TECHNICAL MEMORANDUM

To: Peter J. Mulvey, P.E. c/o Pima County Regional Wastewater Reclamation Department (PCRWRD) Product Selection Committee (PSC)

From: PREDL Systems / Alonso Vidal, P.E.

Date: June 10, 2018

Subject: Revised Submittal (1) - PREDL Systems Hybrid PVC Manhole System Alternate Material for Proposed Manhole #63, Phase 1-Old Nogales Interceptor/Aerospace Corridor and Park Avenue Relief Sewer Augmentation. Revision to include 60" manhole and temperature derating.

Background

This submittal is to address the stipulations set forward by PCRWRD PSC as stated in your letter (May 11, 2018) to approve the referenced installation as a Product Test subject and revised to include an assessment for the use of 60" manholes for the same application.

The stipulation requirements are interpreted as follows:

1) Resubmit calculations with a review from an Arizona Registered Engineer,
2) Include a statement by the Arizona Registered engineer about the applicability of the product for use in public right-of-way installations.
3) Identify materials and procedures for installation of the test manhole.
4) Describe backfill procedures specific to this product and identify any related variance from PCRWRD compaction standards.

Additionally, temperature derating considerations are included in response to Dibble Engineering's request.

Content/Review

1) The computation submitted by PREDL for the 48" and 60" manholes are based on ASTM F 1759 – 97 (Reapproved 2004) which is the Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications, Please see Table 1 and Table 2 in the attachments of this document.. The input parameters of the submitted spreadsheets (PVC Calculation Sheet-2.xls) were revised and checked OK for typical installations, some results were also verified as OK. The calculations submitted by PREDL consist of an Excel spreadsheet with pipe strain calculations for a loading scale from 4 to 25 ft depths. This shows a

0.00146 % and a 0.00116 % strain for the 48" and 60" PVC SR51 pipes respectively at 25 feet depth with a combined effective load (lithostatic + hydrostatic) of 2,154 pounds per square feet. The overall purpose of this table is to show that structural calculations confirm that the proposed PVC manholes will withstand the burial loads for typical manhole depths with no problem.

To verify the PVC pipe stress conditions at depth shown in these spreadsheets a percent deflection in buried flexible pipe utilizing the Modified Iowa Equation was performed which show a 3.3% deflection at 25 feet burial which is OK. See Table 3 in the attachments for more details.

2) The 48" PVC Manhole as manufactured and installed by PREDL Systems is OK for use in public Right-of Way areas given the specific tests performed as described below, the 60" PVC manhole is inferred to be acceptable given the considerations given below. The proposed manhole counts with the standard concrete collar and riser rings, and standard concrete base but proposes a fiberglass reinforced plastic (FRP) interior lined surfaces and PVC manhole walls (or shaft).

   The manhole load bearing capacity was tested per ASTM D 3753-12 Glass-Fiber-Reinforced Polyester Manholes and Wetwells, section 6.4.1 Load Rating (see attachments) and passed for a H-20 Loading per the American Association of State Highway Transportation Officials (AASHTO) as published in its bridge design criteria, commonly known as H-20 or HS-20. It consists of truck axle loading of 32,000 lbs. or wheel loading of 16,000 lbs. This is considered as Medium duty and is the one commonly used for public works.

   The FRP liner used at the base passed the Pickle Jar Test (see attachments), with is considered acceptable by the industry. This test checks the weight change, but additional tests were performed for tensile strength, hardness, flexural strength, ignition loss of fiberglass, abrasion, and compression. Even though there are not strict pass-fail thresholds it is accepted by agencies using the popular Green Book.

   The proposed PREDL PVC manhole was also vacuum tested following ASTM C1244-11 Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill using two configurations consisting in two different gaskets which both passed the test, see attachments for more details. PREDL is recommending the use of mastic joint sealant for this project.

   The 60" PVC manhole has not been ASTM D 3753-12 tested but the structural framework and installation are very similar. In a brief comparison based on their similitude and focused on the results on the ASTM F 1759 – 97 (2004) strain results for the 48" tested manhole and the 60" manhole, the increase in manhole wall thickness shows the 60" manhole to be acceptable application. Please refer to the attachments for more details.

3) The PREDL proposed manhole materials are listed as follows:

- Manhole wall: Diamond Plastics Trans-21 C900 48” DR51 Pressure class PVC Pipe.
- Manhole Lid: H-20 rated ASTM C478 precast concrete w/ integrated PREDL FRP liner and telescopic access collar.
- Grade raiser rings: ASTM C478 precast concrete grade rings.
- Manhole frame and cover: to Pima County Wastewater Standard
- Joint sealant: ASTM C990 butyl rubber with ASTM C877 joint wrap
- All ASTM C478 concrete from NPCA certified manufacturer.

Please see in the corresponding attachments a draft drawings titled: PVC MANHOLE DESIGN w/ 51" OD BASE and PVC MANHOLE DSIGN WITH 64” OD BASE for more details on the materials used.

The installation of the proposed PVC is depicted in PREDL literature included in the attachments.

4) Backfill material shall conform to Subsection 3.1.3(E) and S.D. RWRD-104, no other specific backfill requirements are needed for the PREDL PVC manhole.

Conclusions

The PREDL PVC manholes (48” and 60”) are good candidates’ product for PCRWRD Product Selection Committee list. PREDL has performed tests with successful results for the 48” manhole, the 60” manhole being similar with thicker manhole walls tend to prove both good for use in public right-of -way and with minimum variance to standard manhole installations. The low potential impact of temperature with basically no need for temperature derating and the long-term use of the FRP has also been checked with Pickle Jar test commonly used in the industry.

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Alonso Vidal, P.E.

ATTACHMENTS

PVC PIPE - CALCULATIONS

Table 1 - 48" Manhole ASTM F 1759-97 (2004) Computations

PREDL SYSTEM NORTH AMERICA
7520 Conrad Street, Burnaby, BC V5A 2H7

Design Calculations For 48" Dia. PVC Manhole Riser

PVC Material Information:

PVC Pipe I.D.	48.000	inch
Wall Thickness	1.000	inch
I of Wall	0.083	inch^4/in.
Material Modulus, E	400000.000	psi
Poisson's Ratio	0.380	
Tensile Strength	1000.000	psi
Comp. Strength	4000.000	psi
Axial Strain Limit	0.035	
Ring Strain Limit	0.050	

Soil Information:

Soil Dry Density	120.000	lbf/sf
Soil Sat. Density	135.000	lbf/sf
Internal Friction Angle	30.000	
Friction Coefficient	0.400	
Soil Modulus, E'	1000.000	psi
Active Earth Pres. Coef.	0.333	

Other Information:

Critical R.T., Dry	2252.809	lbf/in
Critical Axial Strain	0.025	
H20 wheel load	16000	lbs

Considerations and Assumptions to ASTM F 1759-97 (2004):

1. Dry soil and Saturated soil conditions
2. H20 Live Load
3. Soil Modulus = 1000 psi
4. Backfill Width 24" minimum.
5. Ring Thrust Compression and Bending
6. Axial soil Down Drag Load
7. PVC Pipe Material to *"Hand Book of PVC PIPE DESIGN AND CONSTRUCTION", 5th Edition*

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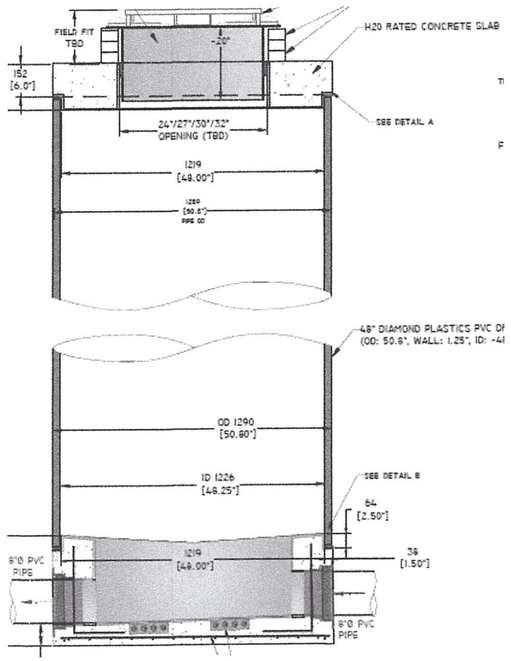


Note: Cells in yellow are the input variables. Outputs are the Safety Factors, which are reflecting the performance of Pipe Ring Deformation, Ring Stress, Axial Deformation and Bouyancy Effect, respectively. All Safety Factors should be greater than 2, except Bouyancy Effect should be greater than 1.0

Manhole Depth	PVC Length	Dry Radial Pres.	Wet Radial Pres.	D.D. Shear Stress	D.D. Force	R.T. Stress	R.B. Stress	Strain of T+B	Strain of Axial	C.R.T Stress	Safety Factor Index			
ft	ft	lb/sf	lbf/sf	lbf/sf	lbs	lbf/in	lbf/in	%	%	lbf/in	Ring Deform.	Ring Stess	Axial Deform.	Bouyancy Effect
4.00	1.00	121.00	229.21	27.23	356.37	39.00	9.55	0.024%	0.029%	909.22	208	23	87	1.3
5.00	2.00	169.40	320.89	38.12	997.85	54.60	13.38	0.034%	0.030%	932.17	148	17	84	1.2
6.00	3.00	217.80	412.57	49.01	1924.42	70.19	17.20	0.043%	0.032%	955.33	115	14	79	1.2
7.00	4.00	266.20	504.25	59.90	3136.09	85.79	21.02	0.053%	0.034%	978.67	94	11	74	1.3
8.00	5.00	314.60	595.93	70.79	4632.87	101.39	24.84	0.063%	0.037%	1002.18	80	10	69	1.4
9.00	6.00	363.00	687.62	81.68	6414.74	116.99	28.66	0.072%	0.040%	1025.82	69	9	64	1.5
10.00	7.00	411.40	779.30	92.57	8481.71	132.59	32.48	0.082%	0.043%	1049.56	61	8	59	1.6
11.00	8.00	459.80	870.98	103.46	10833.78	148.19	36.31	0.092%	0.047%	1073.37	55	7	54	1.8
12.00	9.00	508.20	962.66	114.35	13470.95	163.79	40.13	0.101%	0.052%	1097.22	49	7	49	1.9
13.00	10.00	556.60	1054.34	125.24	16393.22	179.38	43.95	0.111%	0.057%	1121.07	45	6	45	2.1
14.00	11.00	605.00	1146.03	136.13	19600.59	194.98	47.77	0.120%	0.062%	1144.90	42	6	41	2.2
15.00	12.00	653.40	1237.71	147.02	23093.06	210.58	51.59	0.130%	0.068%	1168.66	38	6	37	2.4
16.00	13.00	701.80	1329.39	157.91	26870.63	226.18	55.41	0.140%	0.074%	1192.33	36	5	34	2.5
17.00	14.00	750.20	1421.07	168.80	30933.30	241.78	59.24	0.149%	0.081%	1215.86	33	5	31	2.7
18.00	15.00	798.60	1512.75	179.69	35281.07	257.38	63.06	0.159%	0.088%	1239.23	31	5	29	2.9
19.00	16.00	847.00	1604.44	190.58	39913.93	272.98	66.88	0.169%	0.096%	1262.39	30	5	27	3.0
20.00	17.00	895.40	1696.12	201.47	44831.90	288.58	70.70	0.178%	0.104%	1285.32	28	4	24	3.2
21.00	18.00	943.80	1787.80	212.36	50034.97	304.17	74.52	0.188%	0.113%	1307.98	27	4	23	3.4
22.00	19.00	992.20	1879.48	223.25	55523.13	319.77	78.34	0.197%	0.122%	1330.34	25	4	21	3.5
23.00	20.00	1040.60	1971.16	234.14	61296.40	335.37	82.17	0.207%	0.132%	1352.37	24	4	19	3.7
24.00	21.00	1089.00	2062.85	245.03	67354.76	350.97	85.99	0.217%	0.142%	1374.04	23	4	18	3.9
25.00	22.00	1137.40	2154.53	255.92	73698.23	366.57	89.81	0.226%	0.152%	1395.32	22	4	17	4.1

D.D. Force: *Down Drag Force*
R.T. Stress: *Ring Thrust Stress*
R.B. Stress: *Ring Bending Stress*
Strain of T+B: *Combined Strain of Ring Thrust and Bending*
C.R.T Stress: *Critical Ring Thrust Stress*

Counter Weight (Base and Lid) = ***3500 lbs***
PVC Riser Weight (per foot length) = ***110 lbs***

Table 2 - 60" Manhole ASTM F 1759-97 (2004) Computations

PVC Material Information

PVC Pipe ID	60.000	inch
Wall Thickness	1.208	inch
I of Wall	0.147	Inch^4/in
Material Modulus	400000.000	psi
Poisson Ratio	0.380	
Tensile Strength	1000.000	psi
Comp. strength	4000.000	psi
axial strain limit	0.035	
ring strain limit	0.050	

Soil Information

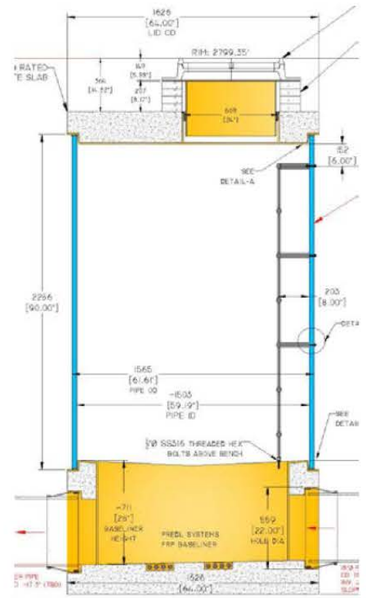
soil dry density	120.000	lbf/sq.f
soil sat. density	135.000	lbf/sq.f
soil intet.friction angle	30.000	
friction coefficient	0.400	
Soil Modulus	1000.000	psi,E'
active Earth pres. Coe.	0.333	

Other

Critical R.T,Dry	2721.393	lbf/in
Critcal Axial Strain	0.025	
H20 wheel load	16000	lbs

Calculation Sheet

Design Calculation For 60" Dia. PVC Manhole Riser



Considerations and Assumptions to ASTM F 1759-97 (2004)

1. Dry soil and Satuated soil conditions
2. H20 live load
3. Soil modulus = 1000 psi
4. Backfill Width 24" minimum.
5. Ring Thrust Compression and Bending
6. Axial soil down drag load
7. PVC Pipe Material to *"Hand Book of PVC PIPE DESIGN AND CONSTRUCTION", 5TH Edition*

Note: Cells in yellow are the input variables. Outputs are the safety factors which are reflecting the performance of Pipe Ring Deformation, Ring Stress, Axial Deformation Bouyancy , respectively, All safety factors should be greater than 2 except Bouyancy Effect should be greater than 1.0

Manhole Depth	PVC Length	Dry radial Pres.	Wet.radial Pres.	D.D.Shear Stress	D.D. Force	R.T. Stress	R. B. Stress	Strain of T+B	Strain of Axial	C.R.T Stress	Safety Factor Index			
ft	ft	lb/sf	lbf/sf	lbf/sf	lbs	lbf/in	lbf/in	%	%	lbf/in	Ring Deform.	Ring Stess	Axial Deform.	Bouyancy effect
4.00	1.00	121.00	229.21	27.23	444.87	48.71	14.91	0.025%	0.018%	1080.10	197	22	139	1.1
5.00	2.00	169.40	320.89	38.12	1245.63	68.20	20.87	0.036%	0.019%	1107.36	141	16	133	1.1
6.00	3.00	217.80	412.57	49.01	2402.29	87.68	26.83	0.046%	0.020%	1134.87	109	13	124	1.1
7.00	4.00	266.20	504.25	59.90	3914.85	107.17	32.80	0.056%	0.021%	1162.60	89	11	115	1.1
8.00	5.00	314.60	595.93	70.79	5783.30	126.65	38.76	0.066%	0.023%	1190.53	76	9	105	1.2
9.00	6.00	363.00	687.62	81.68	8007.65	146.14	44.72	0.076%	0.026%	1218.61	66	8	95	1.3
10.00	7.00	411.40	779.30	92.57	10587.89	165.62	50.69	0.086%	0.029%	1246.81	58	8	86	1.4
11.00	8.00	459.80	870.98	103.46	13524.03	185.11	56.65	0.097%	0.032%	1275.10	52	7	78	1.5
12.00	9.00	508.20	962.66	114.35	16816.06	204.59	62.61	0.107%	0.035%	1303.43	47	6	70	1.6
13.00	10.00	556.60	1054.34	125.24	20463.99	224.08	68.58	0.117%	0.039%	1331.76	43	6	63	1.7
14.00	11.00	605.00	1146.03	136.13	24467.81	243.56	74.54	0.127%	0.044%	1360.07	39	6	57	1.8
15.00	12.00	653.40	1237.71	147.02	28827.53	263.05	80.50	0.137%	0.048%	1388.30	36	5	51	1.9
16.00	13.00	701.80	1329.39	157.91	33543.15	282.53	86.47	0.147%	0.053%	1416.41	34	5	46	2.1
17.00	14.00	750.20	1421.07	168.80	38614.66	302.02	92.43	0.158%	0.059%	1444.37	32	5	42	2.2
18.00	15.00	798.60	1512.75	179.69	44042.06	321.50	98.39	0.168%	0.065%	1472.13	30	5	38	2.3
19.00	16.00	847.00	1604.44	190.58	49825.36	340.99	104.36	0.178%	0.071%	1499.64	28	4	35	2.5
20.00	17.00	895.40	1696.12	201.47	55964.56	360.47	110.32	0.188%	0.077%	1526.88	27	4	32	2.6
21.00	18.00	943.80	1787.80	212.36	62459.65	379.96	116.28	0.198%	0.084%	1553.80	25	4	29	2.7
22.00	19.00	992.20	1879.48	223.25	69310.64	399.44	122.25	0.208%	0.092%	1580.36	24	4	27	2.9
23.00	20.00	1040.60	1971.16	234.14	76517.52	418.93	128.21	0.218%	0.100%	1606.53	23	4	25	3.0
24.00	21.00	1089.00	2062.85	245.03	84080.30	438.41	134.17	0.229%	0.108%	1632.27	22	4	23	3.1
25.00	22.00	1137.40	2154.53	255.92	91998.97	457.90	140.13	0.239%	0.116%	1657.55	21	4	21	3.3

D.D.FORCE: *Down Drag Force*
R.T.Stress: *Ring Thrust stress*
R.B.Stress: *Ring bending Stress*
Stain of T+B: *Combine strain of Ring Thrust and Bending*
C.R.T Stress: *Critical Ring Thrust Stress*

Counter weight (base and lid) = **5000 lbs**
PVC Riser Weight (per foot length)= **155 lbs**

Table 3 48" PVC Pipe Deflections at Burial Depths

Parameters

Deflection Lag Factor (DLF)	1.000	Bedding Constant (K)	0.1
Pipe Stiffness (PS)	14 psi	Soil Modulus (E')	1000 psi
Add. Live Load	H20 Highway	Weight of Backfill	120 lbs/Ft^3
Depth of Burial	4 / 25 / 1		

Results

Depth	Deflection	Dead Load	Live Load	Total Load
4'	0.97%	3.33 PSI	2.78 PSI	6.11 PSI
5'	0.94%	4.17 PSI	1.74 PSI	5.91 PSI
6'	1.01%	5 PSI	1.39 PSI	6.39 PSI
7'	1.12%	5.83 PSI	1.22 PSI	7.05 PSI
8'	1.17%	6.67 PSI	0.69 PSI	7.36 PSI
9'	1.19%	7.5 PSI	0 PSI	7.5 PSI
10'	1.32%	8.33 PSI	0 PSI	8.33 PSI
11'	1.45%	9.17 PSI	0 PSI	9.17 PSI
12'	1.59%	10 PSI	0 PSI	10 PSI
13'	1.72%	10.83 PSI	0 PSI	10.83 PSI
14'	1.85%	11.67 PSI	0 PSI	11.67 PSI
15'	1.98%	12.5 PSI	0 PSI	12.5 PSI
16'	2.11%	13.33 PSI	0 PSI	13.33 PSI
17'	2.25%	14.17 PSI	0 PSI	14.17 PSI
18'	2.38%	15 PSI	0 PSI	15 PSI
19'	2.51%	15.83 PSI	0 PSI	15.83 PSI
20'	2.64%	16.67 PSI	0 PSI	16.67 PSI
21'	2.77%	17.5 PSI	0 PSI	17.5 PSI
22'	2.91%	18.33 PSI	0 PSI	18.33 PSI
23'	3.04%	19.17 PSI	0 PSI	19.17 PSI
24'	3.17%	20 PSI	0 PSI	20 PSI
25'	3.3%	20.83 PSI	0 PSI	20.83 PSI

$$\%\frac{\Delta Y}{D} = \frac{(D_L KP + KW')100}{0.149PS + 0.061E'}$$

EXPIRES: 9/30/2020

PVC MANHOLE – USE IN PUBLIC RIGHT OF WAYS – TESTS AND RESULTS

RAMTECH LABORATORIES

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REVISED*
MASTER TEST REPORT

LABORATORY NUMBER:
3804-16-11 (A1)

EVALUATION OF:
FRP (IPS 7000-204HB Resin)

PREPARED FOR:
Predl System North America
Burnaby, BC

TEST CONDUCTED AT:
Ramtech Laboratories
14104 Orange Avenue
Paramount, CA 90723

APPROVED BY:

STEVEN BERGGREN
LABORATORY ADMINISTRATOR
DATE ISSUED: June 28, 2018

Note: This report has been revised in accordance with the client's request. Please refer to original report 3804-16-11 dated August 5, 2017 for original comments and observations

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Issue Date: June 28, 2018

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BODY OF REPORT

LABORATORY NUMBER: 3804-16-11 (A1)
Issue Date: June 28, 2018

Introduction:

As requested by the client, Ramtech Laboratories conducted testing on the submitted FRP (IPS 7000-204HB Resin) specimens.

The client has stated the purpose of this testing was to determine the chemical resistance as well as various mechanical and physical properties of the client's product as outlined in Section 1 of this report. Chemical resistance testing included weight change in general accordance with the Standard Specifications for Public Works (Greenbook) as well as the retaining of mechanical properties in general accordance with product approval requirements of major municipal jurisdictions

The following data and results is presented in general accordance with the reporting requirements of ISO 17025

General Information:

1 The identification of the test method used:

1.1 The following tests were conducted as requested by the client

- 1.1.1.1 Chemical Resistance SSPWC 211-2 (Pickle jar Test)
- 1.1.1.2 Weight change
- 1.1.1.3 Tensile strength
- 1.1.1.4 Hardness
- 1.1.1.5 Flexural
- 1.1.1.6 Ignition Loss of Fiberglass
- 1.1.1.7 Abrasion
- 1.1.1.8 Compression

2 A description of the items tested:

2.1 The samples are described (by the client) as a Custom Built Concrete Protective Liner intended for use in Municipal Sewer Systems

3 Sampling:

3.1 Ramtech Laboratories received the material tested from the client's manufacturing facility in Burnaby BC as presented below:

- 3.1.1 Company Name: Predl Systems North America
- 3.1.2 Address: 7520 Conrad Street
- 3.1.3 Country: Buraby BC, V5A2H7 Canada

4 The date of receipt of the test items:

4.1 Ramtech Laboratories received the test specimens as shown below beginning in December 2016

5 The date of performance of the test:

5.1 All testing began in February 2017 and was completed in 2018:

6 Clarification of any deviations, additions and exclusions from the test method:

6.1 Ramtech Laboratories tested the submitted samples in general accordance with the prescribed test methods.

BODY OF REPORT

LABORATORY NUMBER: 3804-16-11 (A1)
Issue Date: June 28, 2018

A Chemical Resistance (Pickle Jar—Weight Change):

A1 Test Results:

The results of the Weight Loss Test are summarized below with graphical results presented in Appendix 1

Chemical Solution	Concentration	28-day	56-day	84-day	112-day
Sulphuric Acid (H2SO4)	20%	0.007%	0.013%	0.022%	0.030%
Sodium Hydroxide (NaOH)	5%	0.010%	0.019%	0.030%	0.040%
Ammonium Hydroxide (NH4OH)	5%	0.006%	0.012%	0.019%	0.026%
Nitric Acid (HNO3)	1%	0.005%	0.009%	0.015%	0.021%
Ferric Chloride (FeCL3)	1%	0.003%	0.006%	0.009%	0.014%
Sodium Hypochlorite (NaOCl)	1%	0.003%	0.006%	0.011%	0.016%
Soap	0.1%	0.002%	0.003%	0.005%	0.007%
Detergent (LAS)	0.1%	0.002%	0.003%	0.007%	0.011%
Bacteriological	BOD 700 ppm	0.007%	0.010%	0.020%	0.027%

A2 Conditions of Acceptance:

As provided in the 2012 Greenbook (Table 211-2B), the allowable weight change was 0.75% when testing a product having a nominal thickness of 0.375 inches or less.

A3 Conclusions:

To the extent tested, the FRP (IPS 7000-204HB Resin) specimens (as described in this test report) meet the conditions of acceptance as described in the Standard Specifications for Public Works Construction (Greenbook 2012) Section 211-2 having a weight change after 112 days of exposure not exceeding the limits of 0.75%

A4 Observations and Comments:

The submitted test specimens were prepared as “Composite-Materials” as defined in Section 211-2 having 2 adjacent edges sealed and protected

B Chemical Resistance (Pickle Jar—Tensile Strength):

B1 Test Results:

Tensile Strength is summarized below with detailed results presented in Appendix 2

Chemical Solution	Concentration Level	Tensile Strength (psi)	Retained Strength (%)
Control--Initial	N/A	7229	N/A
Sulphuric Acid (H2SO4)	20%	6805	94%
Sodium Hydroxide (NaOH)	5%	6588	91%
Ammonium Hydroxide (NH4OH)	5%	6953	96%
Nitric Acid (HNO3)	1%	7022	97%
Ferric Chloride (FeCL3)	1%	6871	95%
Sodium Hypochlorite (NaOCl)	1%	7158	99%
Soap	0.1%	7169	99%
Detergent (LAS)	0.1%	7157	99%
Bacteriological	BOD 700 ppm	6909	96%

B2 Conditions of Acceptance:

The Greenbook has not established the allowable change in Tensile Strength

B3 Conclusions:

The results of this test are presented for “Client Information Only”

B4 Observations and Comments:

The observations comments can be found in Appendix 2.

C Chemical Resistance (Pickle Jar—Hardness):

C1 Test Results:

Hardness (Shore "A") is summarized below with detailed results presented below

Chemical Solution	Concentration Level	Hardness Start	Hardness End	Retained (%)
Control--Initial	N/A	96	N/A	N/A
Sulphuric Acid (H2SO4)	20%	95	90	95%
Sodium Hydroxide (NaOH)	5%	97	89	92%
Ammonium Hydroxide (NH4OH)	5%	96	93	97%
Nitric Acid (HNO3)	1%	96	92	96%
Ferric Chloride (FeCL3)	1%	95	90	95%
Sodium Hypochlorite (NaOCl)	1%	96	94	98%
Soap	0.1%	97	97	100%
Detergent (LAS)	0.1%	96	96	100%
Bacteriological	BOD 700 ppm	96	90	94%

C2 Conditions of Acceptance:

The Greenbook has not established the allowable change in Hardness

C3 Conclusions:

The results of this test are presented for "Client Information Only"

D Flexural Strength (ASTM D790):

D1 Test Results:

	DIMENSION		Loading	Indicated	Modulus of	Modulus of
SAMPLE	Base	Depth	Span	LOAD	Rupture (MOR)	Elasticity (MOR)
ID	(b)	(d)	(in)	(lbf)	(lbf / in^2)	(lbf / in^2)
1	0.508	0.310	2.50	106	**8142**	**234649**
2	0.508	0.310	2.50	123	**9448**	**249788**
3	0.508	0.310	2.50	133	**10216**	**267014**
4	0.508	0.310	2.50	105	**8066**	**262489**
5	0.508	0.310	2.50	152	**11676**	**262489**
Average	**0.508**	**0.310**	**2.5**	**124**	**9510**	**255286**
Max	0.508	0.310	2.5	152	11676	267014
Min	0.508	0.310	2.5	105	8066	234649
STDEV	0.000	0.000	0.0	20	1512	13204

D2 Conditions of Acceptance:

The Greenbook has not established the allowable change in Flexural Strength

D3 Conclusions:

The results of this test are presented for "Client Information Only"

E Ignition Loss (ASTM D-2584)

E1 Purpose:

The purpose of this test was to determine the resin content of the test specimen

E2 Test Procedure:

E2.1 The test specimen was placed into a crucible and weighed to the nearest 1.0 mg
E2.2 The test specimen was heated in a Bunsen flame until the specimen ignited
E2.3 The test specimen was allowed to burn at a uniform and moderate rate until only ash and carbon remained

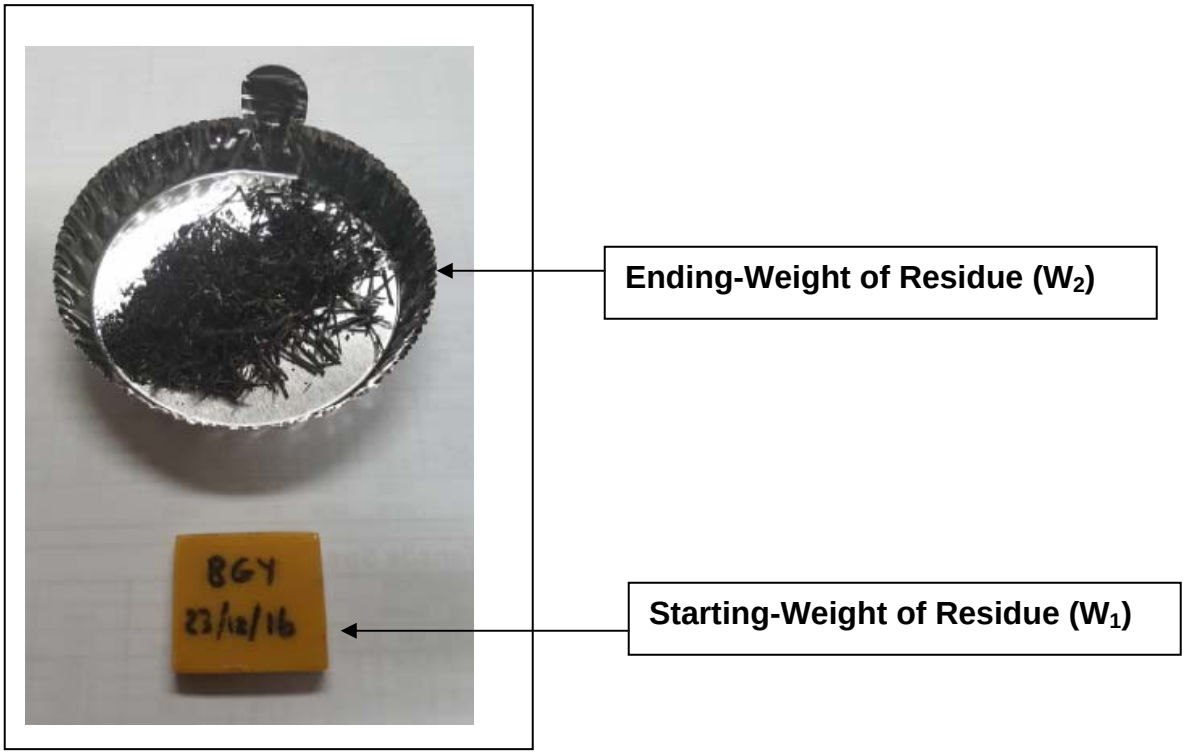
E3 Test Results:

The Ignition test results are summarized below

Test No.	Starting Weight (Grams)	Ending Weight (Grams)	Weight Loss (Grams)	Ignition Loss (%)
1	4.301	2.103	2.198	51.1%
2	4.501	2.205	2.296	51.0%
3	4.184	2.005	2.179	52.1%
4	4.463	2.101	2.362	52.9%
5	4.355	2.008	2.347	53.9%
			Average	**52.2%**

Ignition Loss, weight % = $[(W_1 - W_2)/W_1] \times 100$

Where: **W_1 = Starting-Weight of Specimen in grams**
W_2 = Ending-Weight of Residue in grams



LABORATORY NUMBER: 3804-16-11 (A1)
Issue Date: June 28, 2018

F Abrasion (ASTM D-4060)

F1. Introduction:

In accordance with the client's request, a Taber Abrasion Test was performed on the following products:

A. FRP (IPS 7000-204HB Resin)

F2. Purpose:

The purpose of this test was to determine the resistance of the client's submitted products to abrasion produced by the Taber Abraser

F3. Sampling:

Ramtech Laboratories did not independently sample the material tested and makes no comment as to the sampling procedures that may have been conducted by others

F4. Test Procedure:

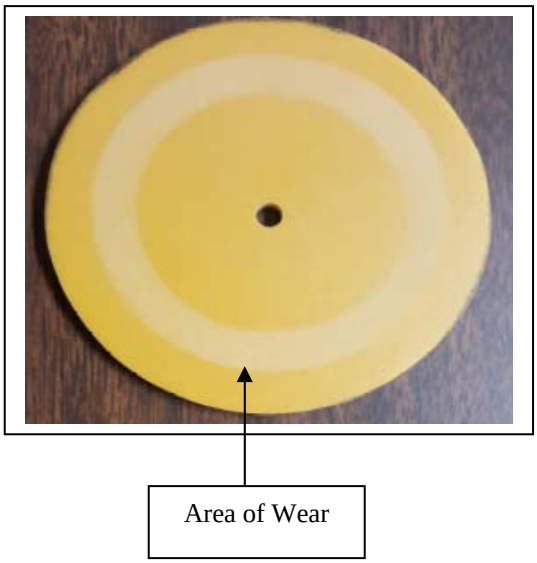
Ramtech Laboratories tested the submitted products in general accordance with ASTM D-4060 using CS-17 wheels with 1000 grams applied to each wheel and subjected to 1000 revolutions

F5. Test Results:

The results of this test are presented in the table below

FRP (IPS 7000-204HB Resin)

Sample ID	Starting Weight (Grams)	Ending Weight (Grams)	Loss (%)
1	51.850	51.809	0.044%
2	43.412	43.368	0.048%
3	54.216	54.179	0.057%
4	44.601	44.566	0.066%



LABORATORY NUMBER: 3804-16-11 (A1)
Issue Date: June 28, 2018

G Compression (ASTM D-695)

G1 Introduction:

In accordance with the client's request, a Compressive Strength Test was performed on the FRP (IPS 7000-204HB Resin) product

G2 Purpose:

The purpose of this test was to determine the resistance of the client's submitted products to a compressive force produced by a universal testing machine

G3 Sampling:

Ramtech Laboratories did not independently sample the material tested and makes no comment as to the sampling procedures that may have been conducted by others

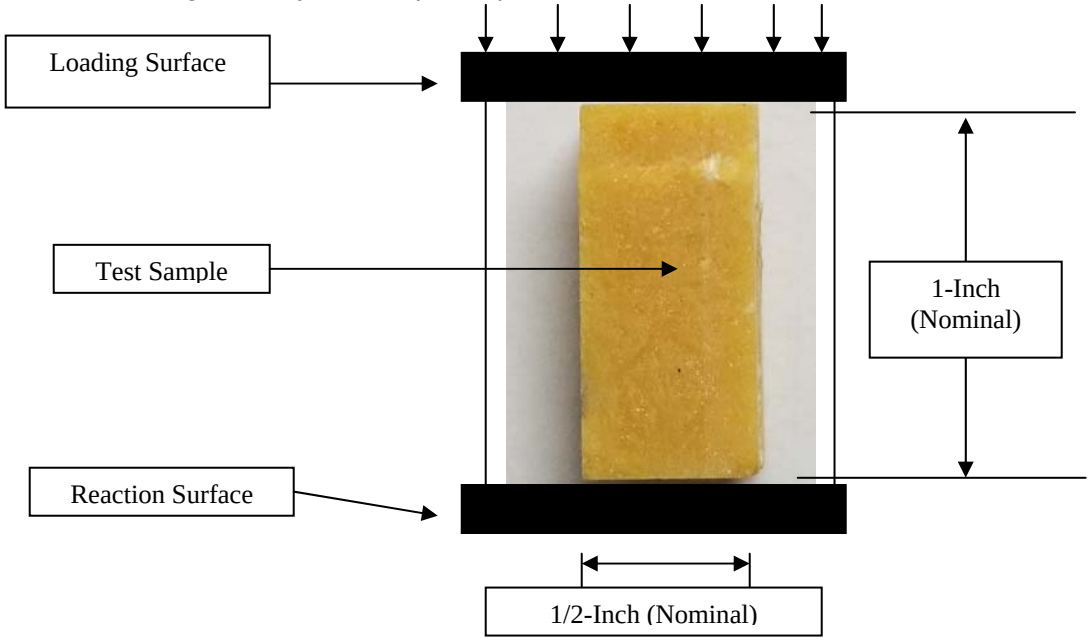
G4 Test Procedure:

Ramtech Laboratories tested the submitted products in general accordance with ASTM D-695

G5 Test Results:

The results of this test are presented in the below

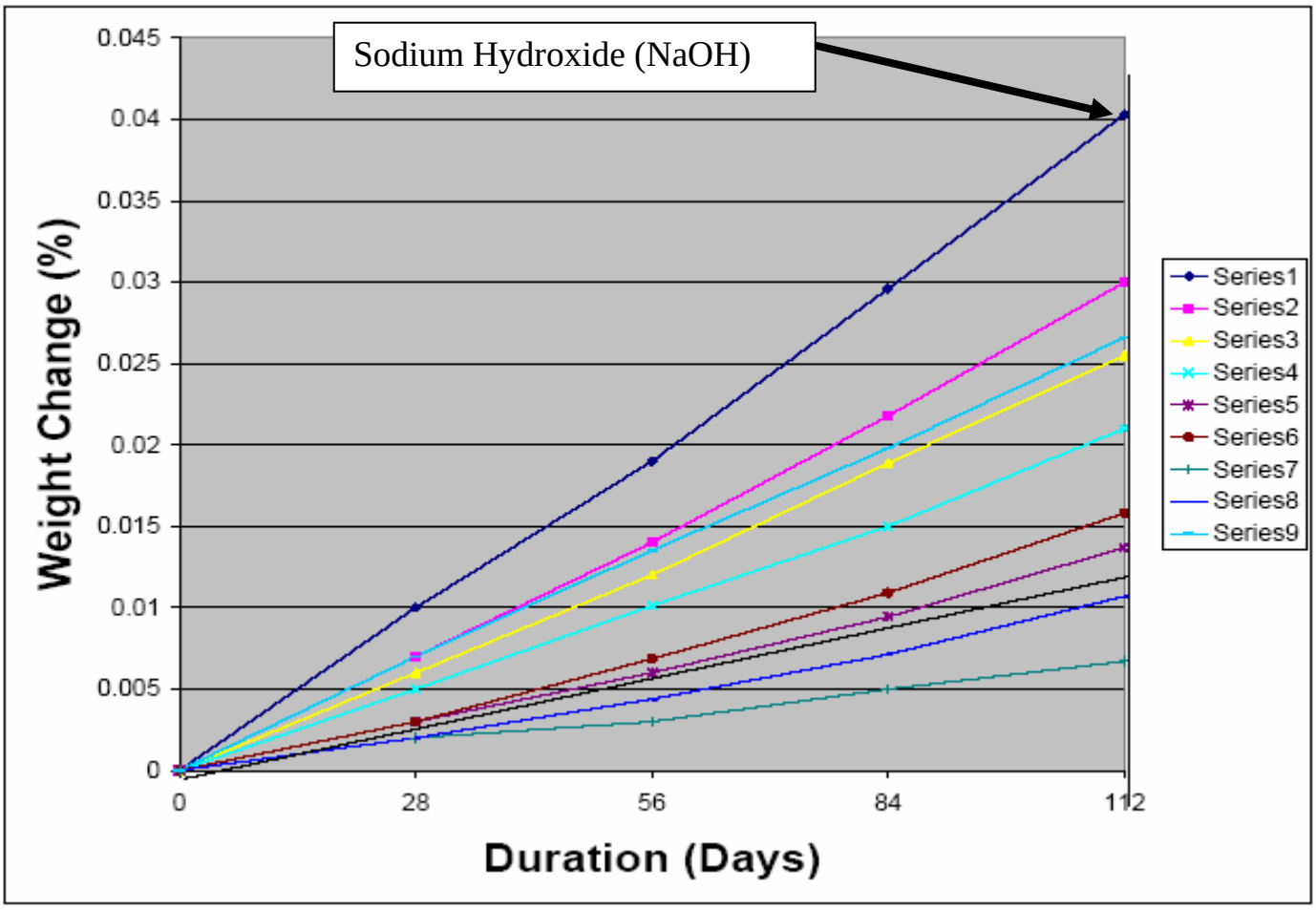
1. Average Compressive Stress = 13,313 psi (STDEV = 1518 psi)
2. Average Density = 63.96 pound per cubic foot



APPENDIX 1

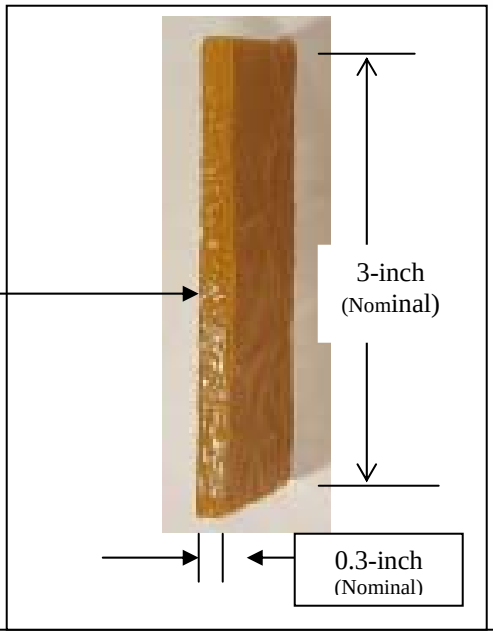
(Pickle-Jar Weight Change)

LABORATORY NUMBER: 3804-16-11 (A1)
Issue Date: June 28, 2018



The results of the 112 day test are outlined below

Sulphuric Acid (0.030%)
Sodium Hydroxide (0.040%)
Ammonium Hydroxide (0.026%)
Nitric Acid (0.021%)
Ferric Chloride (0.014%)
Sodium Hypochlorite (0.016%)
Soap (0.007%)
Detergent (0.011%)
Bacteriological (0.027%)

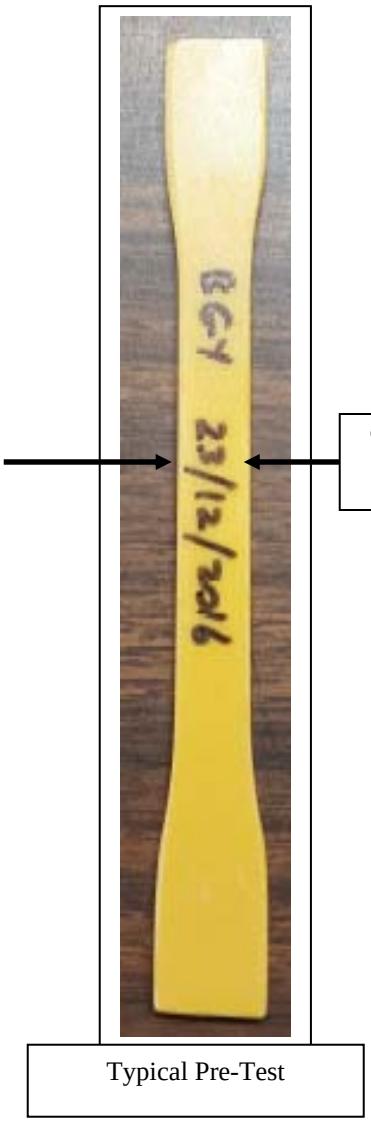


APPENDIX 2

(Pickle-Jar Tensile Strength)

LABORATORY NUMBER: 3804-16-11 (A1)
Issue Date: June 28, 2018

Chemical Solution	Concentrate Level	Ave. Tensile Strength (psi)	Max Tensile Strength (psi)	Min Tensile Strength (psi)	STDEV (psi)	Retained Strength (%)
Control--Initial	N/A	7229	8511	6489	941	N/A
Sulphuric Acid	20%	6805	8016	6100	889	94%
Sodium Hydroxide	5%	6588	7745	5905	855	91%
Ammonium Hydroxide	5%	6953	8186	6242	902	96%
Nitric Acid	1%	7022	8255	6294	911	97%
Ferric Chloride	1%	6871	8085	6153	898	95%
Sodium Hypochlorite	1%	7158	8442	6399	950	99%
Soap	0.1%	7169	8475	6412	958	99%
Detergent (LAS)	0.1%	7157	8441	6411	942	99%
Bacteriological	BOD 700 ppm	6909	8117	6225	875	96%



Typical Pre-Test

Typical Post-Test

Typical Width

Observation & Comment
Tensile Strength of the Material within the Reduced Section

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File No. 20248
Date: 15 June 2018

PREDL SYSTEMS
7520 Conrad Street
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Attn: Jed Friesen jed.friesen@predlsystems.com

Project: Load testing on PVC manhole (as named by client) -Reference standard- ASTM D3753-12, Clause 6.4.1

1.0 INTRODUCTION

As requested, Metro Testing Laboratories (Burnaby), a division of CCMET Inc. (Metro) visited PREDL Systems (Yard) to perform load testing on the PVC manhole on 17 May 2018. Metro referred to clause 6.4.1 of ASTM D3753-12 standard to conduct the testing. There were several meetings in past between Metro and PREDL Systems since December 2017 to plan, design, and arrange for the load testing

Client confirmed that this PVC manhole used for testing is manufactured with the similar consistency as the actual service manholes. It was concentric type of manhole (as shown in figure.1).

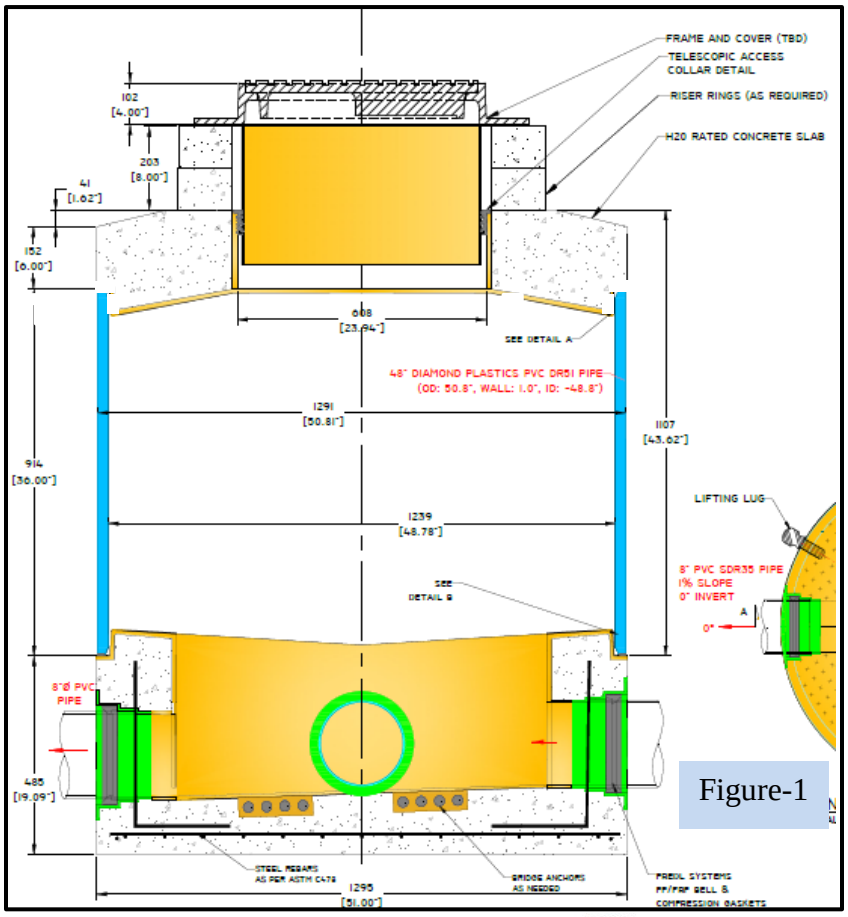

Figure-1

2.0 TESTING PROCEDURE AND RESULTS

ASTM D3753-12 clause 6.4.1 states that:

> *"The complete manhole shall have a minimum dynamic-load rating of 16,000 lbf. To establish this rating, the complete manhole shall not leak, crack, or suffer any damage when tested to 40,000lbf* (~178kN) *and shall not deflect vertically downward more than 0.25 in. (6.35 mm) at the point of load application when loaded to 24,000 lbf* (~107kN)."

Following is the test procedure:

- Metro applied the loads using the prefabricated steel bridges. The test load was applied eccentrically (See figure.2)

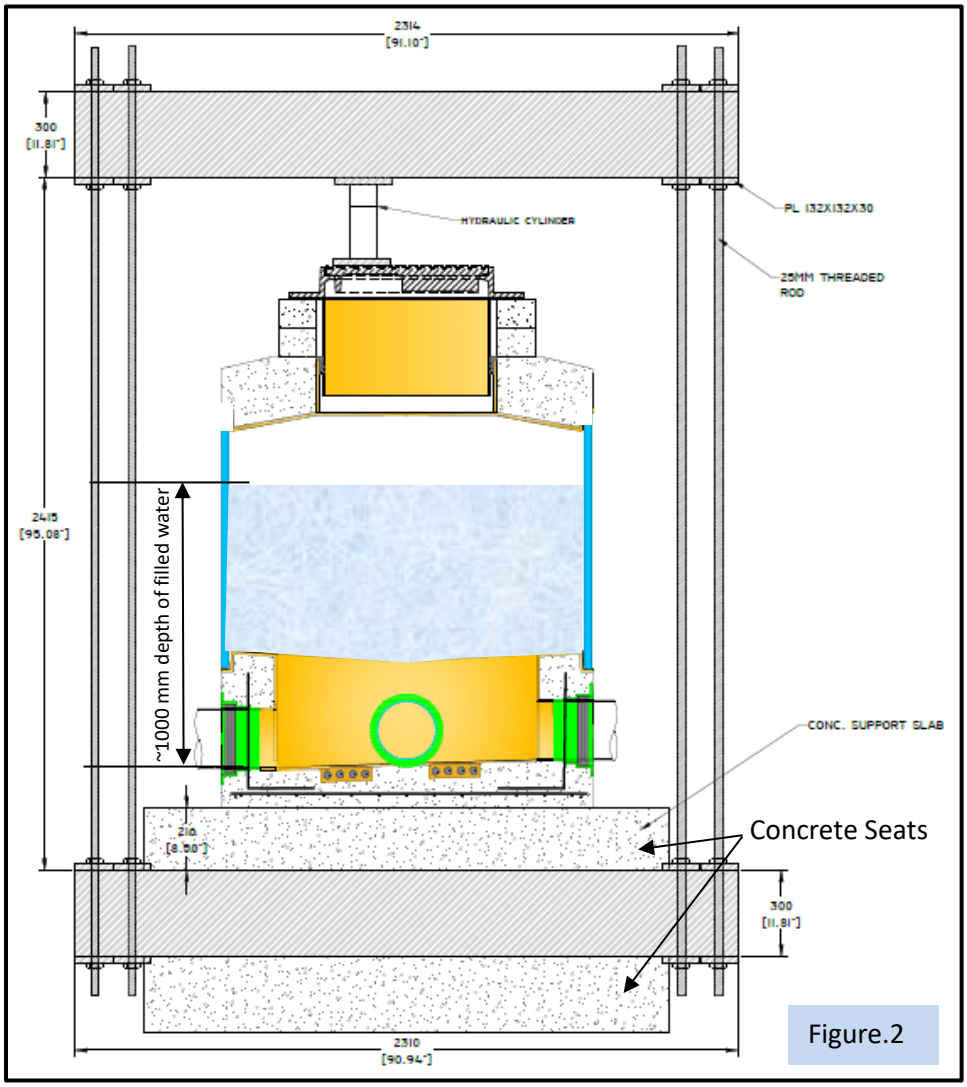

Figure.2

- Metro marked the locations of any existing minor cracks and any flaw which may mislead the tester during the load application.

- Manhole was filled with water up to an approximate depth of 1000mm during entire duration of testing.

- A digital indicator was installed in vertical direction (as per clause 6.4.1 of ASTM D3753-12) to measure deflection. Vertical digital indicator was installed in vicinity to the point of load application.

- Two additional gauges (not required as per ASTM D3753-12) i.e. one digital indicator (named as west side in table-1) and one dial gauge (named as east side in table -1) were installed in horizontally opposite directions to each other approximately at the center of manhole. These gauges were installed to measure the horizontal deflections.

- Gauges were installed on separate standalone arms which were bolted in concrete floor.

- Metro used 30 Ton Ram and 10,000 PSI gauge to perform testing. Calibration sheet is attached in appendix.

- As per clause 8.4.1.1 of ASTM D3753-12, Loading was applied in increments of 2000 lbf intervals. Metro inspected of manhole after every applied increment.

- As per ASTM D3753-12, testing was conducted up to 40,000 lbf (~178kN) and deflection was measured at various load intervals (see table-1).

- Specified load of 40,000 lbf (~178kN) was maintained for 15 minutes.

- Residual deflection was measured after gradual release of load.

Following table.1 shows the loading and deflection measurements:

No.	Load Applied	kN	Deflection		
	lbf (kgf)		Vertical inches (mm)	West Side inches (mm)	East Side inches (mm)
1	2000 (907)	9	All dial guages were zeroed at 2000 lbf.		
2	**4000 (1814)**	**18**	-0.0016 (-0.04)		0
3	6000 (2721)	27			
4	8000 (3629)	36			
5	**10000 (4536)**	**44**	-0.017 (-0.45)		0.025 (0.64)
6	12000 (5443)	53			
7	14000 (6350)	62			
8	**16000 (7257)**	**71**	-0.047 (-1.21)		-0.013 (-0.33)
9	18000 (8165)	80			
10	**20000 (9072)**	**89**	-0.067 (-1.72)	0.0028 (0.07)	-0.017 (-0.43)
11	22000 (9979)	98			
12	**24000 (10886)**	**107**	-0.085 (-2.17)	0.006 (0.15)	-0.022 (-0.56)
13	26000 (11793)	116	-0.094 (-2.4)	0.0086 (0.22)	-0.022 (-0.56)
14	28000 (12700)	125			
15	**30000 (13608)**	**133**	-0.108 (-2.76)	0.018 (0.46)	-0.024 (-0.61)
16	32000 (14514)	142			
17	34000 (15422)	151			
18	**36000 (16329)**	**160**	-0.128 (-3.27)	0.04 (1.04)	-0.028 (-0.71)
19	38000 (17236)	169			
20	**40000 (18144)**	**178**	-0.14 (-3.71)	0.053 (1.36)	-0.033 (-0.84)
	After 15 mins of maintaining the specified load of 40000 lbf		-0.15 (-3.83)	0.052 (1.33)	-0.033 (-0.84)
	Residual		-0.015 (-0.39)	0.019 (0.5)	0.037 (0.94)

Table.1

Notes: Metro realised that during testing horizontal west side digital indicator was not in contact with surface until applied load of 18,000 lbf. This digital indicator was adjusted and the readings were recorded from 20,000 lbf loading onwards. However, measurement of horizontal deflections (in this case west & east side gauges) are not a required as per ASTM D3753-12

3.0 OBSERVATIONS AFTER MANHOLE DISMANTLING:

On 08 June 2018, Metro observed the following after dismantling of Manhole components:

- Gaskets were installed at the top and bottom vertical interfaces of PVC pipe and concrete pieces. One layer of the mastic was observed at the bottom horizontal interface of the PVC pipe and concrete base (pressed thickness of the mastic was 1-2 mm).

Client informed Metro that Hamilton Kent, Tylox Type “C” gasket, Model 5796 as an ASTM C443ASTM compliant Manhole Riser gasket, was used.

ConSeal, CS-102 Butyl Rubber Sealant (called mastic in this report) was used in the manhole assembly. As per the materials technical data sheet, the mastic is an ASTM C990-compliant Butyl Mastic Sealant.

4.0 CONCLUSION:

- The recorded vertical deflection at 24000 lbf was 0.085 in. (2.17 mm), which is below than the allowable deflection value of 0.25 in. (6.35 mm) as per clause 6.4.1 of ASTM D3753-12.
- After maintaining the 40,000 lbf load for 15 minutes as per clause 6.4.1 of ASTM D3753-12, Metro did not observe water any leakage, new cracks or damages in the manhole structure.

Metro closely reviewed different parts of the manhole such as the fiber glass collar under the concrete rings to detect any potential damage.

As per test results, Metro hereby confirms that test manhole meets the 16000lbf (~71kN) dynamic load rating as per clause 6.4.1 of ASTM D3753-12.

We trust that this report meets your present requirements; if you have any questions, please feel free to contact us at 604-436-9111.

For Metro Testing Laboratories (Burnaby)
A division of CCMET Inc.

Amit Sayal, E.I.T

Reviewed by:

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. YADEGARI VARNAMKHASTI
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Materials Engineer

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APPENDIX

- Site Pictures
- Calibration chart

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Pic.1: Manhole Test Assembly

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Pic.2: Testing in progress

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Pic.3: Bridge assembly and standalone arms for Gauges

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Pic.4: Filled water up to a depth of ~1000 mm.

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Pic.5: Hydraulic ram set up

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Pic.6: Local contact marks on the fiber glass collar under the concrete rings, does not indicate any signs of the failure

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Pic.7 Local contact marks on the fiber glass collar under the concrete rings, does not indicate any signs of the failure the concrete rings

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Pic.8: Inside view of manhole after testing

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Pic.9: Gasket on vertical interface of concrete and PVC pipe

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Pic.10: Gasket on vertical interface of concrete and PVC pipe and Mastic on Horizontal surface of concrete

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File No. 20248
Date: 15 June 2018

PREDL SYSTEMS
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Attn: Jed Friesen (jed@diamondprecast.com)

Project: Vacuum Testing on 48" PVC Manhole (as named by client)-Reference standard-ASTM C1244-11

1.0 INTRODUCTION

As requested, Metro Testing Laboratories (Burnaby), a division of CCMET Inc. (Metro) visited PREDL Systems plant to perform vacuum testing on 48" PVC manhole on 8 June 2018. Metro conducted the test as per ASTM C1244-11 Standard. There were several meetings in past between Metro and PREDL Systems since May 2018 to plan, design, and arrange for the vacuum testing.

Client confirmed that the tested manhole is manufactured with the similar consistency as the actual service manholes. It was concentric type of manhole (as shown in figure.1).

As informed by the client, Hamilton Kent, Tylox Type "C" gasket, Model 5796 (called gasket in this report) as an ASTM C443ASTM compliant Manhole Riser gasket, was used.

ConSeal, CS-102 Butyl Rubber Sealant (called mastic in this report) were used in the manhole assembly. As per the materials technical data sheet of the material, the mastic is an ASTM C990-compliant Butyl Mastic Sealant. The Manhole was tested in two different assembly configurations:

- **Configuration 1:**
  Gaskets were installed at the top and bottom vertical interfaces of PVC pipe and concrete pieces. One layer of the mastic was observed at the bottom horizontal interface of the PVC pipe and concrete base (pressed thickness of the mastic was 1-2 mm). The manhole assembly was the same as the one which was used in the load testing conducted by Metro on May 17, 2018 with the same elements and configuration. It should be noted that for both configurations, the top lid was replaced with an airtight lid (See picture 2).
- **Configuration 2:** Gaskets were removed and two ¾" thick mastics were installed at the top and bottom horizontal interface of PVC pipe and concrete portions.

2.0 TESTING PROCEDURE AND RESULTS

Metro used Karol Wagner Vacuum Gauge (Serial Number 7686) which was factory calibrated on April 4, 2018.The absolute atmosphere pressure was measured 759 mm HG at the Diamond Precast yard level (see Picture 1). Metro relatively decreased the pressure up to 254 mm HG (10 in of HG) (Absolute pressure 759-254=505 mm HG) and shut the valve to disconnect the manhole from the vacuum pump. Metro then measured the time for the manhole pressure to drop from 10" HG to 9" HG (Absolute pressure drop from 505 mm HG to 531 mm HG).

Metro repeated the test twice for each configuration. For the first configuration the recorded time was **30** and **35 seconds**. For the second configuration for the first round of the test, the first measured time was 195 seconds and for the second time it was more than 300 second (the test stopped at 5 minute (300 second) at 524 mm HG.

As per the ASTM Table 1 for the Manhole with a nominal 48 in of the diameter and 6 feet depth, the minimum specified time is **15 seconds**.

3.0 Conclusion:

As per test results, Both Manhole configurations have successfully passed the test and meet of ASTM C1244-11 specifications.

We trust that this report meets your present requirements; if you have any questions, please feel free to contact us at 604-436-9111.

Metro Testing Laboratories (Burnaby)
A division of CCMET Inc.

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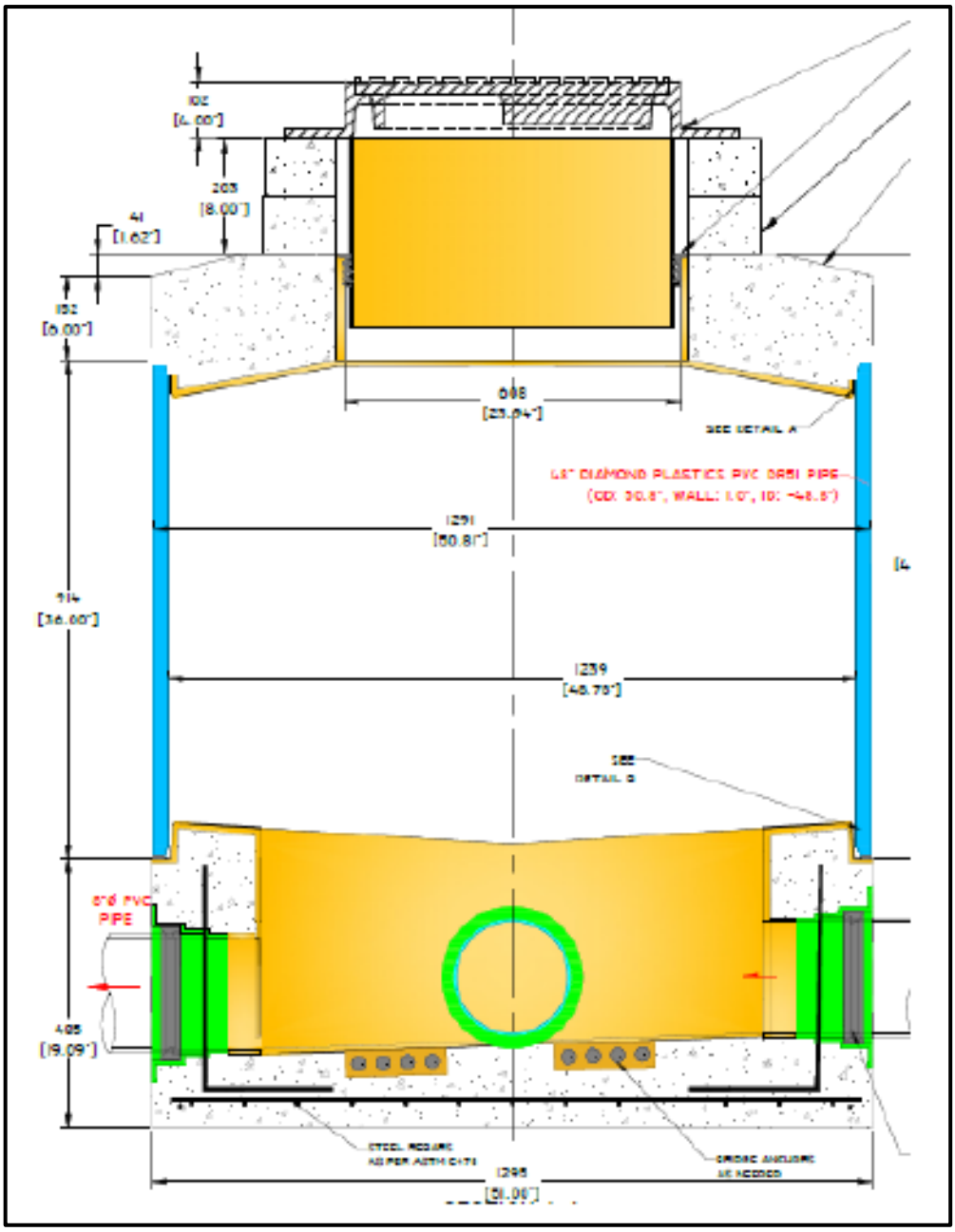


Figure 1- Schematic Manhole Assembly

Figure 2- Installed lid with vacuum rubber

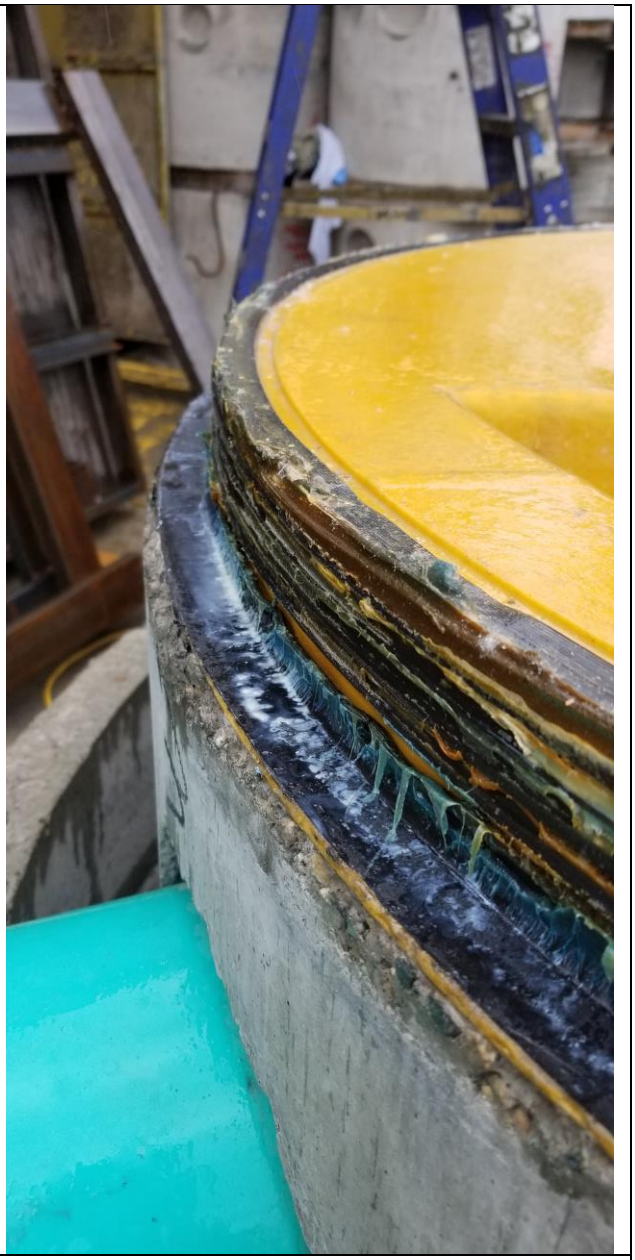


Figure 3- Installed gasket (Assembly Configuration 1)

Metro Testing Laboratories (Burnaby)
A Division of CCMET INC.
HEAD OFFICE
6991 Curragh Avenue
Burnaby, BC V5J 4V6

t 604.436.9111
tf 1.877.436.9117
f 604.438.5317
e info@metrotesting.ca
w metrotesting.ca

Figure 4- Installed mastic (Assembly configuration 2).
19 mm thickness before installing the concrete cap

Figure 5- Installed mastic (Assembly configuration 2).
1-2 mm thickness after installing the concrete cap

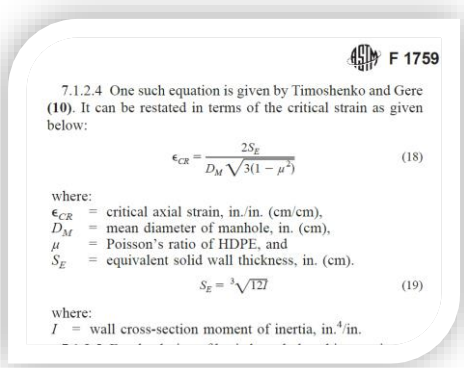
DEFORMATION AND SAFETY INDEXES OF THE 48" PVC TESTED MANHOLE COMPARED TO THE 60" PVC PROPOSED MANHOLE

Since the 60" manhole has a thicker wall the results will obviously be more favorable in many loading reaction calculations, but this is what makes the 60" PVC equivalent or better to the 48" PVC manhole .

Table 4 Material properties comparison 48" and 60" PVC Manholes

PVC Material Informati	Units	48" PVC	60" PVC	Difference
PVC Pipe ID	inch	48	60	12
Wall Thickness	inch	1	1.208	0.208
I of Wall	Inch^4/in	0.083333333	0.146899243	0.063565909
Material Modulus	psi	400000	400000	0
Poisson Ratio		0.38	0.38	0
Tensile Strength	psi	1000	1000	0
Comp. strength	psi	4000	4000	0
axial strain limit		0.035	0.035	0
ring strain limit		0.05	0.05	0

Starting with the material properties shown in Table 4 where not only the wall thickness is improved but this improves the moment of inertia (I) which when applied to equations such as the one shown in Figure 1 in the denominator portion will reduce the calculated strain in obvious improvements. This is also exposed in Table 5 where the axial strain is reduced by up to 33 percent on the upper part of the manhole wall down to 20 percent reduction at the bottom.



F 1759

7.1.2.4 One such equation is given by Timoshenko and Gere **(10)**. It can be restated in terms of the critical strain as given below:

$$\epsilon_{CR} = \frac{2S_E}{D_M\sqrt{3(1-\mu^2)}} \quad (18)$$

where:
ϵ_{CR} = critical axial strain, in./in. (cm/cm),
D_M = mean diameter of manhole, in. (cm),
μ = Poisson's ratio of HDPE, and
S_E = equivalent solid wall thickness, in. (cm).

$$S_E = \sqrt[3]{12I} \quad (19)$$

where:
I = wall cross-section moment of inertia, in.^{4}/in.

Figure 1 Clip of ASTM F 1759-97 (2004)

Table 5 Comparison of results

	48"	60"	48"	60"		48"	60"	
Manhole Depth	D.D. Force	D.D. Force	Strain of Axial	Strain of Axial		Ring Stess	Ring Stess	
ft	lbs	lbs	%	%	%	23	22	-5%
4	356.37	444.87	0.00027	0.00018	-33%	17	16	-5%
5	997.85	1,245.63	0.00028	0.00019	-33%	14	13	-5%
6	1,924.42	2,402.29	0.00029	0.00020	-32%	11	11	-5%
7	3,136.09	3,914.85	0.00031	0.00021	-31%	10	9	-5%
8	4,632.87	5,783.30	0.00034	0.00023	-30%	9	8	-5%
9	6,414.74	8,007.65	0.00036	0.00026	-29%	8	8	-5%
10	8,481.71	10,587.89	0.00040	0.00029	-28%	7	7	-5%
11	10,833.78	13,524.03	0.00044	0.00032	-27%	7	6	-5%
12	13,470.95	16,816.06	0.00048	0.00035	-26%	6	6	-5%
13	16,393.22	20,463.99	0.00053	0.00039	-25%	6	6	-5%
14	19,600.59	24,467.81	0.00058	0.00044	-25%	6	5	-5%
15	23,093.06	28,827.53	0.00063	0.00048	-24%	5	5	-5%
16	26,870.63	33,543.15	0.00070	0.00053	-23%	5	5	-5%
17	30,933.30	38,614.66	0.00076	0.00059	-23%	5	5	-5%
18	35,281.07	44,042.06	0.00083	0.00065	-22%	5	4	-5%
19	39,913.93	49,825.36	0.00091	0.00071	-22%	4	4	-5%
20	44,831.90	55,964.56	0.00099	0.00077	-22%	4	4	-5%
21	50,034.97	62,459.65	0.00107	0.00084	-21%	4	4	-5%
22	55,523.13	69,310.64	0.00116	0.00092	-21%	4	4	-5%
23	61,296.40	76,517.52	0.00126	0.00100	-21%	4	4	-5%
24	67,354.76	84,080.30	0.00135	0.00108	-20%	4	4	-5%
25	73,698.23	91,998.97	0.00146	0.00116	-20%	0	0	0%

D.D. = Down Drag Force

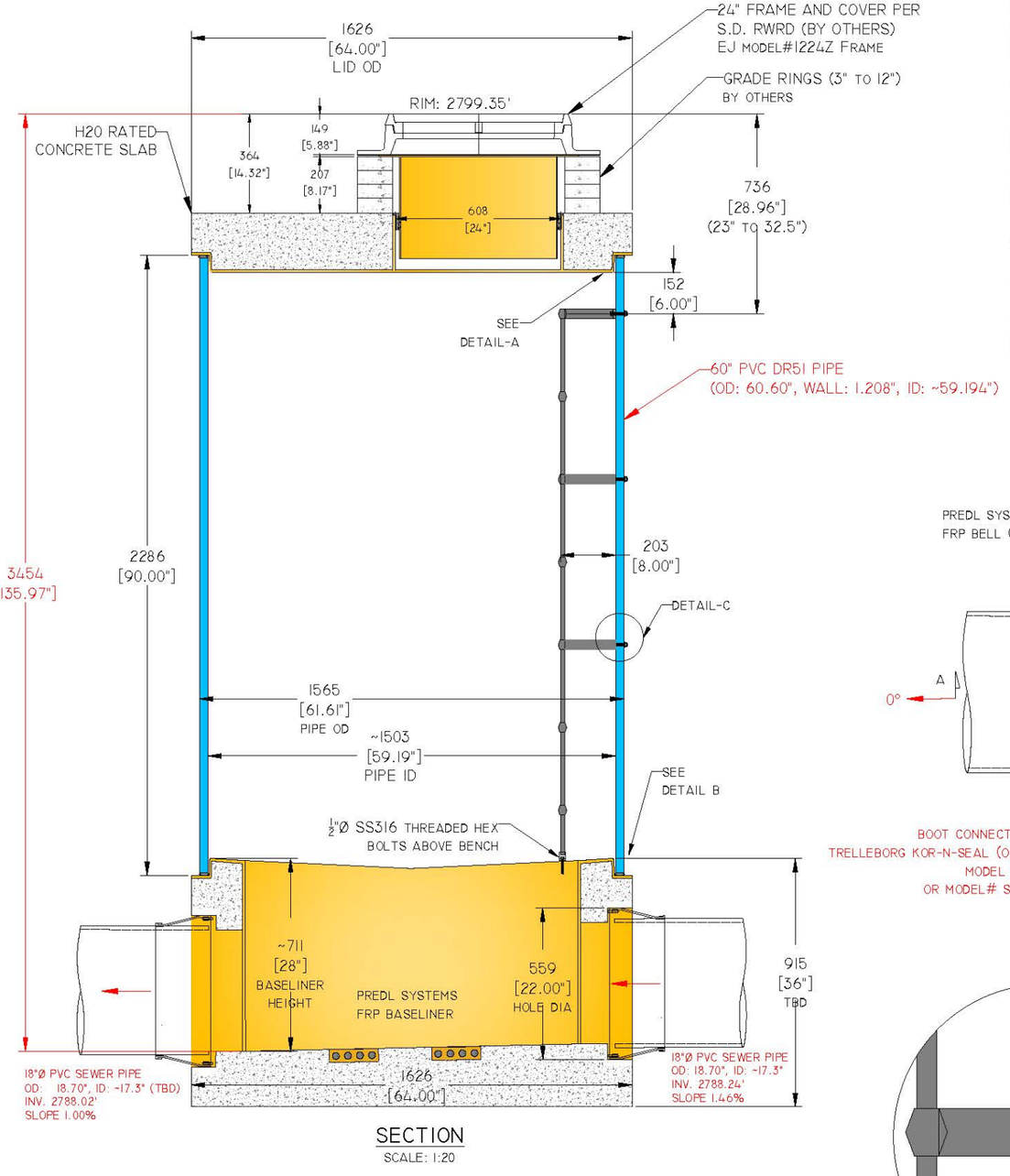
ASTM F 1759-97 (2004) calculation comparison of Table 5 also demonstrate a constant 5% reduction on the ring stress.

EXPIRES: 9/30/2020

Alonso Vidal, P.E.

ATTACHMENTS

PVC MANHOLE MATERIALS AND INSTALLATION



SECTION
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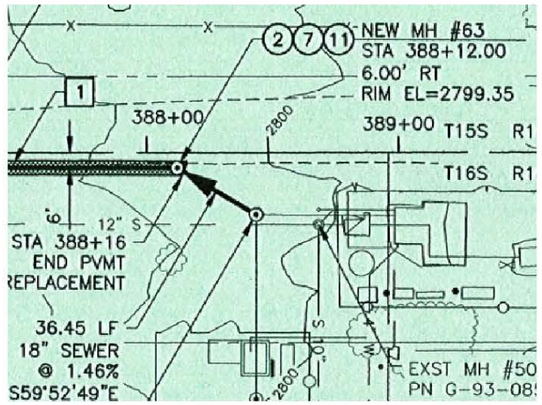

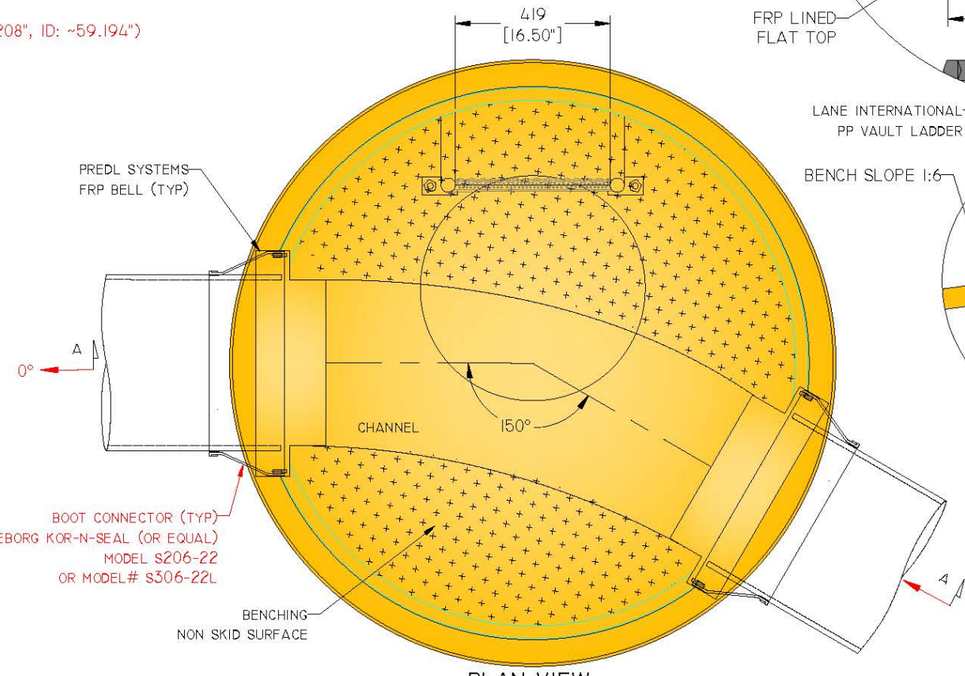

PLAN VIEW
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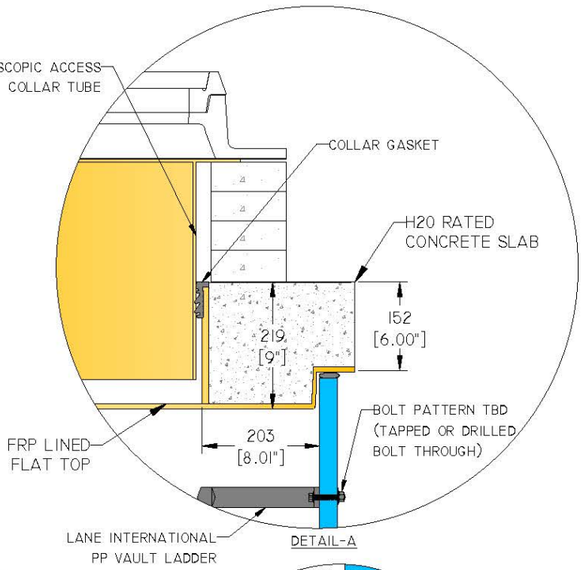
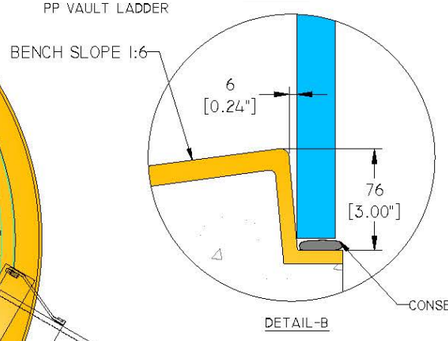
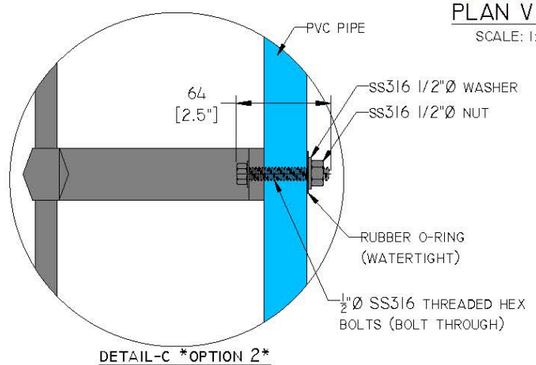






DETAIL-C *OPTION 2*
DRILLED HOLE (SELF DRILLING)
SCALE: 1:4

SPECIFICATIONS

1. THIS DRAWING REPRESENTS THE CONCRETE PROTECTIVE LINER DESIGN. ALL CONCRETE DIMENSIONS TO BE VERIFIED FROM THE CONTRACTOR OR PRECAST CONCRETE MANUFACTURER.
2. ALL "PIPE TO MANHOLE" CONNECTIONS SHALL HAVE GASKETS AS SHOWN IN THE DRAWINGS UNLESS OTHERWISE NOTED.
3. ALL PIPE GASKETS SHALL BE INSTALLED USING THE MANDREL RECOMMENDED BY THE GASKET MANUFACTURER.
4. ONLY PREDL CERTIFIED WELDERS AND FABRICATORS ARE AUTHORIZED TO FABRICATE, REPAIR, WELD, OR TEST THE LINERS.
5. ALL LINER SECTIONS SHALL BE WELDED OR JOINED TOGETHER AS PER THE MANUFACTURER INSTRUCTIONS UNLESS OTHERWISE NOTED.
6. LINER IS NOT TO BE COMPROMISED BY DRILLING OR PUNCTURING UNLESS SPECIFIED AND APPROVED BY PREDL LINER MANUFACTURER. PERFORATION OF LINER TO INSTALL LADDER RUNGS IS NOT RECOMMENDED.
7. PREDL CONCRETE LINER IS A NON-STRUCTURAL ELEMENT. ALL PRECAST CONCRETE SHALL BE DESIGNED, CONSTRUCTED AND INSTALLED IN ACCORDANCE WITH LOCAL STANDARDS PRIOR TO FINAL INSTALLATION AND TESTING OF CPL.
8. ROUND MANHOLE STRUCTURES TYPICALLY DESIGNED TO ASTM C478. NON-ROUND MANHOLE STRUCTURES TYPICALLY DESIGNED TO ASTM C913.
9. PRECAST CONCRETE STRUCTURE WITH INTEGRAL PREDL CPL TO BE VACUUM TESTED IN ACCORDANCE WITH ASTM C1244 PRIOR TO FINAL INSTALLATION AND TESTING OF CPL.

FIBERGLASS REINFORCED POLYMER (FRP)

TYPICAL PHYSICAL PROPERTIES

(FOR COMPONENTS)	TESTING METHOD	COMP.A	COMP.B
VISCOSITY, CPS	BROOKFIELD L.V.F. SPINDLE #2 @ 30 RPM	200	400 - 600
SPECIFIC GRAVITY	ASTM D-1638	1.20	1.15
WEIGHT PER GAL. LBS.		10.00	9.58
COLOUR	VISUAL	DARK BROWN	LIGHT BROWN
STYRENE MONOMER CONTENT	ASTM D-1638	20 % IN SYSTEM 1.20	1.15
MIX RATIO	BY WEIGHT	31	69
(FOR CURED MATERIAL)	TESTING METHOD	RESULTS (0% GLASS)	
TENSILE STRENGTH, PSI	ASTM D-638	13,000	
TENSILE MODULUS, PSI	ASTM D-638	450,000	
FLEXURAL STRENGTH, PSI	ASTM D-790	28,000	
FLEXURAL MODULUS, PSI	ASTM D-790	400,000	
HEAT DISTORTION TEMP.	ASTM D-648	160° F	
ELONGATION, %	ASTM D-638	4	
BARCOL HARDNESS		42	
SHORE D HARDNESS		85	
LINEAR SHRINKAGE, %	ASTM D-2566-88	85	
REACTIVITY DATA (100 GRAM MASS @ 74° F)			
DEMOLD TIME		10 - 15 MIN.	
GEL TIME		120 - 180 SECONDS	
PERFORMANCE CHARACTERISTICS			
FIBER WETTING		EXCELLENT	
SAGGING / DRAINING		MINIMAL	
FABRICATING METHOD		ALL ROOM TEMPERATURE METHODS	

PREDL SYSTEMS
7520 CONRAD STREET
BURNABY, B.C. V5A 2H7
PHONE : 604 415-9944
FAX : 604 415-9954

DRAWN BY:	DATE DRAWN:
-	7/20/2018

NOTES: PRELIMINARY ONLY

REV NO	DATE/DESCRIPTION
3	8/14/2018
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-

SPECIFIED FOR:
PIMA COUNTY, AZ

PROJECT DESCRIPTION:
PH1-OLD NOGALES INTERCEPTOR/ AEROSPACE CORRIDOR & PARK AVE RELIEF SEWER

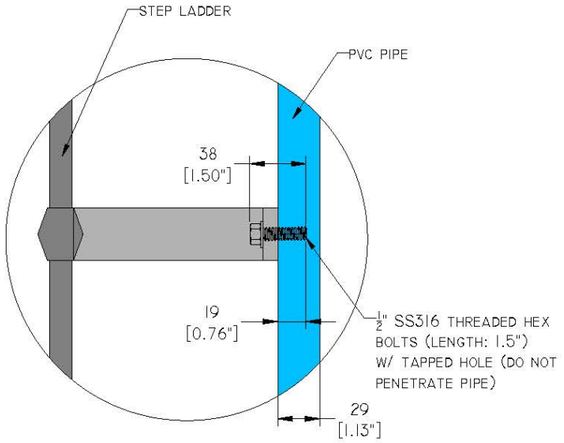
DRAWING DESCRIPTION:
MH#63

PVC MANHOLE DESIGN
w/ 64" OD BASE
w/ 60" PVC PIPE

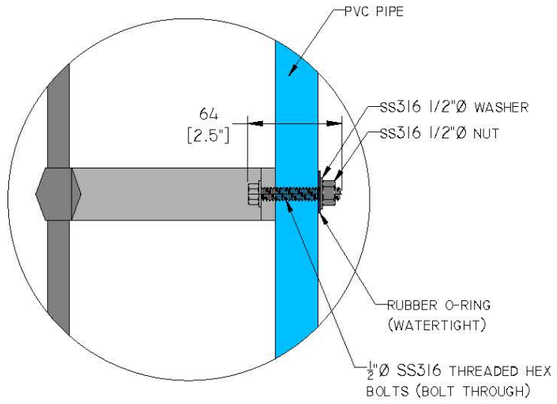
DWG NO:	REV NO:
2141977-MH63-PIMA	3

SCALE: AS NOTED

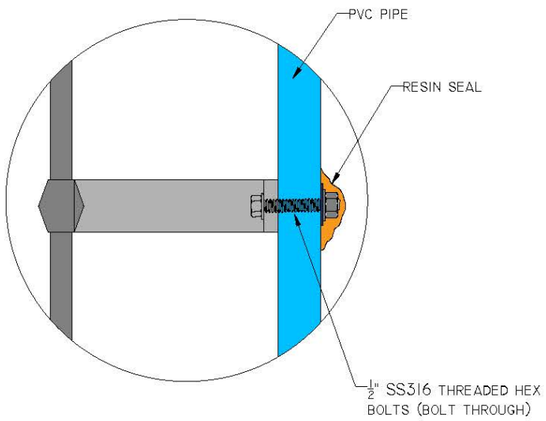
CLIENTS JOB NUMBER:



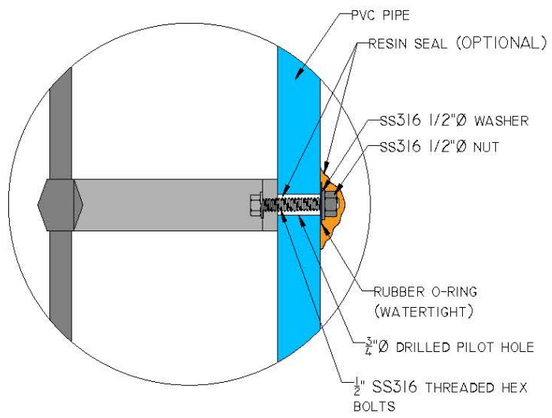
DETAIL-C *OPTION 1*
TAPPED HOLE
SCALE: 1:4



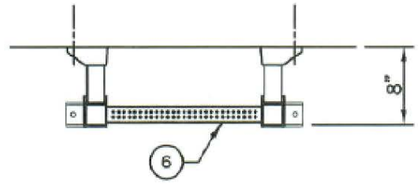
DETAIL-C *OPTION 2*
DRILLED HOLE (SELF DRILLING)
SCALE: 1:4



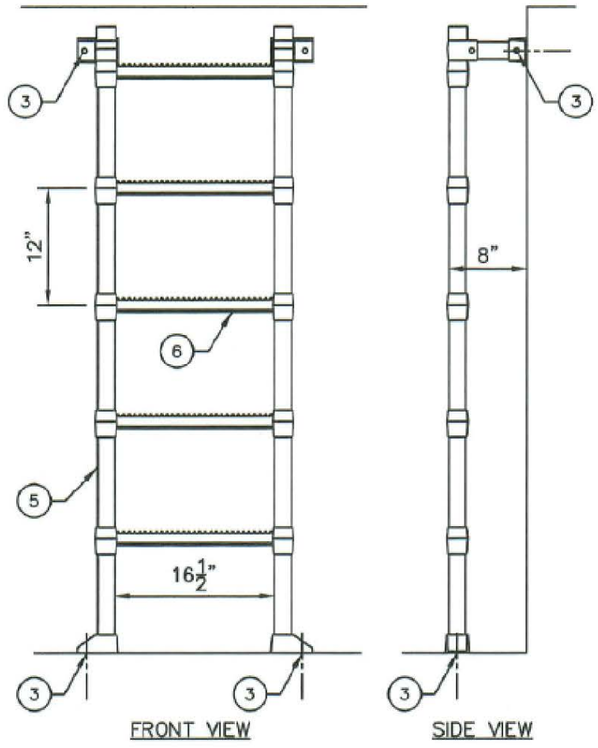
DETAIL-C *OPTION 3*
DRILLED HOLE (SELF DRILLING) W/ RESIN SEALANT
SCALE: 1:4



DETAIL-C *OPTION 4*
DRILLED HOLE (PILOT HOLE) W/ RESIN SEALANT
SCALE: 1:4



TOP VIEW



FRONT VIEW SIDE VIEW

LANE POLYPROPYLENE VAULT LADDER

NOTES:

1. LADDERS AVAILABLE IN 2 RUNG THROUGH 25 RUNG.
2. POLYPROPYLENE CONFORMS TO ASTM D-4101. LADDERS MEET ALL ASTM C-497 LOAD REQUIREMENTS AND OSHA 1910.26 AND 1910.27 SPECIFICATIONS.
3. FASTEN LADDER TO FLOOR AND WALL WITH 1/2"x 3-3/4" ANCHORS. ANCHORS TO BE INSTALLED PER MANUFACTURERS INSTRUCTIONS.
4. STANDARD ADJUSTABLE MOUNTING BRACKET – 8" O.D.
5. ALUMINUM REINFORCED COPOLYMER POLYPROPYLENE RAIL 1-3/4"x 1-3/4" DIA.
6. STEEL REINFORCED COPOLYMER POLYPROPYLENE RUNG 1-5/8"x 1-1/4" DIA. WITH MOLDED FINGER GRIPS, 12" C.C.

PREDL SYSTEMS
7520 CONRAD STREET
BURNABY, B.C. V5A 2H7
PHONE : 604 415-9944
FAX : 604 415-9954

DRAWN BY:	DATE DRAWN:
-	7/16/2018

NOTES: PRELIMINARY ONLY

REV NO	DATE/DESCRIPTION
-	-
-	-
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-	-
-	-

SPECIFIED FOR:
PIMA COUNTY, AZ

PROJECT DESCRIPTION:
PH1-OLD NOGALES INTERCEPTOR/ AEROSPACE CORRIDOR & PARK AVE RELIEF SEWER

DRAWING DESCRIPTION:
DETAIL-C
LADDER RUNG DETAIL
MH#63

PVC MANHOLE DESIGN
w/ 51" OD BASE

DWG NO:	REV NO:
2141977-MH63-DETAILC	-

SCALE:
AS NOTED

CLIENTS JOB NUMBER:

PREDL systems

THE MANHOLE LINER EXPERTS

Concrete Protective Liners for ALL Collection Systems

INTERTEK CERTIFICATION™

ISO 9001:2015
ISO 14001:2015

PREDL PVC MANHOLE

DESIGN, FABRICATION & INSTALLATION GUIDE

DEVELOPMENT: FOREST HOMES (CHILLIWACK, BC)
ENGINEER: WEDLER ENGINEERING (CHILLIWACK, BC)
DEVELOPER: WESTBOW CONSTRUCTION GROUP (CHILLIWACK, BC)
CONTRACTOR: TIMBRO CONSTRUCTION (AGASSIZ, BC)

INSTALLATION

ASTM C990 BUTYL RUBBER MH JOINT SEALANT

3RD PARTY (CSA) CERTIFIED ASTM C478-COMPLIANT MH BASE w/ INTEGRAL PREDL FRP BASELINER w/ BELL & COMPRESSION GASKETS FOR 200mm (8") SDR35 PVC

1200mm (48") ID DIAMOND PLASTICS DR51 PVC PIPE RISER SET TO MH BASE

STUB-OUT OF INLET

ASTM C877-COMPLIANT EXTERNAL MH JOINT WRAP (INCLUDES PRIMER)

PARTIAL BACKFILL

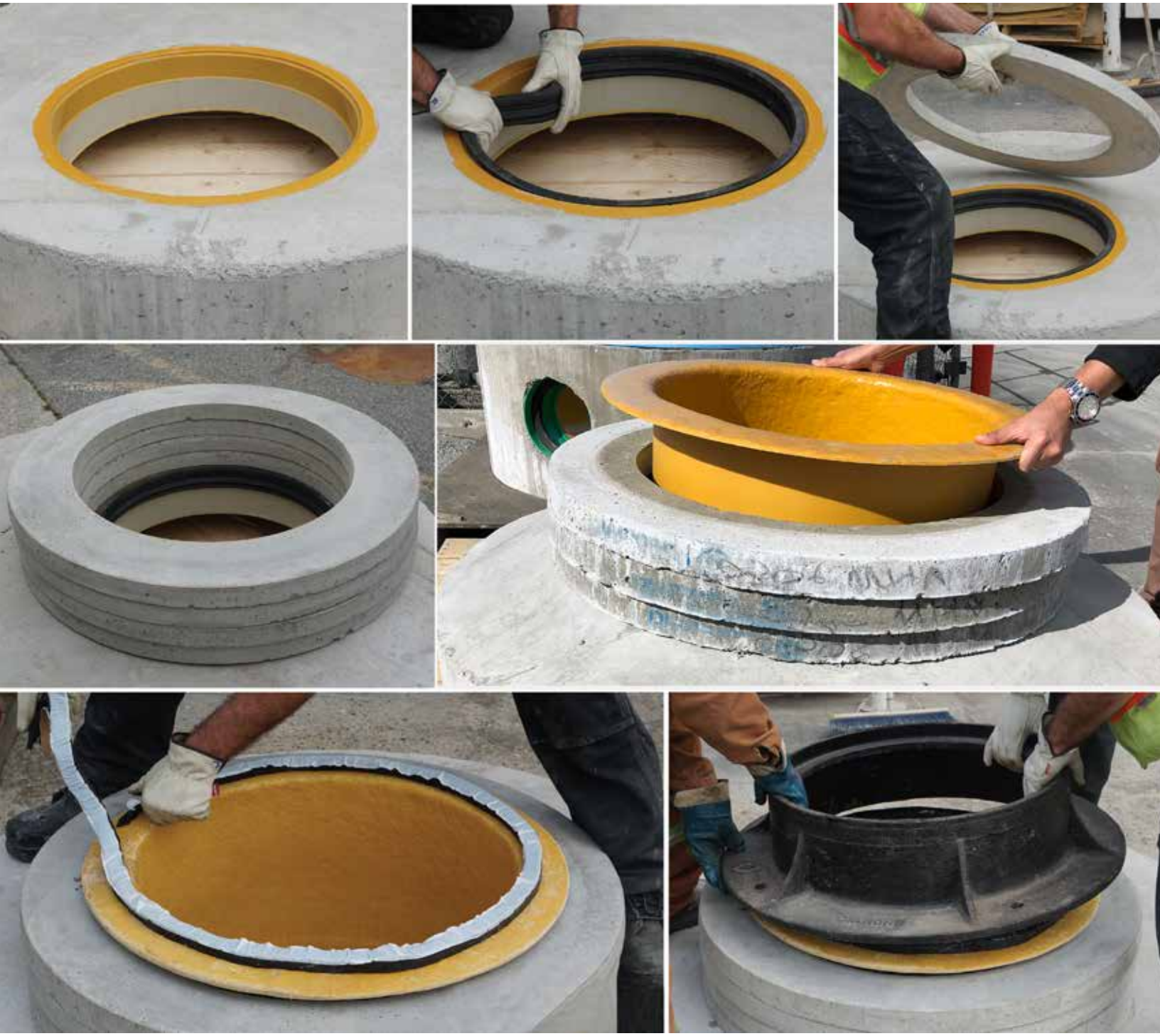
INSTALLATION

ASTM C990 BUTYL RUBBER MH JOINT SEALANT

INSTALL H-20 RATED ASTM C478 PRECAST MH LID
w/ INTEGRAL PREDL FRP LINER & TELESCOPIC ACCESS COLLAR (NOT SHOWN)

INSTALLATION of TELESCOPIC ACCESS COLLAR

COMPLETION DURING FINAL GRADING



Temperature Derating considerations

Background
This submittal is to address the request to assess the temperature effects or derating on the PREDL's Hybrid PVC Manhole System.

The author considers the subject a very specialized one given the application in question: a sewer manhole, and could not find any directly related published study or testing standard on the matter.

Given the above statements, the approach of the assessment is to first analyze the potential site conditions of the manhole installation in relation to temperature and then consider the potential effects.

Content/Review
The PREDL's Hybrid PVC Manhole for the Old Nogales Interceptor/Aerospace Corridor could be potentially exposed to soil with temperatures classified as Thermic by the NRCS, see Figure 3 Soil Temperature Regimes. The mean annual soil temperature is 60° F or higher but lower than 72° F, and the difference between mean summer and mean winter soil temperatures is more than 43° F either at a depth of 20 in. from the soil surface.
Other potential condition of the manhole installation could be contact with shallow groundwater which could be around 72° F, see Figure 2 Ground Water Temperature.
Additionally, the PREDL's Hybrid PVC Manhole could be exposed to typic ustic (Semiarid climate) or udict ustic (Humid or subhumid) climate soil moisture conditions which could affect the temperature conditions.

The manhole components with potential adverse effect to temperature could be the PVC pipe wall/barrel and the seals but given that the potential temperatures of the installation site (Nogales / Santa Cruz County) area should be below 80° F the published threshold to initiate derating or pressure pipe, temperature should not affect the manhole and there is no need to de-rate for temperature, see Figure 4 Thermal de-rating of PVC pipe, special attention to notes 3 and 4 shown below

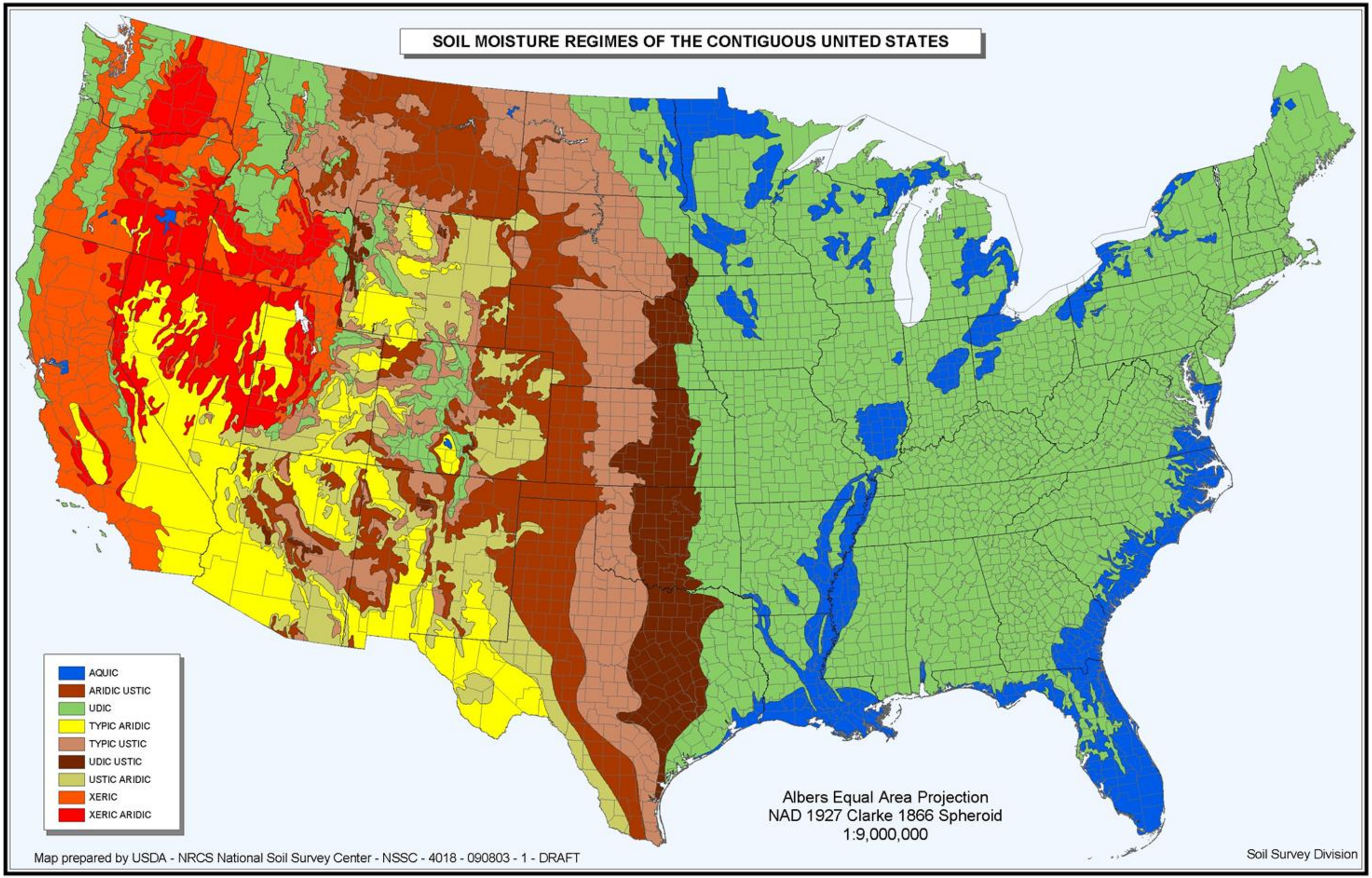
> "*3. Pipe gaskets are generally suitable for continuous use in water at the temperatures listed above.*
> *4. The de-rating factors assume sustained elevated service temperatures. When the contents of a buried PVC pressure pipe are only intermittently and temporarily raised above the service temperature shown, derating may not be needed*"
> Handbook of PVC Pipe Design and Construction 5th edition.

Note that this assessment is specific to the application/installation and summarizes empirically from interpolation of extreme pressure situations to moderate cases. If different conditions are expected such as high thermal effluents from process plants or other extreme conditions, temperature derating might be necessary.

Conclusions

The PREDL PVC manhole is a good in relationship to temperature effects for the proposed installation.

Alonso Vidal, P.E.



SOIL MOISTURE REGIMES OF THE CONTIGUOUS UNITED STATES

Figure 1 Soils Moisture Regimes

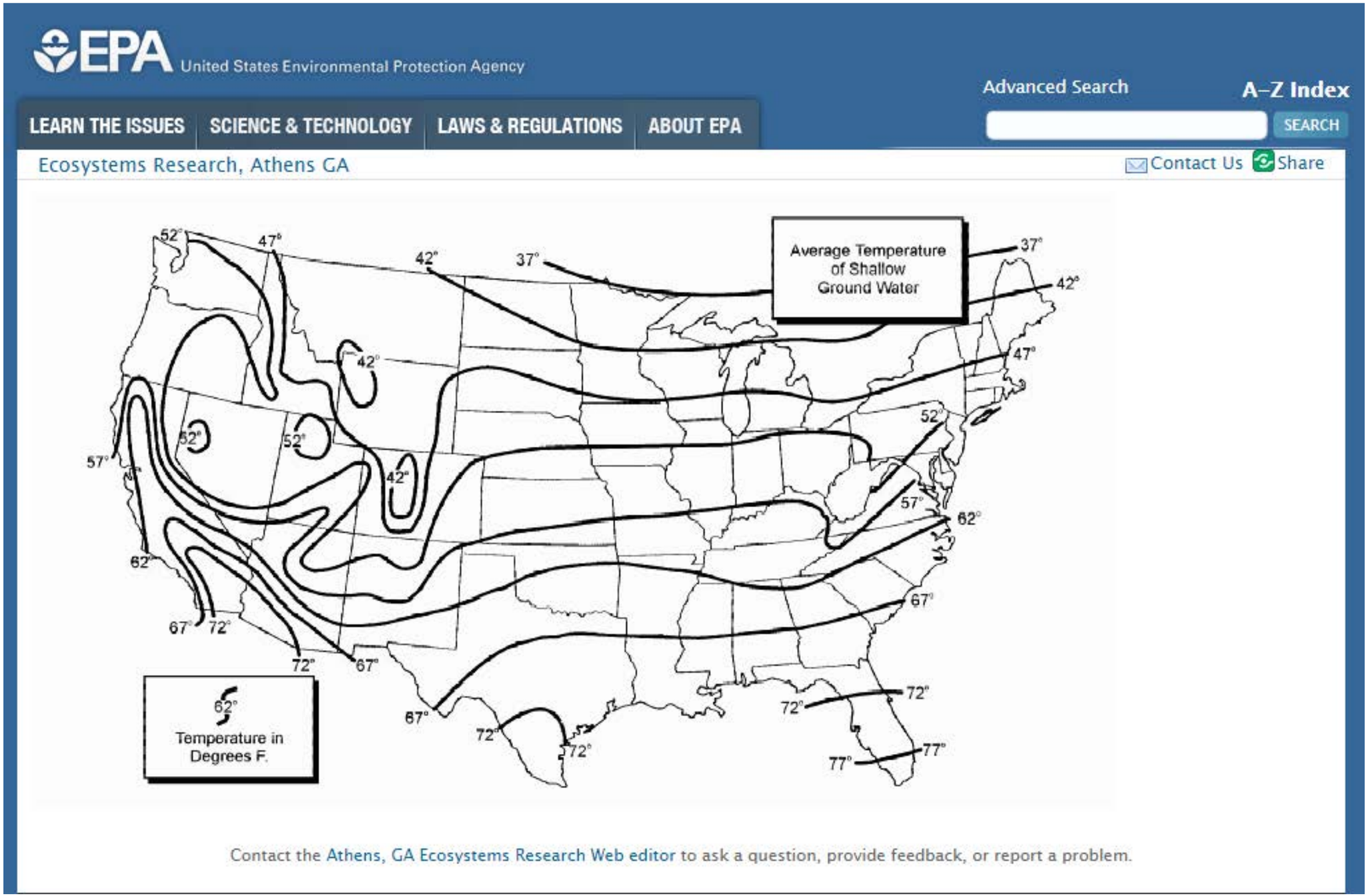


Figure 2 Ground Water Temperature

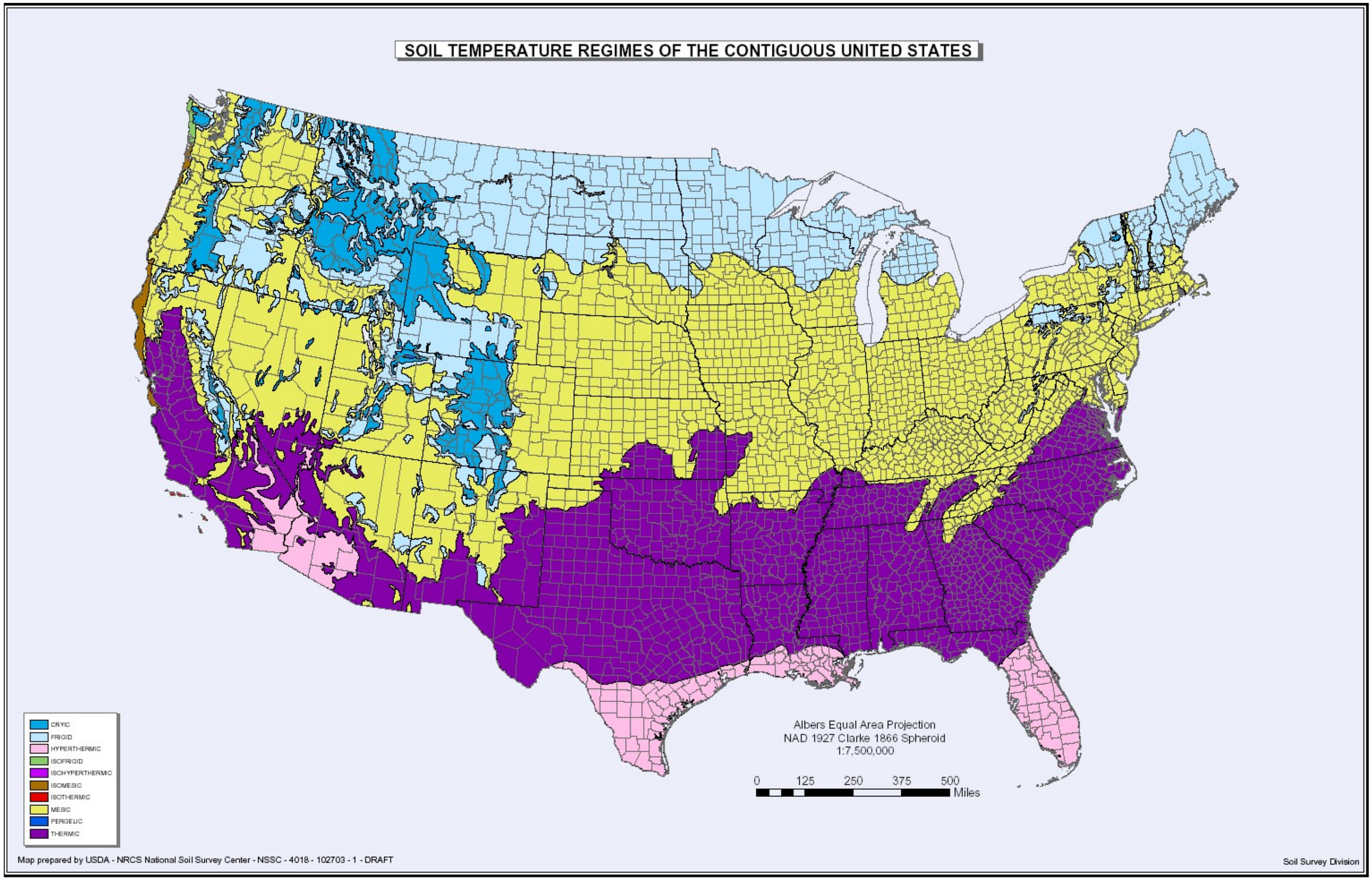


Figure 4 Thermal de-rating of PVC pipe

Table 5.3 Thermal de-rating factors for PVC pressure pipes and fittings

Maximum service temperature °F (°C)	Multiply pressure class (PC) at 73.4°F (23°C) by factor shown
80 (27)	0.88
90 (32)	0.75
100 (38)	0.62
110(43)	0.50
120 (49)	0.40
130(54)	0.30
140(60)	0.22

Notes:

1. The maximum recommended sustained temperature for the wall of PVC pressure pipe and fittings is MOT (60°C).

. Interpolate between the temperatures listed to calculate other factors.

. Pipe gaskets are generally suitable for continuous use in water at the temperatures listed above.

4. The de-rating factors assume sustained elevated service temperatures. When the contents of a buried PVC pressure pipe are only intermittently and temporarily raised above the service temperature shown, de-rating may not be needed.