qt

qa =	6.92 psi	Actual external pressure on liner
qt =	6.92 psi	Allowed external pressure for 0.57 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.57 in liner thickness	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.570 in = 14.5 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 30 / 0.57 = 52.63

Es / (12 x (DR^3)) = 400000/(12 x 52.63^3) = 0.2287

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.57 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

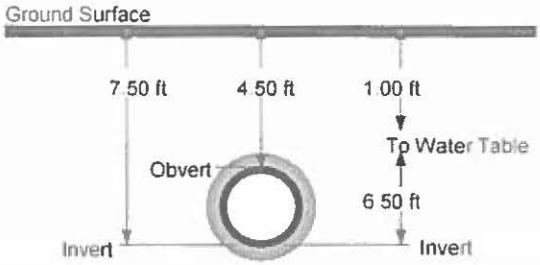
Eq X1.1	Satisfied by 0.57 in liner thickness
Eq X1.2	Satisfied by 0.57 in liner thickness
Eq X1.3	Satsified by 0.57 in liner thickness
Eq X1.4	Satisfied by 0.57 in liner thickness

Required liner thickness for fully deteriorated is: 0.570 in 14.5 mm

EVANS CONTRACTING SERVICES INC.

CIPP-DESIGN
CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-09 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** 20-Mar-2019
City of Jax RFQ 028-19
site#7
36" x 18 mil



Size: 36 in Ovality: 10%
Fully Deteriorated Design
Required Liner Thickness: 18 mm

EXISTING PIPE PARAMETERS	ENTERED
Existing Pipe Condition	Fully Det.
Inside Diameter, D	36 in
Depth to Invert	7.5 ft
Water Table below Surface	1 ft
Ovality of Existing Pipe, Δ	10.0%
Soil Density, w	120 lb/ft3
Soil Modulus, E's	700 psi
Live Load, Ws	HS-20
Other Load	0 psi
Vacuum Condition	0 psi
CIPP LINER PARAMETERS	**ENTERED**
Design Life	50 Years
Flexural Modulus short-term, Es	400,000 psi
Retention for 50 Year Design E	50%
Flexural Strength short-term, σs	4,500 psi
Retention for 50 Year Design σ	50%
Enhancement Factor, K	7
Poisson's Ratio, v	0.3
Safety Factor, N	2
BY ASTM F1216 VERSION	F1216-09

CIPP liner design by ASTM F1216-09 Appendix X1 Method

FACTOR SUMMARY - FULLY DETERIORATED		
Flexural Modulus Design, E	200,000 psi	50% of Short-term
Flexural Strength Design, σ	2,250 psi	50% of Short-term
Minimum Diameter for Existing Pipe	32.40 in	At 10% ovality
Maximum Diameter for Existing Pipe	39.60 in	At 10% ovality
Ovality Reduction Factor, C	0.412	
Water Buoyancy Factor, Rw	0.743	
Coeffecient of Elastic Support, B'	0.2509	
Water Pressure, Invert	2.81 psi	6.50 ft Head
Vacuum Pressure, Invert	0.00 psi	
Total Design Pressure, P, Invert	**2.81 psi**	**For X1.1 & X1.2**
Water Pressure, Obvert	1.52 psi	3.50 ft Head
Soil Pressure, Obvert	2.79 psi	4.50 ft Cover
Live Load Pressure Ws, Obvert	2.25 psi	Note 1
Other Load Pressure, Obvert	0.00 psi	
Total Design Pressure, qt, Obvert	**6.56 psi**	**For X1.3**

NOTES
Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation	Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater	14.8 mm	0.582 in	61.9
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2 - 0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality Governs	18.0 mm	0.707 in	50.9
X1.3: qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads	16.6 mm	0.655 in	55.0
X1.4: (Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.093 For minimum thickness fully deteriorated	12.9 mm	0.507 in	71.0
Required in Place Liner Thickness - Fully Deteriorated	**18.0 mm**	**0.707 in**	**50.9**

t in is rounded-up to 3 decimal places: t mm = t in x 25.4; DR = (Inside Diameter in)/(t in) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 400000 psi (D790); σs ≥ 4500 psi (D790); Thickness ≥ 18 mm.
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON	
Liner Thickness for flow comparison	18.0 mm
Manning n used for before lining	0.0120
Manning n used for after lining	0.0100

FLOW COMPARISON FOR 18 mm LINER	
Inside Diameter before Lining	36.00 in
Inside Diameter after Lining	34.59 in
Flow Capacity after Lining	108% of before lining flow

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: FULLY DETERIORATED DESIGN **F1216-09**

Fully deteriorated design requires satisfying 4 F1216 equations: X1.1, X1.2, X1.3 and X1.4

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner from groundwater and any vacuum

Determine P for liner thickness of: t = 0.707 in = 18.0 mm t is from summary page

K = Enhancement factor = 7 As entered

E_L = Flexural Modulus Design = (Flexural Modulus Short-term) x (Long-term Retention)

E = 400000 x 50% = 200000 psi

v = Poisson's ratio = 0.3 As entered

DR = D/t = 36/0.707 = 50.92 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is existing pipe % ovality Ovality = 10%

C = ([1- 10/100]/[1+10/100]^2)^3 = 0.412

N = Safety Factor = 2 As entered.

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P = [(2 x 7 x 200000)/(1-0.3^2)] x [1/(50.92-1)^3] x [0.412/2] = 5.1 psi

Determine actual external pressure on liner, Pa

Pa = (Ground water pressure, Pgw) + (Vacuum pressure, Pv)

Pgw = 0.433 x H = 0.433 x 6.5 ft = 2.81 psi. Where H is height of water over invert.

Pv = -(0) = 0 psi As entered, 0 psi

Pa = Pgw + Pv = 2.81 + 0 = 2.81 psi

Compare Pa to P

Pa, Actual external pressure on liner = 2.81 psi

P, Allowed external pressure for 0.707 in liner by X1.1= 5.1 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 0.707 in liner thickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 50.92 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 50.9

Check Equation X1.2

$[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Check X1.2 for liner thickness of: t = 0.707 in = 18.0 mm t is from summary page

Δ = 10 As entered.

DR, calculated above for X1.1 = 50.92

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) = 4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 2.81 psi Calculated above for X1.1

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x D] / [0.5 + {0.25 + (6 x (Δ/100)) x [σ_L/(P x N x (1+(Δ/100)))]}^.5]

t = [3 x (10/100) x 36] / [0.5 + {0.25 + (6 x (10/100)) x [2250/(2.81 x 2 x (1+(10/100)))]}^0.5] = 0.707 in

Compare liner t to t required by Equation X1.2

Liner t:	0.707 in	t is from summary page
Required t:	0.707 in	By Equation X1.2
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 0.707 in liner thickness.

Fully Deteriorated calculation details continued on next page

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING FOR 18 mm LINER

Flow = Q = Area x Velocity =[(Pi x D^2)/4] x [(1.486/n) x $R^{2/3}$ x $S^{1/2}$] Manning formula, Imperial units. 18.0 mm liner

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 36 in = 3 ft

Q2/Q1 = {[(Pi x (D_2^2)/4] x [(1.486/n_2)] x $(D_2/4)^{2/3}$} / {[(Pi x (D_1^2)/4] x [(1.486/n_1)] x $(D_1/4)^{2/3}$} D2 = 34.59 in = 2.882 ft

= {[(3.142 x (2.882^2)/4] x [(1.486/0.01)] x (2.882/4)^(2/3)} / {[(3.142 x (3)^2)/4] x [(1.486/0.012)] x (3/4)^(2/3) = 1.08

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 108% of before lining capacity.

ASTM F1216 APPENDIX X1 FULLY DETERIORATED CALCULATION DETAILS CONT'D **F1216-09**

Check Equation X1.3

$q_t = [C/N] \times [32R_wB'E'_s(E_LI/D^3)]^{1/2}$ F1216-07a -

$q_t = [1/N] \times [32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ F1216-09 **Using this equation**

Design is by F1216-09

Where q_t is the maximum allowed external pressure on the liner from cover, live loads and other loads

Determine q_t for liner thickness of: t = 0.707 in = 18.0 mm t is from summary page

C = Ovality Reduction Factor = 0.412 (calculated on page 1)

N = Safety Factor = 2

Rw = Water Bouyancy Factor (Min 0.67, Max 1.0) = 1-0.33(Hw/H) = 1-0.33(3.5/4.5) = 0.743

Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2

B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2509 Where H = 4.5 and e = 2.718

E's = Modulus of soil reaction = 700 psi. As entered.

EL = Long-term modulus for CIPP = 200000 psi (calculated on page 1)

I = Moment of inertia for liner = (t^3)/12 = (0.707^3)/12 = 0.02944944

D = Inside diameter of existing pipe = mean OD of liner = 36 in

qt=[1/N] x [32 x Rw x B' x E's x Cx (E x I/D^3)]^(1/2) X1.3 for F1216-09

qt = [1/2] x [32 x 0.743 x 0.2509 x 700 x 0.412 x (200000 x 0.02944944/36^3)]^(1/2) = 7.37 psi

Determine actual external pressure on liner, qa, due to existing pipe conditions

qa = Ww + W + Ws + Wo

Ww = Water load = 0.433 x Hw = 0.433 x 3.5 = 1.52 psi Hw is water over top of pipe.

W = Soil Load = (w x H x Rw)/144 = (120 x 4.5 x 0.743)/144) = 2.79 psi H is soil height over top of pipe

Ws = Live load = 2.25 psi Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.

Wo = Other load = 0 psi, entered

qa = 1.52 + 2.79 + 2.25 + 0 = 6.56 psi

Compare qa to qt

qa =	6.56 psi	Actual external pressure on liner
qt =	7.37 psi	Allowed external pressure for 0.707 mm liner by Equation X1.3
Is qt ≥ qa?	Yes. Equation X1.3 is satisfied by 0.707 in liner thickness.	

Check Equation X1.4

$(Es \times I)/D^3 = Es/(12 \times (DR^3)) \geq 0.093$

Determine for liner thickness t of: t = 0.707 in = 18.0 mm t is from summary page

Es = initial (short-term) modulus = 400000 psi

DR = liner dimension ratio = D/t = 36 / 0.707 = 50.92

Es / (12 x (DR^3)) = 400000/(12 x 50.92^3) = 0.2525

Is Es / (12 x (DR^3)) ≥ 0.093? Yes. Equation X1.4 is satisfied by 0.707 in liner thickness

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

Eq X1.1	Satisfied by 0.707 in liner thickness
Eq X1.2	Satisfied by 0.707 in liner thickness
Eq X1.3	Satsified by 0.707 in liner thickness
Eq X1.4	Satisfied by 0.707 in liner thickness

Required liner thickness for fully deteriorated is: 0.707 in 18.0 mm

SUBJECT: RFQ FOR STORM SEWER REHABILITATION BY CURED-IN-PLACE PIPE (CIPP) TECHNOLOGY

BID #: RFQ-0208-19 **OPEN DATE: 2018-10-03**

GENERAL GOVERNMENT AWARDS COMMITTEE

KIND AND BASIS OF CONTRACT: CONSTRUCTION SERVICE – FROM CONTRACT EXECUTION THROUGH SEPTEMBER 30, 2020, WITH TWO (2) TWO (2) YEAR RENEWAL OPTIONS

AGENCY: RIGHT OF WAY & STORMWATER MAINTENANCE DIVISION

BASIS OF AWARD: PRE-QUALIFICATIONS

NUMBER OF BIDS INVITED: (9) **NUMBER RECEIVED:** (8) **OTHER:** (0)

SUMMARY OF BIDS AND RECOMMENDED ACTIONS:
Recommend approval to reject Hinterland Group, LLC. for failure to meet all the criteria as specified in the RFQ documents:

Recommend approval to pre-qualify the following firms that have met all the criteria as specified in the RFQ documents: Granite Inliner, SAK Construction, LLC., Insituform Technologies, LLC., Lanzo Trenchless Technologies South, Gulf Coast Underground, LLC., Evans Contracting Services, Inc. and VacVision Environmental, LLC. The period of service shall be from contract execution through September 30, 2020, with two (2), two (2) year renewal options. The maximum value of services to be performed by each firm will be $1,000,000.00, to be formally executed through the Office of General Counsel; and individual projects to be competitively bid by approved firms and awarded by purchase orders utilizing account PWGM462SW-06505-PW0072-01.

Attachments: Recommendation Memo, Evaluation Sheet, Firm Rejection Letter, Scope of Services, Basis of Determining Qualified Firms

Analyst: CHELSEY FLEMING

RESPECTFULLY SUBMITTED: GREGORY PEASE, CHIEF PROCUREMENT DIVISION

CONCURRENCE BY: STEVE D. LONG, JR., P.E., CHIEF, RIGHT OF WAY AND STORMWATER MAINT. DIVISION

(ALL AWARD ACTIONS SUBJECT TO LAWFULLY APPROPRIATED FUNDS)
ACTION OF GGAC COMMITTEE ON RECOMMENDATIONS ABOVE

MEMBERS APPROVING 3 MEMBERS DISAPPROVING Ø DATE: 11/08/18

OTHER:

ACTION OF AWARDING AUTHORITY DATE 11/08/18

APPROVED DISAPPROVED

OTHER

SIGNATURE OF AUTHENTICATION

Sam E. Mousa
Chief Administrative Officer
For: Mayor Lenny Curry
Under Authority of:
Executive Order No. 2015-05

QWS3270X 4/5/2019 8:54 AM
FAML6350 V5.1 ** NW COJ FAMIS PRODUCTION ** 04/05/2019
LINK TO: ACCOUNT SUMMARY INQUIRY 8:53 AM

FISCAL MO/YEAR : 07 2019 CURRENCY CODE :
INDEX CODE : PWGM462SW DSR CAPITAL MAINTENANCE
SUBOBJECT : 06505 OTHER CONSTRUCTION COSTS
PROJECT : PW0072 DRAINAGE SYSTEM REHABILATION
PROJECT DETAIL : 01 DRAINAGE SYSTEM REHABILITATION
GRANT :
GRANT DETAIL :
USER CODE :

S	APR 2019	ANNUAL BALANCE	ALL YEARS BALANCE
ESTIMATED REVENUES	.00	.00	.00
REVENUES	.00	.00	.00
UNREALIZED REVENUES	.00	.00	.00
BUDGET	.00	4,200,000.00	17,279,839.84
EXPENDITURES	327,915.73	2,157,733.73	13,913,926.73
ENCUMBRANCES	-87,316.18	1,196,114.90	2,568,011.11
PRE-ENCUMBRANCES	.00	.00	.00
REMAINING BALANCE	-240,599.55	846,151.37	797,902.00

F1-HELP F2-SELECT F4-PRIOR F5-NEXT
F9-LINK F10-PRIOR-MO F11-NEXT-MO

G014 - RECORD FOUND

QWS3270X 4/5/2019 8:53 AM

FAML6350 V5.1 ** NW COJ FAMIS PRODUCTION ** 04/05/2019

LINK TO: ACCOUNT SUMMARY INQUIRY 8:52 AM

FISCAL MO/YEAR : 07 2019 CURRENCY CODE :

INDEX CODE : PWGM461SW STORMWATER SERVICES

SUBOBJECT : 03410 CONTRACTUAL SERVICES

PROJECT :

PROJECT DETAIL :

GRANT :

GRANT DETAIL :

USER CODE :

S	APR 2019	ANNUAL BALANCE	ALL YEARS BALANCE
ESTIMATED REVENUES	.00	.00	.00
REVENUES	.00	.00	.00
UNREALIZED REVENUES	.00	.00	.00
BUDGET	.00	3,611,350.89	3,611,350.89
EXPENDITURES	100,366.90	951,898.32	951,898.32
ENCUMBRANCES	-100,126.90	1,429,314.35	1,429,314.35
PRE-ENCUMBRANCES	.00	1.00	1.00
REMAINING BALANCE	-240.00	1,230,137.22	1,230,137.22

F1-HELP F2-SELECT F4-PRIOR F5-NEXT

F9-LINK F10-PRIOR-MO F11-NEXT-MO

G014 - RECORD FOUND