Vangorda Water Treatment Plant Sludge Pond to Grum Pit Conveyance System Basis of Design Faro Mine Remediation Project

PREPARED FOR: Government of Yukon

PREPARED BY: CH2M HILL Canada Limited

DATE: August 27, 2014

PROJECT NUMBER: 472645.09.BB.01

Project Overview

Foreword

This technical memorandum serves as the basis of design for the conveyance of sludge dredged from the Vangorda Water Treatment Plant (WTP) sludge pond to the Grum Pit. CH2M HILL Canada Limited (CH2M HILL) is designing the system with input from Tlicho Engineering and Environmental Services (TEES). TEES provided information on existing piping, as well as the 2013 Basis of Design Drawings for the sludge dredging and piping system to the Vangorda Pit.

Project Summary and Scope

The Faro Mine Complex (FMC) is a former lead and zinc mine in the Yukon. Currently, a 50-horsepower submersible Toyo dredge pump is used to hydraulically remove sludge from the Vangorda WTP sludge pond and to transfer it into an existing pipeline where it flows by gravity to the Vangorda Pit. The existing high-density polyethylene (HDPE) pipe is routed on the surface of the ground. This piping is normally used to transfer water pumped from Vangorda Pit up to the treatment plant. The sludge dredging system was installed during the summer of 2013 but required significant time to implement due to the work needed to convert the existing pressure pipeline from Vangorda Pit to a gravity pipeline to backflow the dredged sludge to Vangorda Pit. Also, because the same pipeline was used for both pumping water to the WTP and for sending dredged sludge to the pit, the WTP had to be taken offline during sludge dredging. To allow concurrent sludge removal and treatment, the Government of Yukon (YG) requested that CH2M HILL provide design services for a system to pump sludge from the settling pond to the Grum Pit using the existing dredging system and new aboveground HDPE piping, fittings, and appurtenances (except for road crossings, where system components will be belowground).

Conveyance Design Criteria

Table 1 provides design criteria used for the conveyance system.

TABLE 1
Design Criteria
Faro Mine Remediation Project

Conveyance Component	Criteria
Conveyance System Design Life	15 years
Minimum Pond Water Depth Elevation	1,297 m
Maximum Pond Water Depth Elevation	1,302 m
Conveyance Fluid	Maximum of 5% sand pH range: 9 to 9.5
Existing Pump	Toyo Model Number DL-50B Pump Curve Provided (Attachment 1)

TABLE 1
Design Criteria
Faro Mine Remediation Project

Velocity	
Minimum	1.83 m/s (6.0 feet per second)
Gravity Flow Downstream of High-point Vent	Equal to or greater than pressure-flow velocity
Existing Piping from Pump to Existing Cam-Lock Pipe Connection	115 m (378 feet) long, 200-mm (8-inch)-diameter floating dredge hose
Pipe Material	DR 11 PE4710 HDPE for the following reasons: Good history for aboveground performance. Readily available Will not buckle or overly deflect at buried road crossings from live loads Will not collapse from a full vacuum Good erosive wear characteristics
Pressure Flow:	
Design: Hazen-Williams Coefficient	C=130
New HDPE: Pipe Hazen-Williams Coefficient	C=150
Existing Pump Curve provided by TEES	Attachment 1
Open Channel Gravity Flow:	
Design: Manning's n Coefficient	n=0.014; used pipe condition
Maximum Normal Flow Depth	75%
Flow Condition	Maintain supercritical flow to prevent hydraulic jumps
Special Cam-Lock Transition Connection to HDPE	Provided by TEES
Major Profile Grade Breaks on Gravity Segment	Pipestar DR 11 PE4710 HDPE Long Radius (R=3D) Seamless Bends Or Equal
HDPE Pipe Size Changes	Eccentric reducers to facilitate draining
Insulated Trench at Road Crossings	Insulated trench required to prevent frost heave that would reduce pipe capacity. No pipe casing Minimum bury depth = 762 mm (2.5 feet) Minimum trench width = 2.0, m (~ 6.6 feet) Install pipe in trench centreline Install 200-mm (8 inch) thickness (2 sheets) Dow Chemical Rigid 40 Styrofoam Board Insulation with 0.2 mm(8 mil) poly protective envelope across entire trench width, 150 mm above top of pipe Provide 25-mm (1-inch) minus well-graded granular material from 150 mm below pipe to 150 mm above pipe with 95% relative compaction in accordance with ASTM D698. Provide the required road base material above the insulation with 95% relative compaction in accordance with ASTM D698. Provide flowable, low permeability (hydraulic conductivity $\leq$ 5.0 x 10^{-5} cm/s)controlled low-strength material plug on the upstream end to prevent seepage under pipe and washout
Horizontal Alignment	Follow roads as required for maintenance access Avoid unstable areas to maintain a 15-year Design Life Use curves where required with a minimum nonstressed radius of 40 m

Notes:
~ = approximately
% = percent
$\leq$ = equal to or lesser than
cm/s = centimetre per second
m = metre
mm = millimetre
m/s = metre per second

The existing Toyo submersible pump will be used to pump the fluid to a high point. The pump capacity is approximately 82.0 litres per second (L/s) (1,300 United States gallons per minute [USgpm]) at a total dynamic head of 31.1 m (102 feet). At the high point, the flow will transition from pressure to gravity. An air vent will be installed at the high point to provide an atmospheric condition and prevent vacuum conditions from developing downstream from the high point. From there, the fluid will flow by gravity to the Grum Pit. New aboveground HDPE piping will be installed from the dredge line connection to the Grum Pit. This connection will be a cam-lock fitting. The pipe will be buried in an insulated trench at road crossings. CH2M HILL undertook a hydraulic analysis, using the criteria in Table 1, to verify pipe sizes and flow velocities, and to determine the new operating point on the pump curve.

Hydraulic Analysis

Pressure Flow

CH2M HILL used the latest Applied Flow Technology Fathom 8.0 computer program to analyze pressure flow from the pump to the high point. The existing Toyo pump curve was input to determine the new system operating point at low-pond and high-pond water levels. The following results are based on the assumption that the impeller is in good condition:

- Pump flow range:
  - Near empty pond condition: = ~111.0 L/s (1,760 USgpm)
  - Full pond condition: = ~121.8 L/s (1,930 USgpm)
- Pressure pipe size = 250 mm (10-inch)
  - Minimum velocity at 111.0 L/s (1,760 USgpm) = 2.9 m/s (9.5 feet per second)
  - Maximum velocity at 121.8 L/s (1,930 USgpm) = 3.2 m/s (10.5 feet per second)

Open Channel Gravity Flow

CH2M HILL used the Bentley FlowMaster V8i (Select Series 1) computer program to analyze gravity flow from the High Point to the Grum Pit. This analysis yielded the following results:

- Gravity pipe size: 400-mm (16-inch)
  - Minimum velocity at 111.0 L/s (1,760 USgpm) and 1.4 percent slope= 1.8 m/s (5.8 feet per second)
  - Maximum velocity at 121.8 L/s (1,930 USgpm) and 69 percent slope = 8.6 m/s (28.3 feet per second)
- Gravity pipe (supercritical flow condition) minimum slope = 1.4 percent at 74 percent flow depth for older pipe conditions, at 121.8 L/s (1,930 USgpm)
- Gravity pipe velocity in pipe segment downstream of vent is 3.3 m/s (10.9 feet per second), which provides a smooth transition since it is greater than the pressure flow maximum velocity

Each computer program output file contains detailed results of pressures and flow characteristics. Attachment 1 provides further details.

Design Drawings

Design drawings were developed based on the design criteria stated herein, as well as hydraulic analysis and existing site conditions. Attachment 2 provides the pipeline plan, profile, and associated details. The drawings were developed using the following assumptions:

- TEES will install the pipe and make field adjustments as required.
- Anchor spacing will vary. Therefore, a guidance table for anchor spacing is shown for the (16-inch) and the (10-inch) pipe at an average 20-degree-Fahrenheight change from night to day, based on Faro temperature information (Attachment 3). If the 10-inch pipe remains full after operation movement therein will be minimized. Anchor spacing can be increased by snaking the pipe while maintaining the required continuous slope.
- The vent pipe assembly will be fused at the factory to facilitate field installation.

Table 2 provides pipe lengths based on the drawings.

TABLE 2
Piping Summary
Faro Mine Remediation Project

HDPE Nominal Diameter (mm /inches)	Dimension Ratio	Approximate Length (m/feet)
250/10	11.0	154/505
400/16	11.0	863/2,830

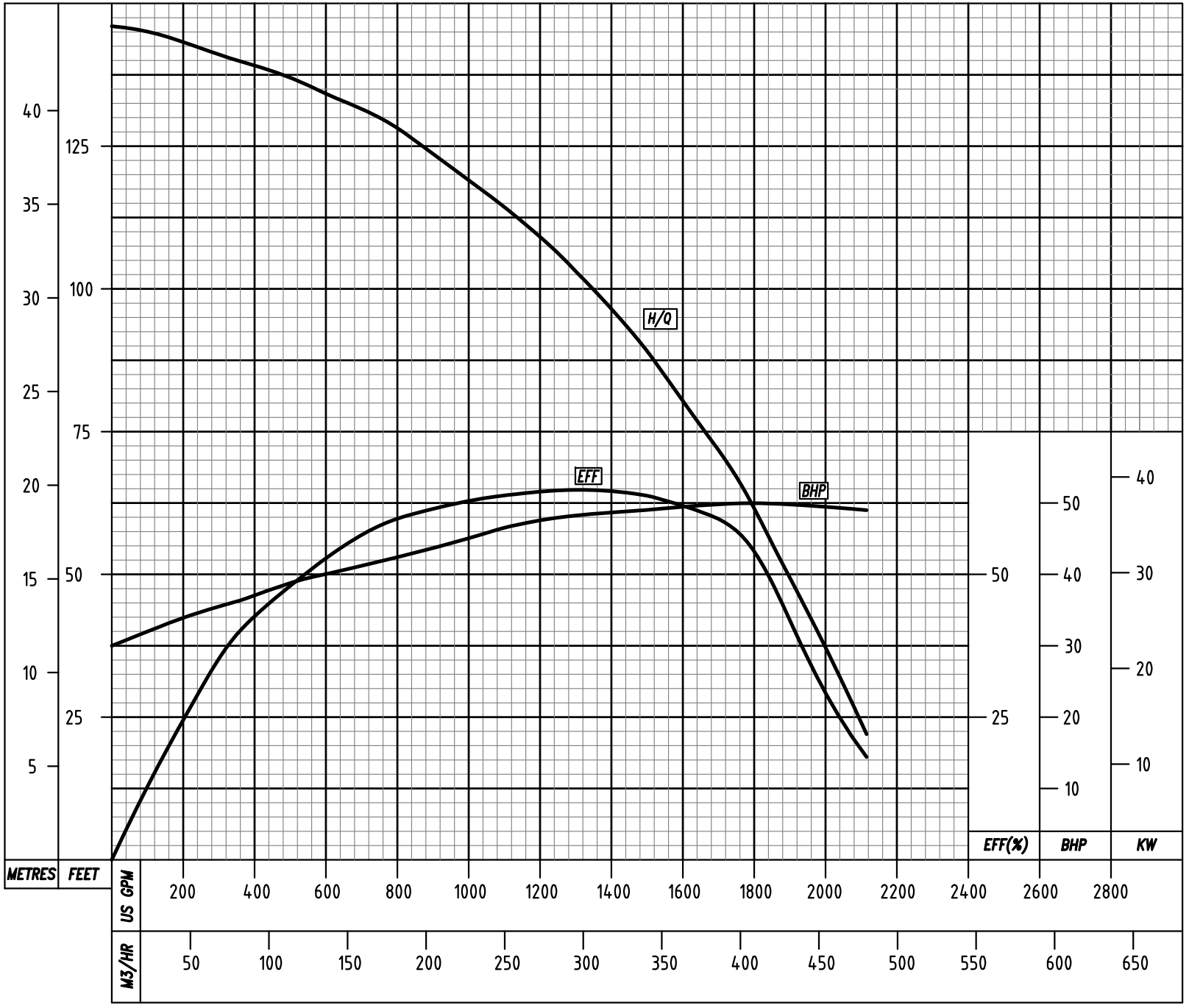
Attachment 1
Pump Curve and Hydraulic Analysis Output Files

ATTACHMENT-1

- **HYDRAULIC ANALYSIS OUTPUTS**
  - **PRESSURE FLOW**
  - **GRAVITY FLOW**

PRESSURE FLOW OUTPUTS

TOYO PUMP CURVE



TOYO PUMPS

WWW.TOYOPUMPS.COM

TOYO PUMPS NORTH AMERICA CORPORATION
BURNABY, BRITISH COLUMBIA
CANADA V5C 6H2
TEL : (604)298-1213 FAX : (604)298-7773

PUMP MODEL	DL 50B		
CURVE NUMBER	A6504	REV.	3
EFFECTIVE DATE	26 NOV 2008		
SUPERSEDES	-	REV.	-

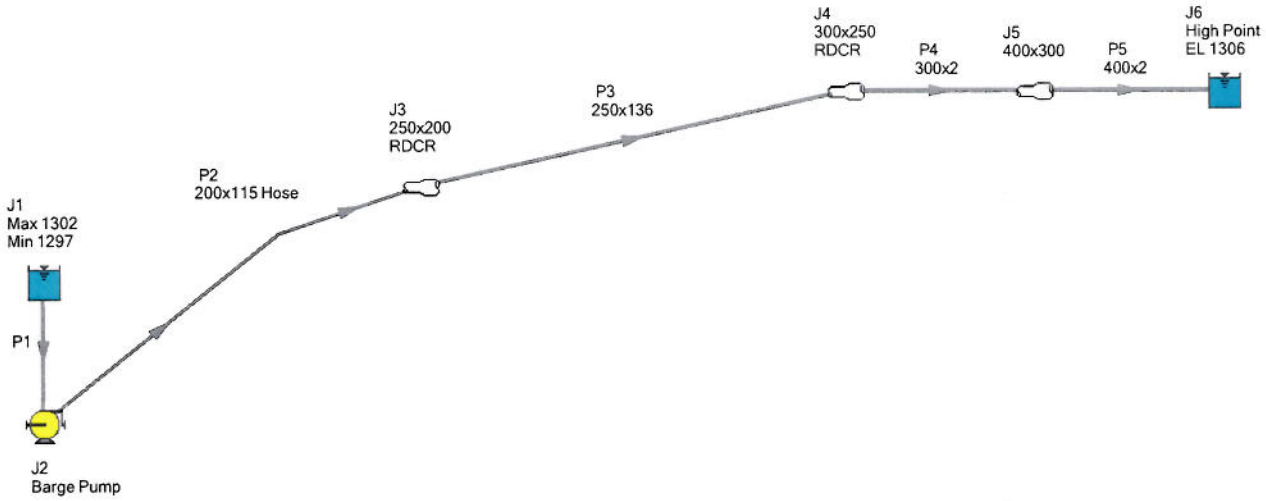
DISCHARGE	INCHES	8
	MM	200
SUCTION	INCHES	N/A
	MM	N/A
TEST NUMBER		-

IMPELLER NO.	021-C75-16	
IMPELLER TYPE	CLOSED	
IMP. DIAMETER	INCHES	12.8
	MM	325
NUMBER OF VANES	-	
MAX.PARTICLE	INCHES	1
	MM	25
VOLUTE NUMBER	020-342-25	

MOTOR OUTPUT	HP/KW	50/37
PHASE X VOLTAGE	3ph x 230/460/575	
RATED CURRENT	AMPS	122/61/48
WINDING INSULATION CLASS	F	
POLES/REVOLUTION	4P / 1800 RPM	

PERFORMANCE FOR WATER @ 68°F/20°C AND 1.0 S.G. CORRECT FOR OTHER CONDITIONS AND/OR SOLIDS EFFECT

POND LEVEL = 1297 METRES
PUMP FLOW ~ 1760 GPM



Model Reference Information

General

Title: AFT Fathom Model
Analysis run on: 3/25/2014 18:31:16
Application version: AFT Fathom Version 8 (2013.02.12)
Input File: \\ODIN\Proj\YukonGovernmentOf\472645FARO\TAR_09_Vangorda_Sludge_Pipeline\Hydraulics\Fathom\2014-03-13 Vangorda Sludge Pipeline.fth
Output File: \\ODIN\Proj\YukonGovernmentOf\472645FARO\TAR_09_Vangorda_Sludge_Pipeline\Hydraulics\Fathom\2014-03-13 Vangorda Sludge Pipeline_1.out

Execution Time= 0.05 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 9
Total Number Of Temperature Iterations= 0
Number Of Pipes= 5
Number Of Junctions= 6
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 60 deg. F
Density= 62.37215 lbm/ft3
Viscosity= 2.72848 lbm/hr-ft
Vapor Pressure= 0.25024 psia
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 1,759 gal/min
Total Outflow= 1,759 gal/min
Maximum Static Pressure is 42.14 psia at Pipe 2 Inlet
Minimum Static Pressure is 14.30 psia at Pipe 3 Outlet

Warnings

No Warnings

Pump Summary

Jct	Name	Vol. Flow (gal/min)	dH (feet)	dP (psid)	Speed (Percent)	Ideal Power (hp)	NPSHA (feet)
2	Barge Pump	1,759	65.32	28.29	100.0	29.02	33.35

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (atm)	Net Vol. Flow (gal/min)
1	Max 1302 Min 1297	Infinite	N/A	4,255	1.000	-1,759
6	High Point EL 1306	Infinite	N/A	4,285	1.000	1,759

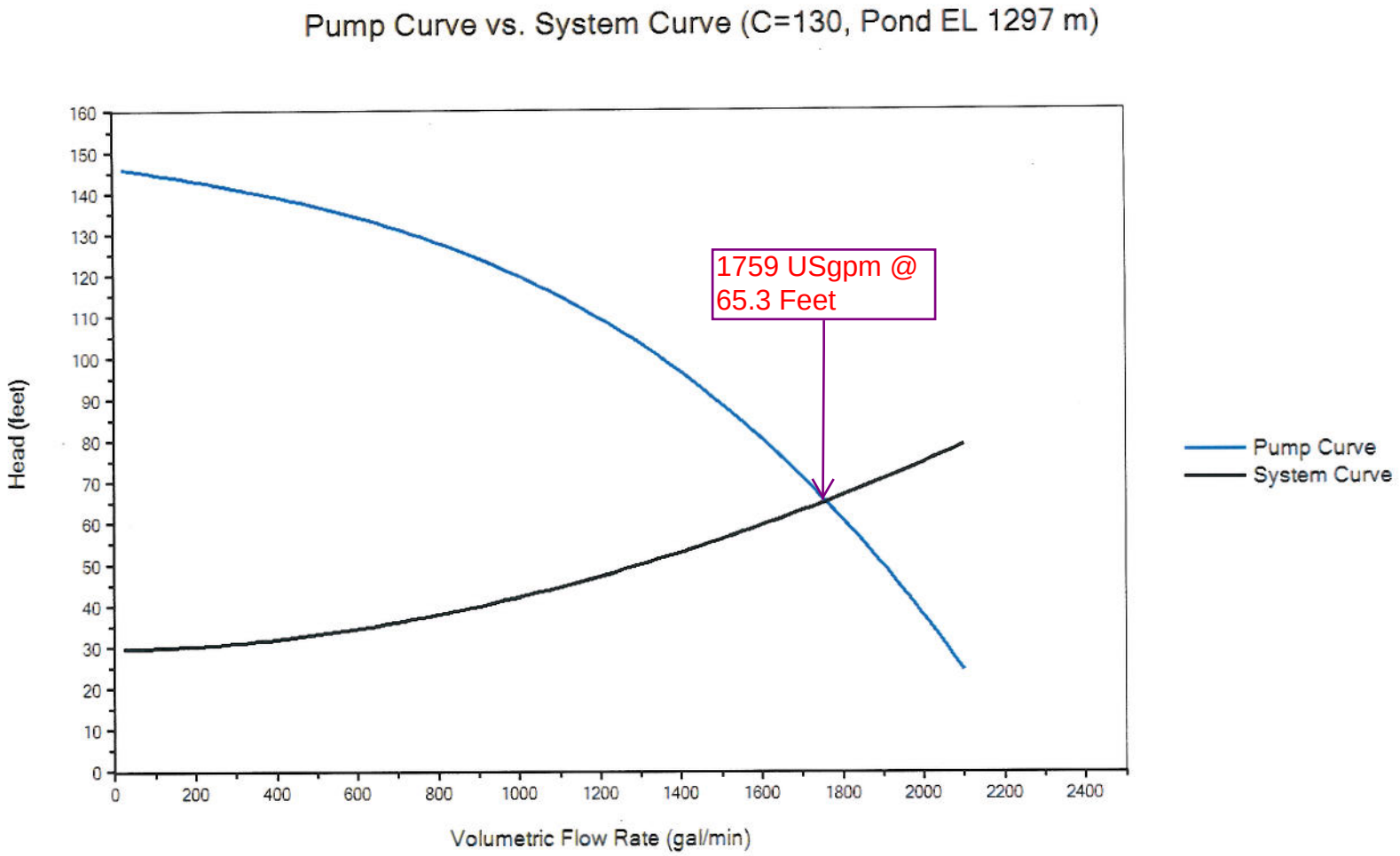
Pipe Output Table

Pipe	Name	Hyd. Diameter (inches)	Pipe Nominal Size	Length (feet)	Pipe Type-Schedule	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Roughness	K	dH (feet)	P Static Min (psig)	dP Stag. Total (psid)
1	Pump Suction	30.000	None	0.3281	None	1,759	0.7983	CHW= 130	0.000	0.00002733	-0.004301	0.00001184
2	200x115 Hose	8.000	None	377.2966	None	1,759	11.2265	CHW= 130	0.000	19.63897253	10.409483	17.03280771
3	250x136	8.678	10 inch	446.1942	SDR 11	1,759	9.5404	CHW= 130	0.000	15.62596888	-0.393066	11.03110603
4	300x2	10.293	12 inch	6.5617	SDR 11	1,759	6.7821	CHW= 130	0.000	0.10010012	-0.151900	0.04335736
5	400x2	12.915	None	6.5617	None	1,759	4.3076	CHW= 130	1.000	0.32968246	-0.124900	0.14279863

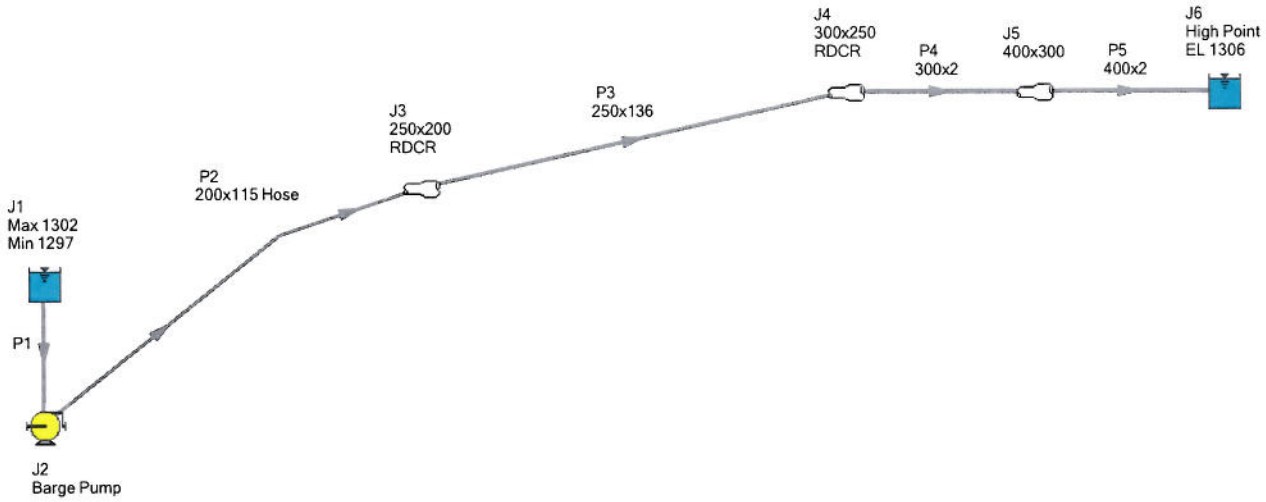
Pipe	dP Static Total (psid)	P Static In (psig)	P Static Out (psig)
1	0.00001184	-0.004290	-0.004301
2	17.03280771	27.442287	10.409483
3	11.03110603	10.638250	-0.393066
4	0.04335736	-0.108542	-0.151900
5	0.14279863	0.017899	-0.124900

All Junction Table

Jct	Name	Vol. Flow Rate Thru Jct (gal/min)	Elevation Inlet (feet)	dH (feet)	dP Static Total (psid)	P Static In (psig)	P Static Out (psig)	dP Stag. Total (psid)	P Stag. In (psig)	P Stag. Out (psig)	Loss Factor (K)
1	Max 1302 Min 1297	1,759	4,255	0.00000	0.0000	0.000000	0.00000	0.000000	0.00000000	0.0000	0.000000
2	Barge Pump	1,759	4,255	-65.31530	-27.4466	-0.004301	27.44229	-28.290663	-0.00001144	28.2906	0.000000
3	250x200 RDCR	1,759	4,275	0.01599	-0.2288	10.409483	10.63825	0.006924	11.25784302	11.2509	0.008162
4	300x250 RDCR	1,759	4,285	0.04278	-0.2845	-0.393066	-0.10854	0.018531	0.21960163	0.2011	0.030247
5	400x300	1,759	4,285	0.03443	-0.1698	-0.151900	0.01790	0.014914	0.15771198	0.1428	0.048169
6	High Point EL 1306	1,759	4,285	0.00000	0.0000	0.000000	0.00000	0.000000	0.00000000	0.0000	0.000000


Pump Curve vs. System Curve (C=130, Pond EL 1297 m)
Head (feet)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Volumetric Flow Rate (gal/min)
1759 USgpm @
65.3 Feet
Pump Curve
System Curve

POND LEVEL = 1302 METRES
PUMP FLOW ~ 1930 GPM



Model Reference Information

General

Title: AFT Fathom Model
Analysis run on: 3/25/2014 18:10:06
Application version: AFT Fathom Version 8 (2013.02.12)
Input File: \\ODIN\Proj\YukonGovernmentOf\472645FARO\TAR_09_Vangorda_Sludge_Pipeline\Hydraulics\Fathom\2014-03-13 Vangorda Sludge Pipeline.fth
Output File: \\ODIN\Proj\YukonGovernmentOf\472645FARO\TAR_09_Vangorda_Sludge_Pipeline\Hydraulics\Fathom\2014-03-13 Vangorda Sludge Pipeline_1.out

Execution Time= 0.05 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 7
Total Number Of Temperature Iterations= 0
Number Of Pipes= 5
Number Of Junctions= 6
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 60 deg. F
Density= 62.37215 lbm/ft3
Viscosity= 2.72848 lbm/hr-ft
Vapor Pressure= 0.25024 psia
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 1,933 gal/min
Total Outflow= 1,933 gal/min
Maximum Static Pressure is 40.67 psia at Pipe 2 Inlet
Minimum Static Pressure is 14.20 psia at Pipe 3 Outlet

Warnings

No Warnings

Pump Summary

Jct	Name	Vol. Flow (gal/min)	dH (feet)	dP (psid)	Speed (Percent)	Ideal Power (hp)	NPSHA (feet)
2	Barge Pump	1,933	45.92	19.89	100.0	22.42	49.76

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (atm)	Net Vol. Flow (gal/min)
1	Max 1302 Min 1297	Infinite	N/A	4,272	1.000	-1,933
6	High Point EL 1306	Infinite	N/A	4,285	1.000	1,933

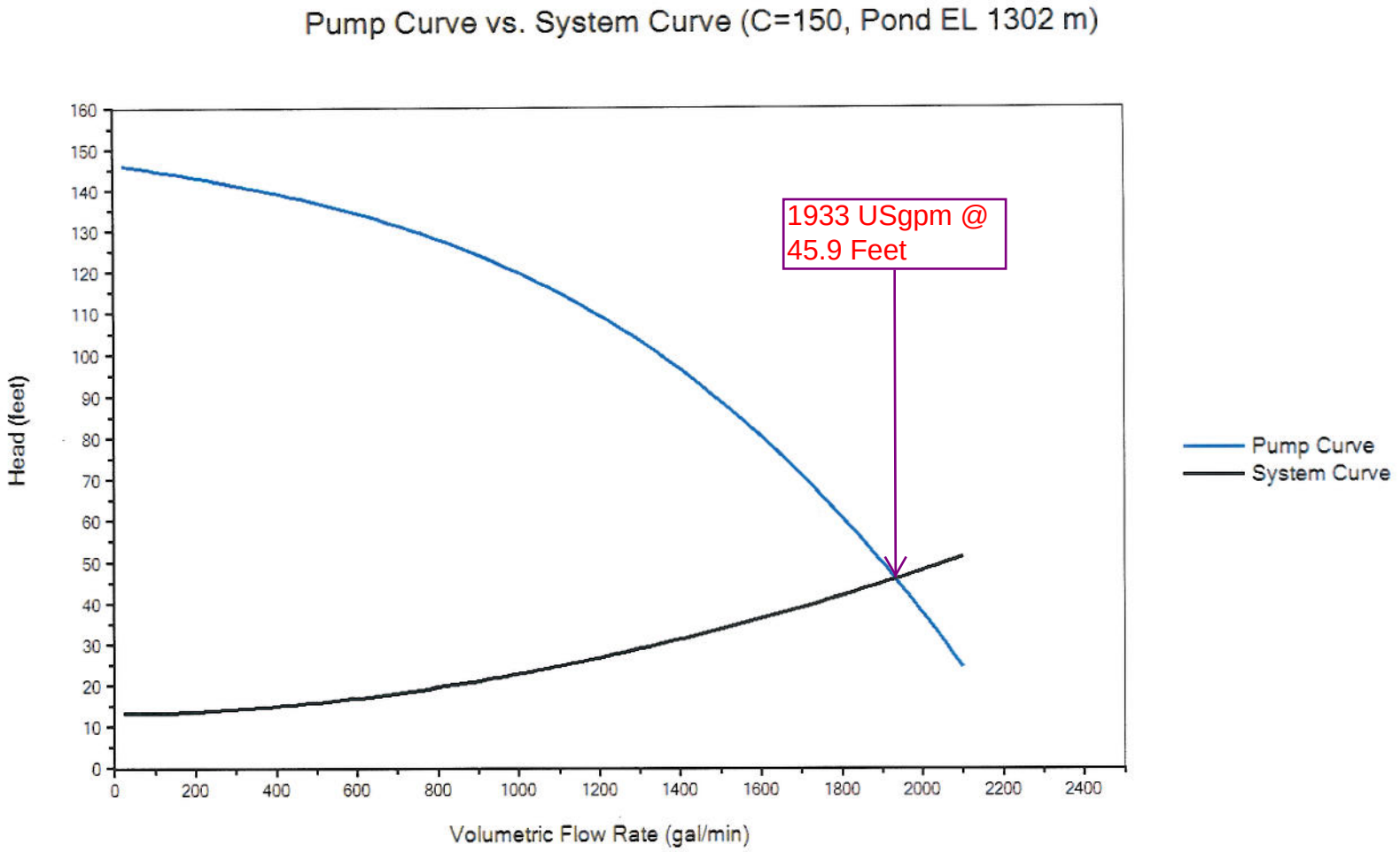
Pipe Output Table

Pipe	Name	Hyd. Diameter (inches)	Pipe Nominal Size	Length (feet)	Pipe Type-Schedule	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Roughness	K	dH (feet)	P Static Min (psig)	dP Stag. Total (psid)
1	Pump Suction	30.000	None	0.3281	None	1,933	0.8772	CHW= 150	0.000	0.00002497	7.1002	0.00001081
2	200x115 Hose	8.000	None	377.2966	None	1,933	12.3362	CHW= 150	0.000	17.94060451	9.6742	16.29717672
3	250x136	8.678	10 inch	446.1942	SDR 11	1,933	10.4834	CHW= 150	0.000	14.27464159	-0.4956	10.44579223
4	300x2	10.293	12 inch	6.5617	SDR 11	1,933	7.4524	CHW= 150	0.000	0.09144352	-0.1916	0.03960784
5	400x2	12.915	None	6.5617	None	1,933	4.7334	CHW= 150	1.000	0.37910169	-0.1508	0.16420408

Pipe	dP Static Total (psid)	P Static In (psig)	P Static Out (psig)
1	0.00001081	7.10018	7.1002
2	16.29717672	25.97138	9.6742
3	10.44579223	9.95043	-0.4956
4	0.03960784	-0.15202	-0.1916
5	0.16420408	0.01339	-0.1508

All Junction Table

Jct	Name	Vol. Flow Rate Thru Jct (gal/min)	Elevation Inlet (feet)	dH (feet)	dP Static Total (psid)	P Static In (psig)	P Static Out (psig)	dP Stag. Total (psid)	P Stag. In (psig)	P Stag. Out (psig)	Loss Factor (K)
1	Max 1302 Min 1297	1,933	4,272	0.00000	0.0000	0.0000	7.10536	0.000000	0.0000	7.1054	0.000000
2	Barge Pump	1,933	4,255	-45.92140	-18.8712	7.1002	25.97138	-19.890392	7.1053	26.9957	0.000000
3	250x200 RDCR	1,933	4,275	0.01930	-0.2762	9.6742	9.95043	0.008361	10.6986	10.6902	0.008162
4	300x250 RDCR	1,933	4,285	0.05166	-0.3436	-0.4956	-0.15202	0.022376	0.2442	0.2218	0.030247
5	400x300	1,933	4,285	0.04158	-0.2050	-0.1916	0.01339	0.018008	0.1822	0.1642	0.048169
6	High Point EL 1306	1,933	4,285	0.00000	0.0000	0.0000	0.00000	0.000000	0.0000	0.0000	0.000000


Pump Curve vs. System Curve (C=150, Pond EL 1302 m)
1933 USgpm @
45.9 Feet
Head (feet)
Volumetric Flow Rate (gal/min)
Pump Curve
System Curve
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400

GRAVITY FLOW OUTPUTS

Worksheet for 16 " DR 11 Gravity Pipe Low Slope Area to Grum-Pit

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.014	
Channel Slope	0.01400	m/m
Diameter	12.916	in
Discharge	1760.00	gal/min

Results

Normal Depth	8.925	in
Flow Area	0.67	ft²
Wetted Perimeter	2.11	ft
Hydraulic Radius	3.810	in
Top Width	303.19	mm
Critical Depth	253.76	mm
Percent Full	69.1	%
Critical Slope	0.01065	ft/ft
Velocity	5.85	ft/s — MINIMUM VELOCITY
Velocity Head	0.53	ft
Specific Energy	388.60	mm
Froude Number	1.26	
Maximum Discharge	2299.41	gal/min
Discharge Full	2137.58	gal/min
Slope Full	0.00949	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.000	in
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	69.10	%
Downstream Velocity	Infinity	ft/s

Worksheet for 16 " DR 11 Gravity Pipe Low Slope Area to Grum-Pit

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	8.925	in
Critical Depth	253.76	mm
Channel Slope	0.01400	m/m
Critical Slope	0.01065	ft/ft

Messages

Notes

CALCULATIONS SHOW THAT AN OLD 16 -INCH DIAMETER DR 11 HDPE PIPE WILL PROVIDE THE FOLLOWING:
1) ADEQUATE CAPACITY @ A MINUMUM 1.4% SLOPE
2) A PIPE VELOCITY NEAR 6.0 FEET PER SECOND
3) A FLOW DEPTH OF ABOUT 69% FULL ALLOWING ROOM FOR ADEQUATE AIR INLET THROUGH A VENT PIPE AND ADDITIONAL CAPACTITY IF REQUIRED.

Worksheet for Steep 16" DR 11 Gravity Pipe Segment

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.012	— NEW PIPE CONDITION
Channel Slope	0.69000	m/m
Diameter	12.916	in
Discharge	1960.00	gal/min

Results

Normal Depth	2.918	in
Flow Area	0.15	ft²
Wetted Perimeter	1.07	ft
Hydraulic Radius	1.735	in
Top Width	274.39	mm
Critical Depth	266.75	mm
Percent Full	22.6	%
Critical Slope	0.00877	ft/ft
Velocity	28.33	ft/s
Velocity Head	12.48	ft
Specific Energy	3876.66	mm
Froude Number	12.07	
Maximum Discharge	18833.15	gal/min
Discharge Full	17507.71	gal/min
Slope Full	0.00865	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.000	in
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	22.59	%
Downstream Velocity	Infinity	ft/s

Worksheet for Steep 16" DR 11 Gravity Pipe Segment

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	2.918	in
Critical Depth	266.75	mm
Channel Slope	0.69000	m/m
Critical Slope	0.00877	ft/ft

Messages

Notes

CALCULATIONS SHOW THAT THE 16 -INCH DIAMETER DR 11 HDPE PIPE SEGMENT DOWNSTREAM OF THE VENT AT THE MAXIMUM SLOPE OF 69%WILL PROVIDE THE FOLLOWING:
1) A VELOCITY OF ABOUT 30.0 FPS AT MAXIMUM FLOW OF 1960 GPM.
3) A FLOW DEPTH OF ABOUT 23% FULL.

5/8

Worksheet for 16 " DR 11 Gravity Pipe Low Slope Area to Grum-Pit

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.014	
Channel Slope	0.01400	m/m
Diameter	12.916	in
Discharge	1930.00	gal/min

Results

Normal Depth	9.603	in
Flow Area	0.73	ft²
Wetted Perimeter	2.24	ft
Hydraulic Radius	3.889	in
Top Width	286.53	mm
Critical Depth	264.91	mm
Percent Full	74.4	%
Critical Slope	0.01173	ft/ft
Velocity	5.93	ft/s
Velocity Head	0.55	ft
Specific Energy	410.34	mm
Froude Number	1.19	
Maximum Discharge	2299.41	gal/min
Discharge Full	2137.58	gal/min
Slope Full	0.01141	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.000	in
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	74.35	%
Downstream Velocity	Infinity	ft/s

Worksheet for 16 " DR 11 Gravity Pipe Low Slope Area to Grum-Pit

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	9.603	in
Critical Depth	264.91	mm
Channel Slope	0.01400	m/m
Critical Slope	0.01173	ft/ft

Messages

Notes

CALCULATIONS SHOW THAT AN OLD 16 -INCH DIAMETER DR 11 HDPE PIPE WILL PROVIDE THE FOLLOWING:
1) ADEQUATE CAPACITY @ A MINUMUM 1.4% SLOPE
2) A PIPE VELOCITY NEAR 6.0 FEET PER SECOND
3) A FLOW DEPTH OF ABOUT 74% FULL ALLOWING ROOM FOR ADEQUATE AIR INLET THROUGH A VENT PIPE AND ADDITIONAL CAPACTITY IF REQUIRED.

7/8

Worksheet for 16 " DR 11 Gravity Pipe Segment Downstream of Vent @

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.014	
Channel Slope	0.06600	m/m
Diameter	12.916	in
Discharge	1960.00	gal/min

Results

Normal Depth	5.861	in
Flow Area	0.40	ft²
Wetted Perimeter	1.59	ft
Hydraulic Radius	3.028	in
Top Width	326.66	mm
Critical Depth	266.78	mm
Percent Full	45.4	%
Critical Slope	0.01194	ft/ft
Velocity	10.88	ft/s ← GOOD
Velocity Head	1.84	ft
Specific Energy	709.38	mm
Froude Number	3.13	
Maximum Discharge	4992.56	gal/min
Discharge Full	4641.20	gal/min
Slope Full	0.01177	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.000	in
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	45.38	%
Downstream Velocity	Infinity	ft/s

Worksheet for 16 " DR 11 Gravity Pipe Segment Downstream of Vent @

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	5.861	in
Critical Depth	266.78	mm
Channel Slope	0.06600	m/m
Critical Slope	0.01194	ft/ft

Messages

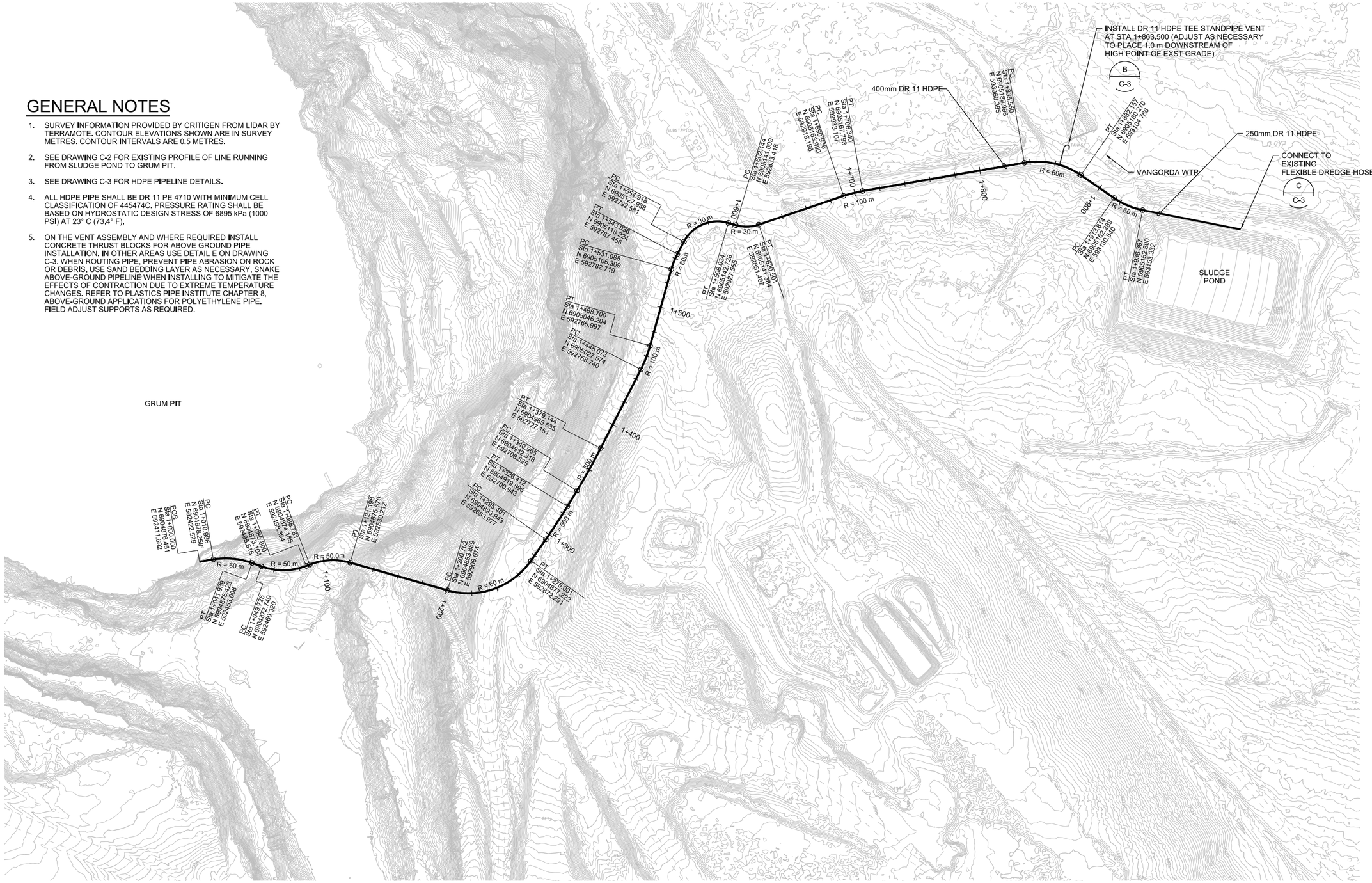
Notes

CALCULATIONS SHOW THAT THE 16 -INCH DIAMETER DR 11 HDPE PIPE SEGMENT DOWNSTREAM OF THE VENT WILL PROVIDE THE FOLLOWING:
1) A VELOCITY OF ABOUT 10.8 FEET PER SECOND @ 6,6% SLOPE AT MAXIMUM FLOW OF 1960 GPM.
3) A FLOW DEPTH OF ABOUT 45% FULL ALLOWING ROOM FOR ADEQUATE AIR INLET THROUGH THE VENT PIPE..

Attachment 2
Drawings

GENERAL NOTES

1. SURVEY INFORMATION PROVIDED BY CRITIGEN FROM LIDAR BY TERRAMOTE. CONTOUR ELEVATIONS SHOWN ARE IN SURVEY METRES. CONTOUR INTERVALS ARE 0.5 METRES.
2. SEE DRAWING C-2 FOR EXISTING PROFILE OF LINE RUNNING FROM SLUDGE POND TO GRUM PIT.
3. SEE DRAWING C-3 FOR HDPE PIPELINE DETAILS.
4. ALL HDPE PIPE SHALL BE DR 11 PE 4710 WITH MINIMUM CELL CLASSIFICATION OF 445474C. PRESSURE RATING SHALL BE BASED ON HYDROSTATIC DESIGN STRESS OF 6895 kPa (1000 PSI) AT 23° C (73.4° F).
5. ON THE VENT ASSEMBLY AND WHERE REQUIRED INSTALL CONCRETE THRUST BLOCKS FOR ABOVE GROUND PIPE INSTALLATION. IN OTHER AREAS USE DETAIL E ON DRAWING C-3. WHEN ROUTING PIPE, PREVENT PIPE ABRASION ON ROCK OR DEBRIS. USE SAND BEDDING LAYER AS NECESSARY. SNAKE ABOVE-GROUND PIPELINE WHEN INSTALLING TO MITIGATE THE EFFECTS OF CONTRACTION DUE TO EXTREME TEMPERATURE CHANGES. REFER TO PLASTICS PIPE INSTITUTE CHAPTER 8, ABOVE-GROUND APPLICATIONS FOR POLYETHYLENE PIPE. FIELD ADJUST SUPPORTS AS REQUIRED.



PLAN

SCALE: 1:1500 (FULL SIZE)
1:3000 (HALF SIZE)

N

NO.	DATE	DSGN	REVISION	BY	APVD
		L ALLIGER	DR	K SILVA	CHK	C FUNK	APVD	J SPITZLEY

PROFESSIONAL ENGINEER — YUKON TERRITORY — JOHN E. SPITZLEY

CH2MHILL®
2525 AIRPARK DR.
REDDING, CA 96001
(530) 243-5831

FARO MINE REMEDIATION PROJECT
TAR009 - SLUDGE MANAGEMENT
GOVERNMENT OF YUKON
DESIGN

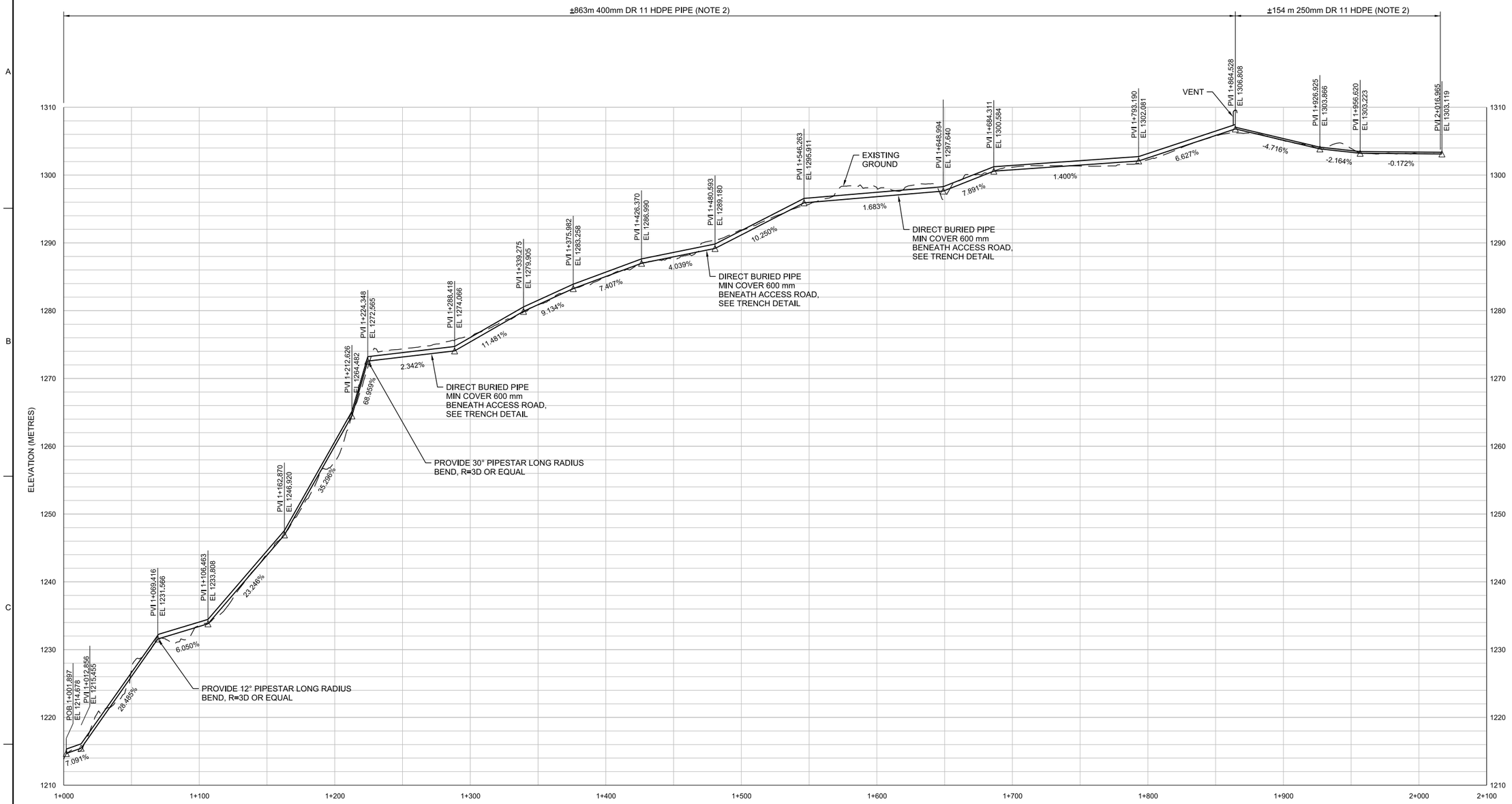
CIVIL

PLAN

AS SHOWN
VERIFY SCALE
BAR IS 25mm ON ORIGINAL DRAWING. 0 — 25mm

DATE	MARCH 2014
PROJ	TA009-427716
DWG	C-1
SHEET	1 of 3

FILENAME: 300-009-C-201_427716.dgn PLOT DATE: 3/28/2014 PLOT TIME: 12:44:46 PM



PROFILE

SCALE: HORIZ: 1:1500 VERT: 1:300 (FULL SIZE)
HORIZ: 1:3000 VERT: 1:600 (HALF SIZE)

NOTES

1. ALL PIPING TO BE INSTALLED WITH A MINIMUM FALL OF 1.4%.
2. ALL HDPE PIPE SHALL BE DR 11 PE 4710 WITH MINIMUM CELL CLASSIFICATION OF 445474C. PRESSURE RATING SHALL BE BASED ON HYDROSTATIC DESIGN STRESS OF 100 PSI AT 73.4 DEGREES F.

PROFESSIONAL ENGINEER — YUKON — JOHN E. SPITZLEY — TERRITORY

NO.	DATE	DSGN	DR	CHK	APVD	BY	APVD
		L ALLIGER	K SILVA	C FUNK	J SPITZLEY		

REVISION

2525 AIRPARK DR.
REDDING, CA 96001
(530) 243-6831

CH2MHILL®

FARO MINE REMEDIATION PROJECT
TAR009 - SLUDGE MANAGEMENT
GOVERNMENT OF YUKON
DESIGN

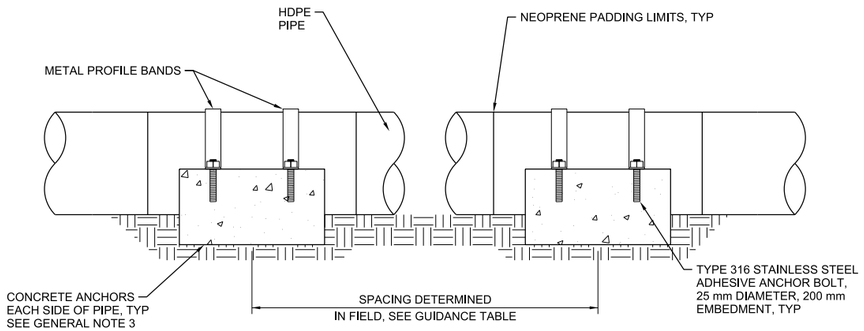
CIVIL

PROFILE

AS SHOWN
VERIFY SCALE
BAR IS 25mm ON ORIGINAL DRAWING. 0 25mm

DATE	MARCH 2014
PROJ	TA009-427716
DWG	C-2
SHEET	2 of 3

FILENAME: 300-009-C-202_427716.dgn PLOT DATE: 3/27/2014 PLOT TIME: 5:50:07 PM



GUIDANCE TABLE

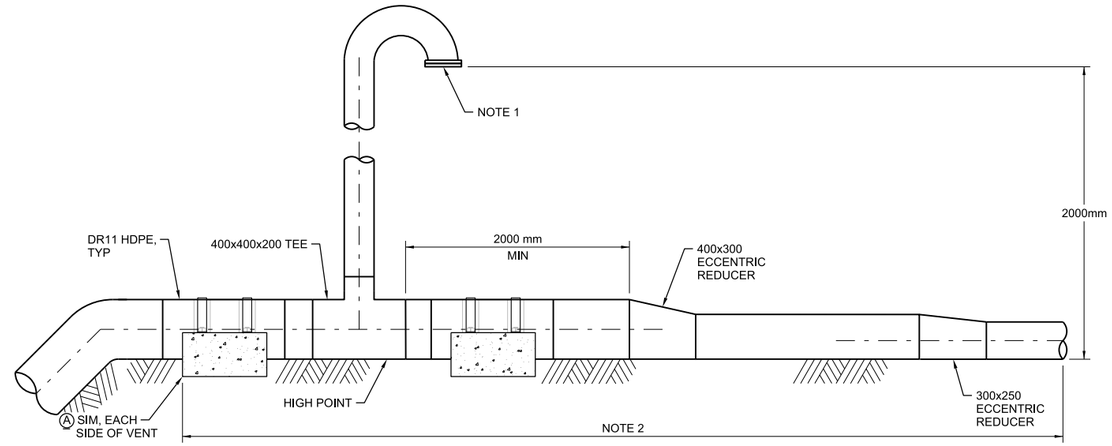
APPROXIMATE HORIZONTAL DEFLECTIONS BETWEEN CONCRETE ANCHORS, SEE NOTE					
BLOCK SPACING			LATERAL DEFLECTION		
METRES		(FEET)	METRES		(FEET)
30.5		(100.0)	0.90		(3.0)
61.0		(200.0)	1.80		(6.0)
91.5		(300.0)	2.60		(8.5)

NOTE: BASED ON AVERAGE 7° C (20° F) TEMPERATURE INCREASE FROM NIGHT TO DAY.

A ABOVE GROUND HDPE PIPING TYPICAL CONCRETE ANCHOR

NTS

A
C-1
AS REQUIRED



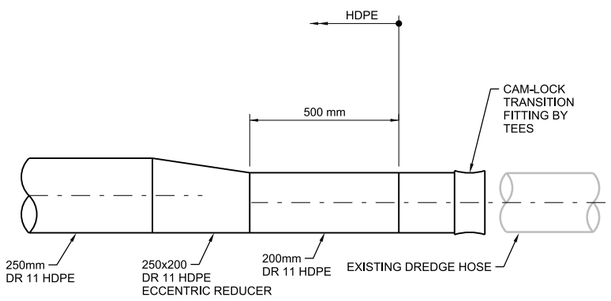
NOTE:

1. PROVIDE TYPE 316 STAINLESS STEEL CONVOLUTED FLANGE WITH STAINLESS STEEL BIRD MESH BETWEEN A TYPE 316 STAINLESS STEEL RING FLANGE.
2. FACTORY FUSED.

B VENT ASSEMBLY

NTS

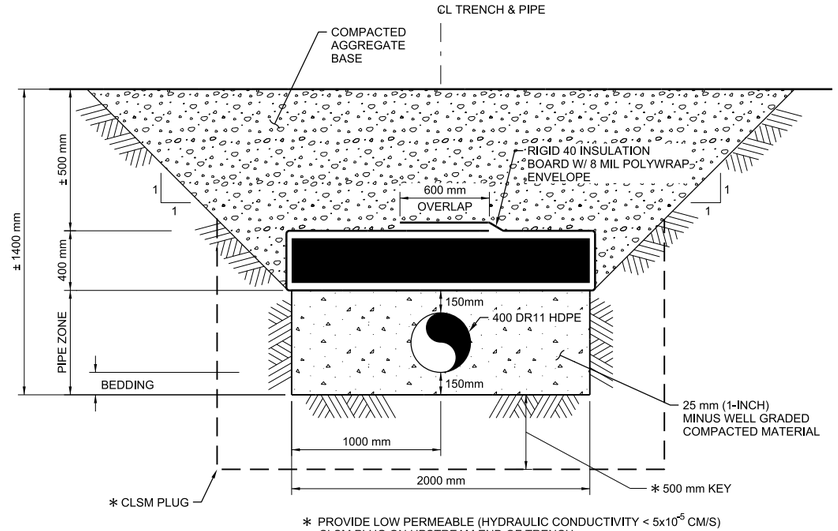
B
C-1



C CONNECTION TO EXISTING FLEXIBLE DREDGE HOSE

1:10

C
C-1

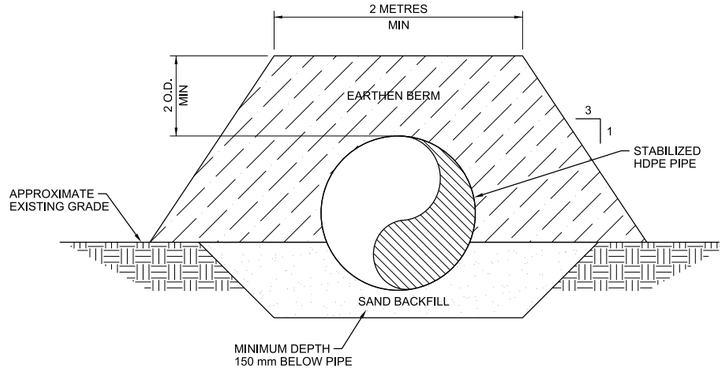


* PROVIDE LOW PERMEABLE (HYDRAULIC CONDUCTIVITY < $5x10^{-5}$ CM/S) CLSM PLUG ON UPSTREAM END OF TRENCH WITH MINIMUM 1000 mm THICKNESS. KEY PLUG INTO SIDES AND BOTTOM A MINIMUM OF 500 mm.

D TRENCH DETAIL

1:20

D



E ABOVE GROUND HDPE PIPING TYPICAL EARTHEN BERM STABILIZATION

NTS

E
C-1

GENERAL NOTES

1. SEE DRAWING C-1 FOR SITE PLAN.
2. SEE DRAWING C-2 FOR PIPING PROFILE.
3. TIRES FILLED WITH CONCRETE MAY BE USED AS ANCHORS IN LIEU OF CONCRETRE BLOCKS. HOWEVER CONNECTIONS FROM THE TIRES TO THE PIPE MUST NOT ALLOW PIPE TO MOVE IN ANY DIRECTION INCLUDING ROTATION.

PROFESSIONAL ENGINEER — YUKON TERRITORY — JOHN E. SPITZLEY

NO.	DATE	DSGN	DR	REVISION	CHK	APVD	BY	APVD
	L ALLIGER			K BISHOP	C FUNK		J SPITZLEY	

2525 AIRPARK DR.
REDDING, CA 96001
(530) 243-5831

FARO MINE REMEDIATION PROJECT
TAR009 - SLUDGE MANAGEMENT
GOVERNMENT OF YUKON
DESIGN

CH2MHILL®

CIVIL

DETAILS

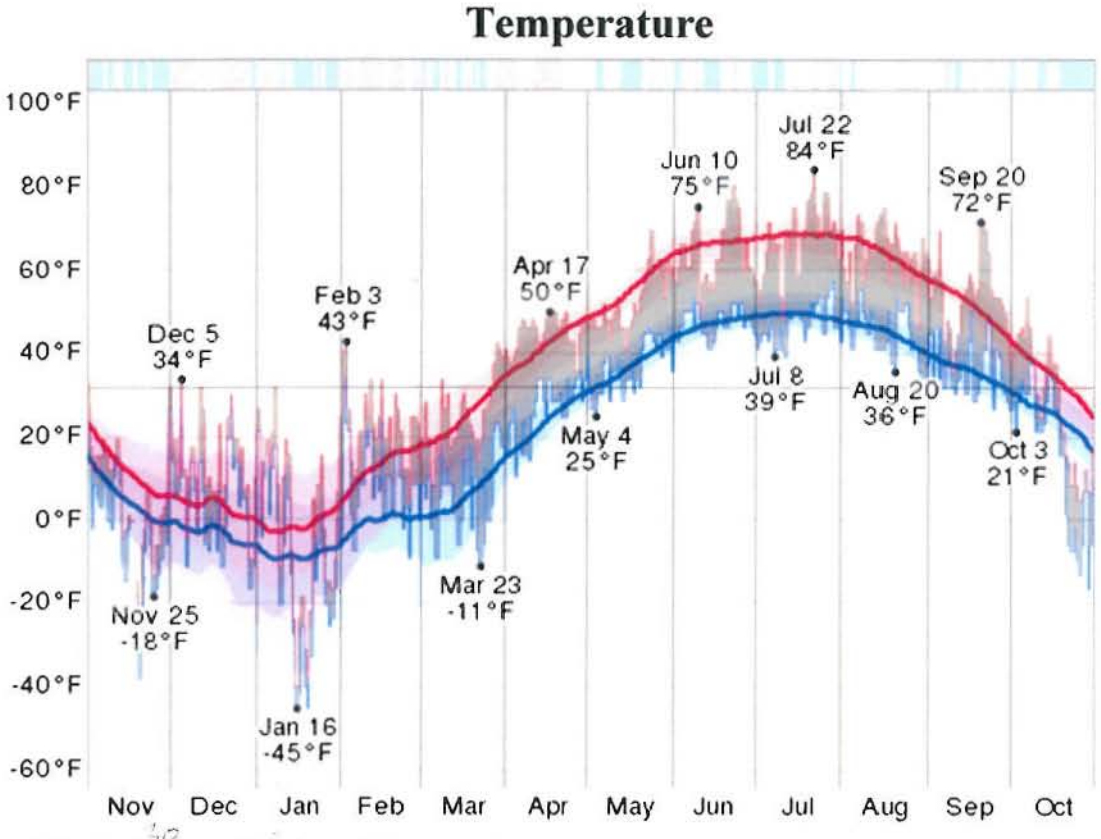
AS SHOWN
VERIFY SCALE
BAR IS 25mm ON ORIGINAL DRAWING. 0 25mm

DATE	MARCH 2014
PROJ	TA009-427716
DWG	C-3
SHEET	3 of 3

FILENAME: 300-009-C-203_427716.dgn PLOT DATE: 3/28/2014 PLOT TIME: 5:38:02 PM

Attachment 3
Faro 2012 Temperatures

largest fraction of warmer than average days with 86% days with higher than average high temperatures.



The daily low (blue) and high (red) temperature during the last 12 months with the area between them shaded gray and superimposed over the corresponding averages (thick lines), and with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile). The bar at the top of the graph is red where both the daily high and low are above average, blue where they are both below average, and white otherwise.

The *coldest day* of the last 12 months was January 16, with a low temperature of -45°F. For reference, on that day the average low temperature is -9°F and the low temperature drops below -37°F only one day in ten. The *coldest month* of the last 12 months was January with an average daily low temperature of -11°F.

Relative to the average, the coldest day was November 20. The low temperature that day was -38°F, compared to the average of 3°F, a difference of 41°F. In relative terms the coldest month was November, with an average low temperature of -3°F, compared to an typical value of 6°F.

The longest *cold spell* was from June 27 to July 13, constituting 17 consecutive days with cooler than average low temperatures. The month of November had the largest fraction of cooler than average days with 80% days with lower than average low temperatures.