WCE
Whipple Consulting Engineers, Inc.

WCE No. 2013-1166

July 23, 2015
Revised October 13, 2016

City of Spokane Valley
11707 E Sprague Ave, Suite 106
Spokane Valley, WA 99206

Attn: Mr. Gabe Gallinger, P.E.

Re: Painted Hills Flood Control Development Narrative (Storage Area #1 & #6, SA1)

Dear Gabe:

This letter is intended to present the flood control plan for the above referenced storage areas in anticipation of the future development.

Background

A hydrologic and hydraulic analysis for Chester Creek was completed by Michael Baker Jr., Inc. and approved by Spokane County in a letter to the Federal Emergency Management Agency dated August 6, 1990. There are no long-term gage records for Chester Creek. The limited gage measurements on Chester Creek were collected near the Dishman-Mica Road crossing of Chester Creek for December 1994 through March 1995 and November 1995 through February 1996 when no flood events occurred. In February 2006, the hydraulic analysis for Chester Creek was revised by West Consultants, Inc. under a FEMA contract. The analysis established flood magnitude-frequency estimates for the watercourse. A steady flow model has been developed for Chester Creek. [1]

The reports conclude that spring floods in the upper Spokane River basin are due to snowmelt runoff from high elevation watersheds. Such floods are of less significance on Chester Creek because the lower elevation of the water shed limit the size of the snowpack so spring runoff occurs about a month earlier and the more gradual rates than on the Spokane River. Nearly all maximum annual flood peaks on Chester Creek occur during the winter. Warm winds and rain can melt the snow rapidly. When winter rain causes snowmelt on frozen soil conditions, short-duration, intense runoff generates a flood peak during winter storms. During the more extreme events, Chester Creek runs over its banks filling depressions in the flood zone. [1]

The duration of flooding is generally between 100 hours and 1000 hours, or between four days and forty days with smaller events occurring with greater frequency than large events. [1]

Channel geometry for Chester Creek were developed from surveys conducted in March 2003. Overbank geometry was developed from topography developed by TerraPoint (2003). Flood plain boundaries for Chester Creek and Unnamed Tributary to Chester Creek were delineated using 2 foot contour interval maps developed by TerraPoint from LiDAR data. [1]

Previously, a watershed plan for Chester Creek was designed with management recommendations for drainage, flooding, water quality, and riparian habitat. As a result, flood control improvements have been implemented along Chester Creek. The improvements area began at the Painted Hills Golf Course. In 1998, a project to install new culverts and extensive dredging of the channel between Thorpe Road and Schaffer Road was implemented. Two large volume borrow pits were constructed downstream. Each pit was designed for the retention and infiltration of Chester Creek floodwaters up to a 25 year event. One borrow pit was constructed just north of E 40th Avenue and the other just south of 28th Avenue. [1]

Before the storage areas #1 and #6 are to be modified (see Site Element Plan), it is important to understand where they are within the Chester Creek Basin, and what floodwaters they receive. Within the Chester Creek Basin, the storage areas are generally located in the northeast corner of the basin along the edge of the valley floor. Specifically, north of Thorpe Road (Storage Area 1) and to the east of 40th Avenue (Storage Area 6).

The flood condition flows as identified by West Consultants are separated into three parts in relation to the three directions of flow that enters into the Painted Hills Development: the main flow (Golf Course Overflow Reach) across Thorpe Road, the secondary (Unnamed Tributary) flow from Highway 27, and the secondary flow across Madison Road. The project is proposing to redirect the anticipated flows of the identified flood events for storage area #1 (main flow and secondary flow) to a discharge point at the north end of the development and for storage area #6 (Unnamed Tributary) to an offsite discharge point to the east of the development.

Storage Area #1 is a large storage area that encompasses the majority of the former Painted Hills Golf Course as well as areas to the east of Madison Road. There is no outflow route for this storage area so it is classified as compensatory storage and is allowed to infiltrate through the native soils and into the Spokane Rathdrum Aquifer. The soils below the storage area include the Spokane Rathdrum Aquifer as its base followed by layers of course sands that are topped by soils of an alluvial fan or an area of natural deposit from Chester Creek, before the creek was channelized.

The floodwaters that enter Storage Area #1 are identified on the July 6, 2010 Firm Map as the Chester Creek Golf Course Overflow. The Chester Creek Golf Course Overflow originates at a point to the south of Thorpe Road where there was at one time a breach in the man-made channel of Chester Creek. The breach was reportedly from a lack of maintenance and the overgrowth of vegetation in the main channel that blocked the main channel during a storm event. This flow of floodwater enters the storage area from the south at a low point in Thorpe Road through two 10" culverts and, if flow is larger, by overtopping the road.

Storage Area #6 is a smaller storage area that is located east of 40th Avenue primarily within a 30-foot-deep gravel pit that was excavated during the early development years of Spokane Valley. Spokane County obtained a drainage easement over the pit in 1983 for storm drainage purposes. The overflow route of storage area #6 is along the south side of 40th Avenue and flows into Storage Area #1 via culverts under Madison Road. The soils below the storage area include the Spokane Rathdrum Aquifer as its base followed by layers of course sands and gravels that were further exposed by the gravel pit excavation.

The Main Flow Across Thorpe Road

Concept Design and Process

For the concept design the 100-year event was used to size facilities. The initial design was to capture the approximately 1,594,812 cf or 36.61 ac-ft into a deep pond for storage and discharge through evaporation. However, it occurred to us when reviewing the Geotechnical Evaluations, Phase I (December 31, 2013 – Revised August 29, 2016) and Phase II (July 23, 2015) that there are "valley gravels" or well-draining soils that lead directly to the Spokane-Rathdrum Aquifer under the poor draining soils that cover the site. If we connected into these soils the compensatory storage may be treated and discharged into these soils. Initially we were looking at 128 double depth drywells with a design outflow rate of 1.0 cfs each. That would provide twice the outflow rate of 128 cfs to the 64 cfs peak inflow rate of the flow across Thorpe Road. However, as the construction consideration of the drywells was made, it was decided that a gravel gallery system sized to the storm would more evenly distribute the stormwater across a larger area. But after further geotechnical investigation, it was determined the south area may have groundwater at or above the proposed depth of the gravel galleries. Therefore, a new site for the gravel galleries was chosen at the north end of the development where groundwater was determined to be much deeper than the galleries. See Supplemental Geotechnical Evaluation by IPEC dated April 19, 2016.

Proposed Design

See Site Element Plan in the attachments.

Box Culvert/Open Channel

The flow coming from the breach of the east levee upstream on Chester Creek is anticipated to approach Thorpe Road as before at the low point where there are currently 2-10" culverts within the natural drainage way or Golf Course Overflow Reach. The flow will then enter into a 30 foot wide by 3 foot high box culvert under Thorpe Road, replacing the 2 existing culverts. The roadside ditches along Thorpe Road will be regraded to ensure positive flow toward the box culvert. Given the topography of the area, aside from shallow puddles, all stormwater will enter into the proposed box culvert. On the north side of Thorpe Road the flow will exit the box culvert and enter into a 5 foot wide concrete open channel that flows to the east.

Pipe Mainline

The open channel will then turn north and transition into a buried pipe system with manholes along the west side of Madison Road. The flow will enter into a 48" floodwater pipe at the headwall and continue for approximately 270 feet and then transition into a 60" floodwater pipe to the north end of the project with an outfall into a bio-infiltration channel. Each manhole along Madison Road will have a sump for the settling of particles in low flow conditions. These particles or silt can then be vactored out of the manholes as part of the routine maintenance.

Bio-infiltration Channel

The bio-infiltration channel receives the stormwater from the 60" pipe and will be planted with tall dryland grasses. The flow of the floodwater overland through the tall grass provides the last phase of cleaning before the floodwater flows into the gravel gallery system for ultimate disposal into the aquifer, its final destination. See Bio-infiltration worksheet in the attachments.

Gravel Gallery System

Floodwater from the downstream end of the bio-infiltration channel is piped via two 36" pipes to manholes at the east end of the gravel gallery system. From the manholes the floodwater is piped to drywells to evenly distribute the floodwater and enters the gravel galleries by either flowing through the drywell barrels or distributing through 24" pipes to the next drywell and through pipe cross fittings.

The gravel gallery system is based upon four 10 foot wide by 13 foot deep by 450 foot long infiltration trenches that are lined with geo-fabric per WSDOT Std. Spec. 9-33.2(1) and filled with gravel drywell material in conformance with WSDOT Std. Spec. 9-03.12(5). Within the top 3 feet of the infiltration trench runs a 24" pipe at a 1% slope that connects drywells located at the ends and center (totaling 12 drywells) within each trench segment. Pipe cross fittings will be installed every 50 feet with geotech fabric banded over the open ends to allow water within the pipe to enter the rock section without rock entering the pipe. The cross fittings are offset from each other across adjacent trenches. This equidistant separation allows for a balanced distribution of water within the gravel gallery system ensuring all of the gallery is filled and used for infiltration. When the next drywell fills or rises to the invert of the next pipe, stormwater will continue to the next fitting/drywell until the gravel gallery is filled. Once filled the gallery is at its maximum design infiltration rate of 118 cfs (see gravel gallery worksheet in the attachments). A 100-year storm has a peak flow rate in this system of 64 cfs so with a design outflow rate over 1.8 times greater that the design inflow rate the system will not be overwhelmed. This is a conservative measure of protection.

Infiltration Rate

The Phase I geotechnical evaluation performed laboratory grain size analysis tests on soils from the test pits, including at Test Pit TP-29 at the 10 to 12-foot depth. This test showed a fines content of 2.3 percent with design drywell rates of 0.3 and 1.0 cfs for Type A and Type B drywells, respectively.

A full-scale dry well test was performed at the north end of the site. Based on this test we used the design flow rate of 1.8×10^{-3} cfs/sf for design of the gravel galleries in the open space area north of the proposed Cottages residential area. See attached IPEC Geotechnical Report dated June 28, 2016.

Maintenance of the gravel gallery system is a semi-annual inspection of the gallery through the system drywells looking for a build-up of sediment and debris, and if needed, the removal of the sediment and debris by a vactor truck.

Levee

The project site is protected from the main channel of Chester Creek by a levee on the northerly and easterly side of the creek from Thorpe Road to Dishman-Mica Road. This levee will be improved by some minor grading to increase freeboard in the area of the Thorpe Road culvert and at the existing cart crossing bridges. Additionally, new levee will be constructed from the existing levee northwesterly along the easterly side of Dishman-Mica Road terminating at Wilbur Road.

The Secondary Flow Across Madison Road:

The flow across Madison Road is divided into 5 basins from the heights above and to the east of Madison Road that correspond to the 5 culverts that are placed under Madison Road. The most northerly culvert does not have an outlet on the west side of Madison Road. Therefore, the floodwater distributes along the east side of Madison and appears to be separated into 4 culverts that cross Madison Road at Stations (S-N) 13+22, 20+44, 24+43 and 30+43. As the development proposes to widen Madison Road on the west side, the 4 culverts will be replaced and extended. Since the proposed inverts of the extended culverts will fall below the proposed grade of the roadside swales, the culverts will connect into the 60" pipe.

The storm water along the west side of Madison Road will be collected in roadside swales where it will receive treatment. The swales will have catch basins with the rim set 6" above the swale bottom. Any excess treated flow that does not infiltrate and exceeds a 6" depth will enter the catch basins. The catch basins will be connected to the 60" storm pipe.

West Consultants provided the following 100-year storm flows for each culvert during the 100-year storm. We are using these flows to size and design floodwater facilities.

STA.	100 Year Storm Flow (cfs)	
13+22	4	
20+44	1	
24+41	1	
30+42	2	
38+98	7	

Any floodwater generated west of the triangle pond along E 40th Avenue flows to the west. Then at Madison Road it flows south between the road and the easterly hillside. These flows will be intercepted with the replacement culverts installed at Stations 13+22 through 30+42 that are connected at manholes into the 60" pipe.

The Secondary Flow From Highway 27

Proposed Design

The 16 cfs flow from Highway 27 (Unnamed Tributary) is currently conveyed via a 36" culvert that empties into a ditch that flows across the Gustin property. The stormwater flows through the ditch and into the existing borrow pit within the triangular parcel located northeast of E 40th Avenue. The ditch has been maintained over the years by the property owner to ensure that whatever floodwater comes out of the culvert under Highway 27 will be conveyed to the borrow pit. With this project the ditch will be regraded to a uniform 3 foot bottom width and its southern berm will be reconstructed to be certified as a levee so that FEMA does not immediately assume that the berm is breached and the stormwater flows to the lower area to the south. The area north of the ditch is at a higher elevation that prevents flood water from going north.

Design Elements:
Proposed Pond 17,060 sf @ El: 1990.00; 35,812 sf @ El. 1995.00; 84,416 sf @ El. 2000.00
Drywell spacing 30', total drywell outflow 18.0 cfs
Maintenance Access Road: 6" gravel, max grade 10%, min. radius 35'
Fenced with gate

Infiltration Pond
WCE proposes to improve the outflow of the borrow pit by regrading and expanding the lowest bottom area of the borrow pit and installing 18 double depth drywells into the bottom of the internal pond. The drywells will provide outflow during a frozen ground condition. Each double depth drywell will provide a design outflow of 1.0 cfs for a total of 18 cfs per the recommendations in the Geotechnical Evaluation by IPEC dated October 14, 2014.

If you have any questions or comments in regard to this letter please feel free to contact us at (509) 893-2617.

Sincerely,
WHIPPLE CONSULTING ENGINEERS, INC.

Todd R. Whipple, PE

TRW/bng

CC: File

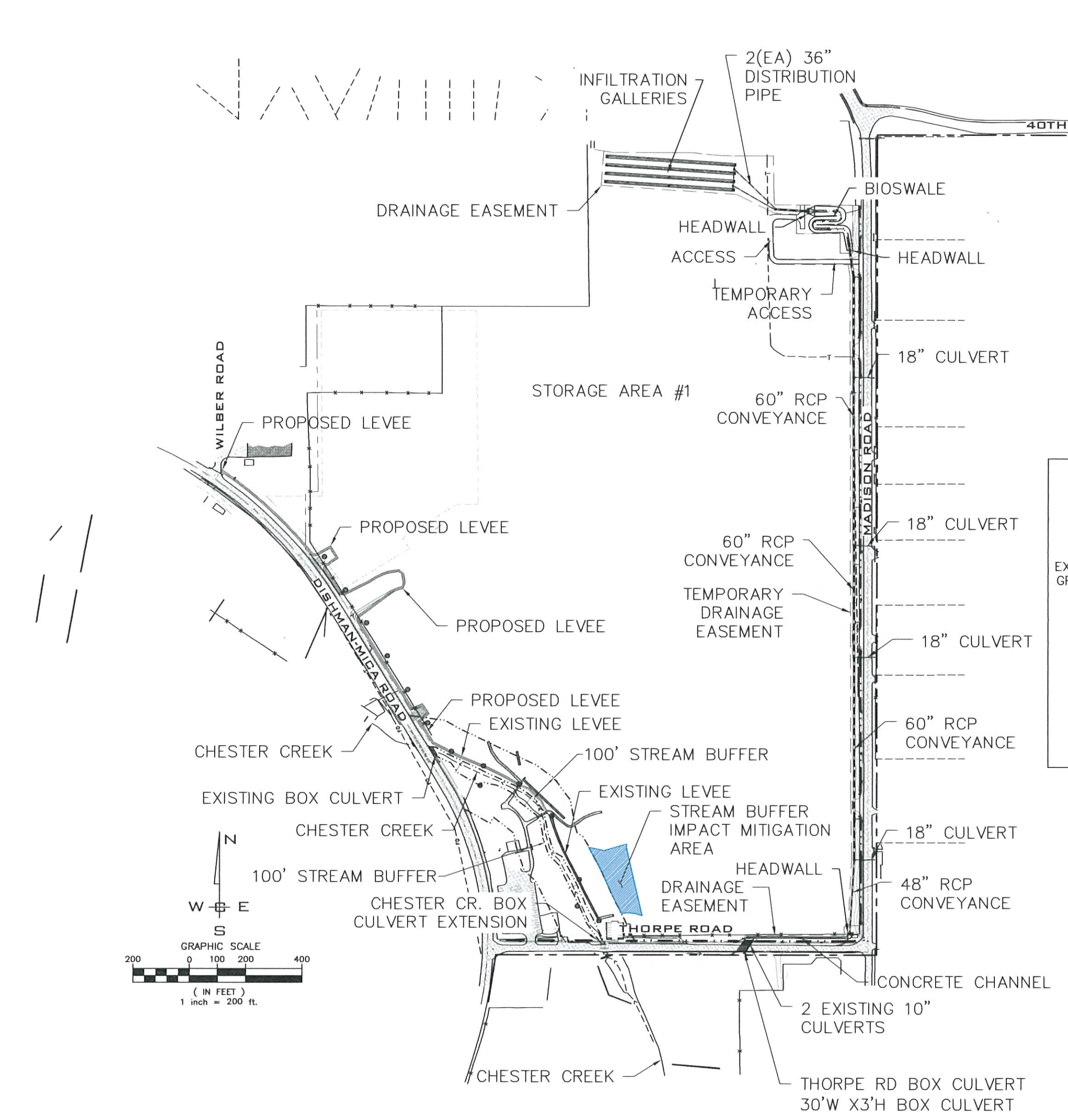
ATTACHEMENTS

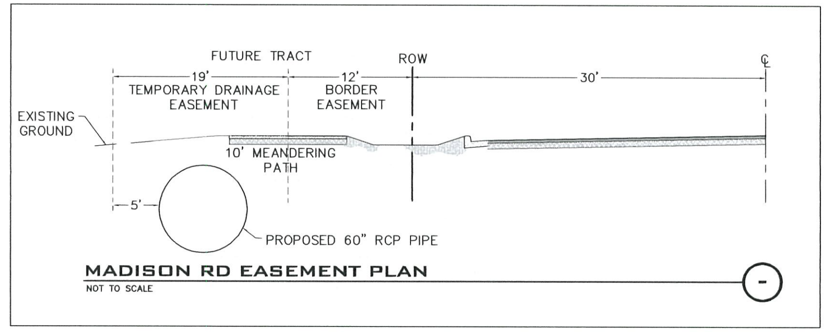
Bibliography
Site Element Plan
Box Culvert/Concrete Channel Calculations
Pipe System Calculations
Gravel Gallery Worksheet – North
Bio-infiltration Channel Worksheet
Madison Rd Culvert Flows
V-Ditch Rock Calculations
IPEC Geotechnical Report dated June 28, 2016

BIBLIOGRAPHY

1) Dawes, Larry. August 30, 2016. Biological Evaluation, Buffer Averaging, and Habitat Management Plan for the Painted Hills PRD. Biology Soil & Water, Inc., Spokane Valley, WA. 12-13.

SITE ELEMENT PLAN





MADISON RD EASEMENT PLAN

NOT TO SCALE

UNDERGROUND SERVICE ALERT
ONE-CALL NUMBER
811
CALL TWO BUSINESS DAYS BEFORE YOU DIG

Spokane County Permit No.:

Floodplain-
Grading-

City of Spokane Valley Permit No.:

SUB-2015-0001
FPD-2016-
EGR-201X-XXXX

City of Spokane Valley Development Engineering

Reviewer:
New Street Miles – Public:

☐ Not Reviewed
☐ Reviewed for Conformance to Street Standards and Accepted per Chapter 1.2
Date Accepted
Acceptance Comments

SEPTEMBER 2016
PLANS NOT APPROVED BY AGENCY

TODD R. WHIPPLE
STATE OF WASHINGTON
25462
REGISTERED
PROFESSIONAL ENGINEER

DATUM: NAVD - 88

TBM S-5 OF THE SOUTH PONDEROSA SEWER PROJECT WITH AN ELEVATION OF 2005.87 (NAVD29) = 2009.67 (NAVD88) WAS USED FOR THE VERTICAL DATUM FOR THIS MAP.

NO	DATE	BY	REVISIONS
1	08-12-16	JPP	ORIGINAL PREPARATION

SCALE:
HORIZONTAL: 1" = 200'
VERTICAL: N/A

PROJ #: 13-1166
DATE: 08/17/16
DRAWN: JPP
REVIEWED: TRW

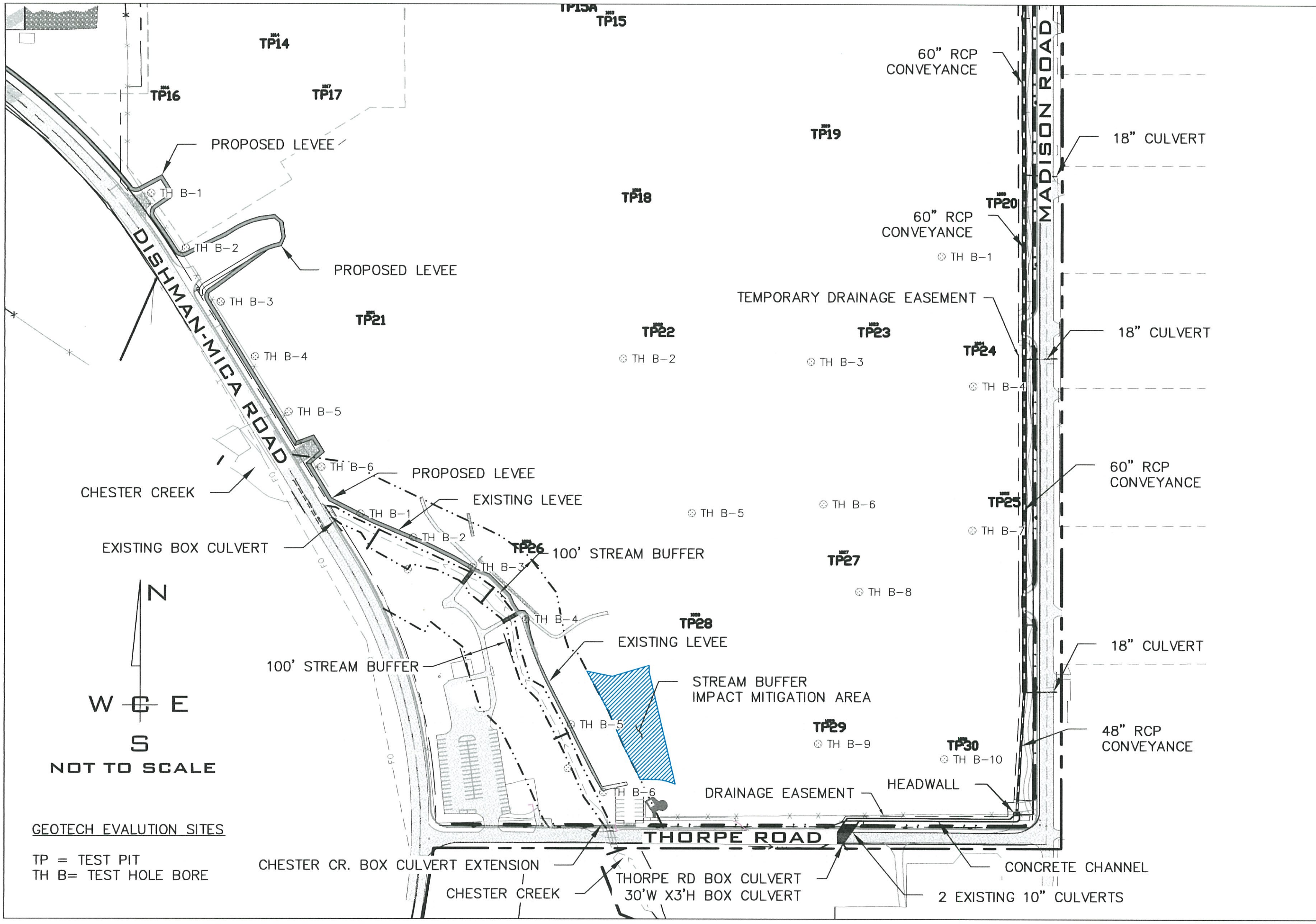
X CIVIL
STRUCTURAL
SURVEYING
TRAFFIC
PLANNING
LANDSCAPE
OTHER

WCE
WHIPPLE CONSULTING ENGINEERS
2528 NORTH SULLIVAN ROAD
SPOKANE VALLEY, WA 99216
PH 509-893-2617 FAX 509-926-0227

SPOKANE VALLEY PAINTED HILLS PRD
SITE ELEMENT PLAN
DISHMAN-MICA RD.
SPOKANE VALLEY,WA

SHEET
C1.3

JOB NUMBER
13-1166



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WHIPPLE CONSULTING ENGINEERS
CIVIL, STRUCTURAL AND
TRANSPORTATION ENGINEERING
2528 NORTH SULLIVAN ROAD
SPOKANE VALLEY, WASHINGTON 99216
PH: 509-893-2617 FAX: 509-926-0227

PROJ #: 13-1166
DATE: 10/11/16
DRAWN: JPP
APPROVED: TRW

SOUTH ONSITE ELEMENT PLAN
PAINTED HILLS PRD
DISHMAN-MICA RD AND THORPE RD
CITY OF SPOKANE VALLEY, WASHINGTON

SHEET
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OF
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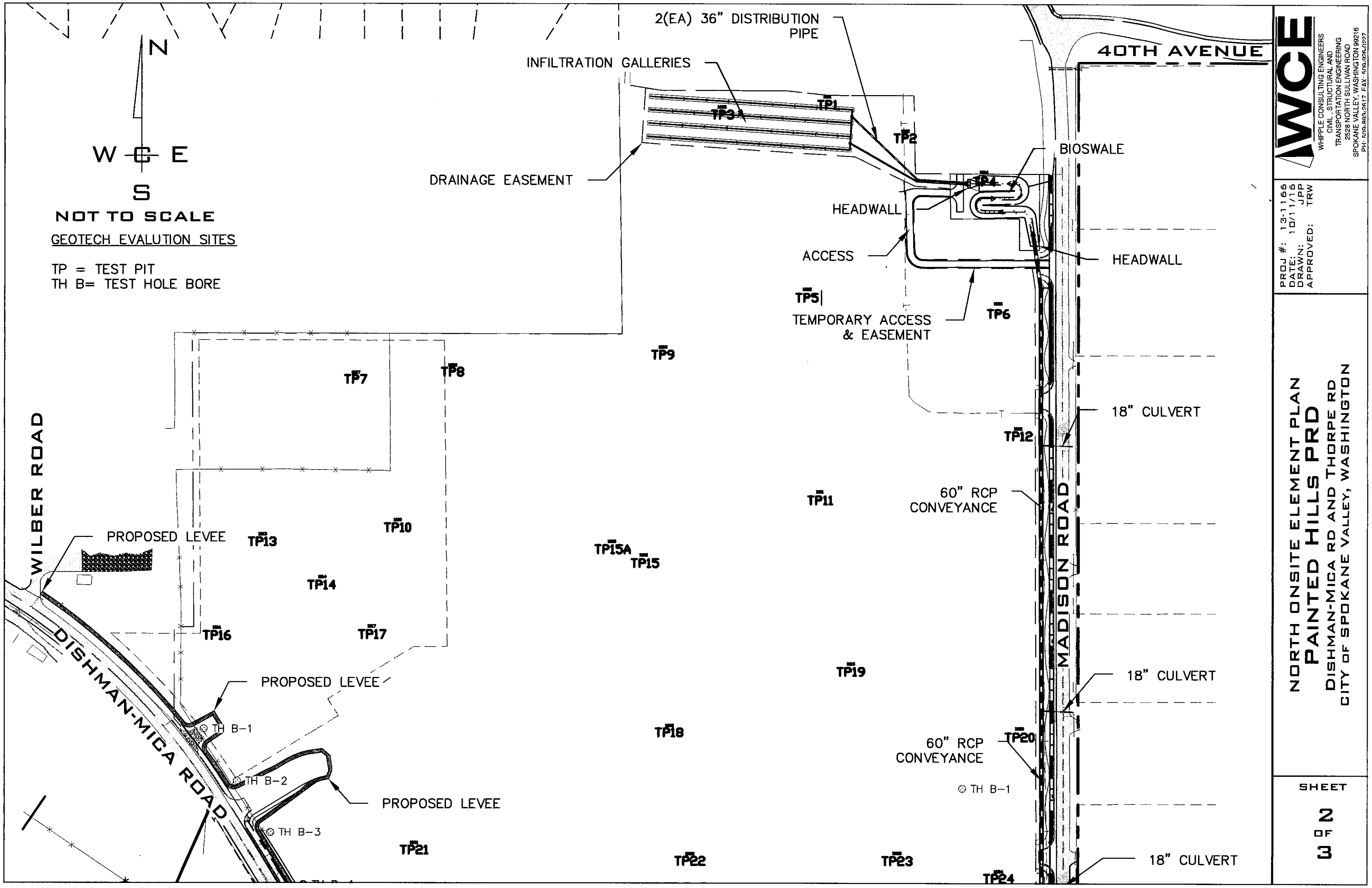
N
W E
S
NOT TO SCALE
GEOTECH EVALUTION SITES
TP = TEST PIT
TH B= TEST HOLE BORE
2(EA) 36" DISTRIBUTION PIPE
INFILTRATION GALLERIES
DRAINAGE EASEMENT
BIOSWALE
HEADWALL
ACCESS
HEADWALL
TEMPORARY ACCESS & EASEMENT
40TH AVENUE
MADISON ROAD
18" CULVERT
60" RCP CONVEYANCE
18" CULVERT
60" RCP CONVEYANCE
18" CULVERT
WILBER ROAD
DISHMAN-MICA ROAD
PROPOSED LEVEE
PROPOSED LEVEE
PROPOSED LEVEE
TH B-1
TH B-2
TH B-3
TH B-1
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP10
TP11
TP12
TP13
TP14
TP15A
TP15
TP16
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TP20
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TP22
TP23
TP24
WCE
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NORTH ONSITE ELEMENT PLAN
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CITY OF SPOKANE VALLEY, WASHINGTON
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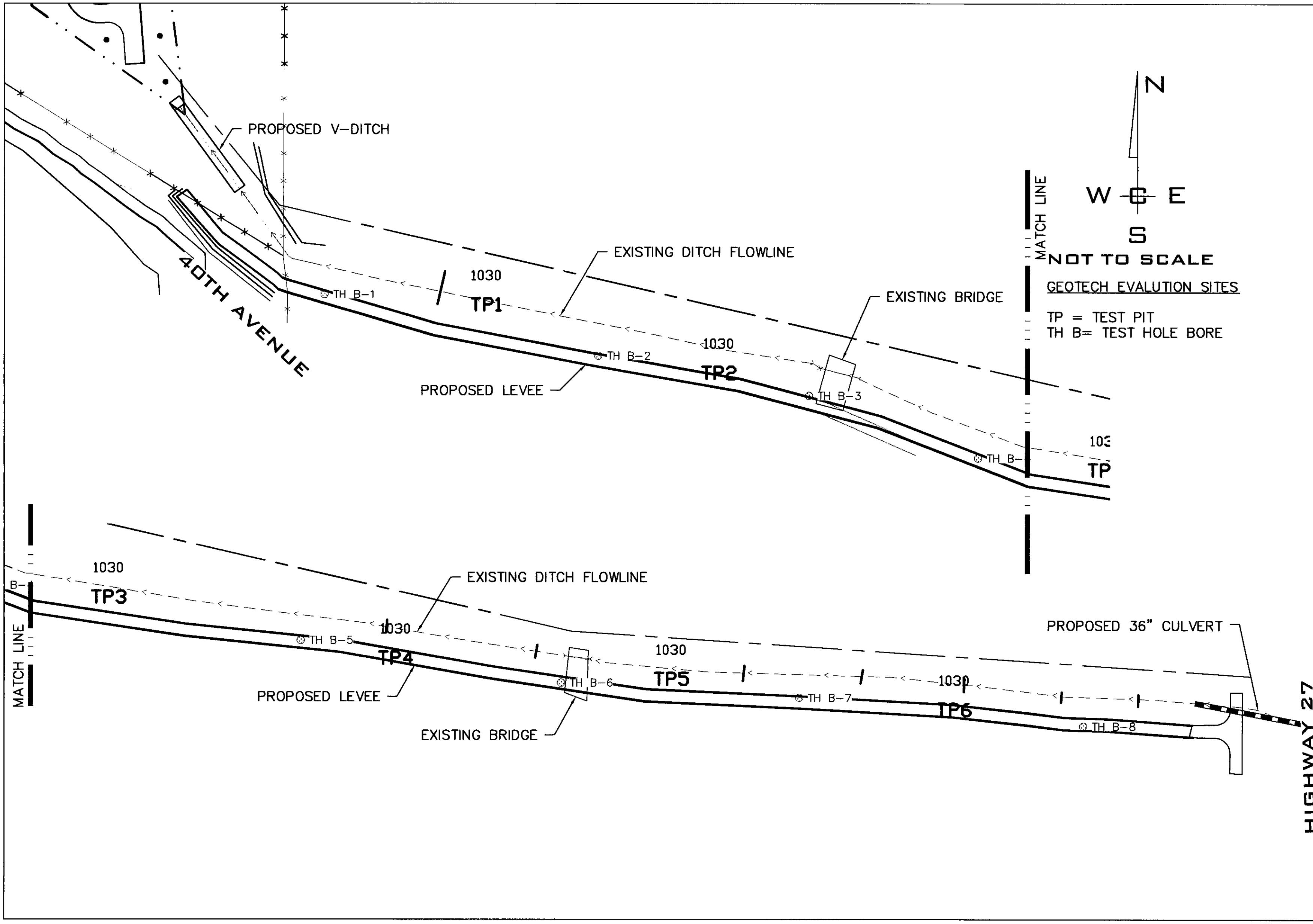


WCE

WHIPPLE CONSULTING ENGINEERS
CIVIL, STRUCTURAL AND
TRANSPORTATION ENGINEERING
2528 NORTH SULLIVAN ROAD
SPOKANE VALLEY, WASHINGTON 99216
PH: 509-893-2617 FAX: 509-926-0227

PROJ #: 13-1166
DATE: 10/11/16
DRAWN: JPP
APPROVED: TRW

GUSTIN DITCH ONSITE ELEMENT PLAN
PAINTED HILLS PRD
DISHMAN-MICA RD AND THORPE RD
CITY OF SPOKANE VALLEY, WASHINGTON

SHEET 3 OF 3

BOX CULVERT/CONCRETE CHANNEL CALCULATIONS

Channel Report

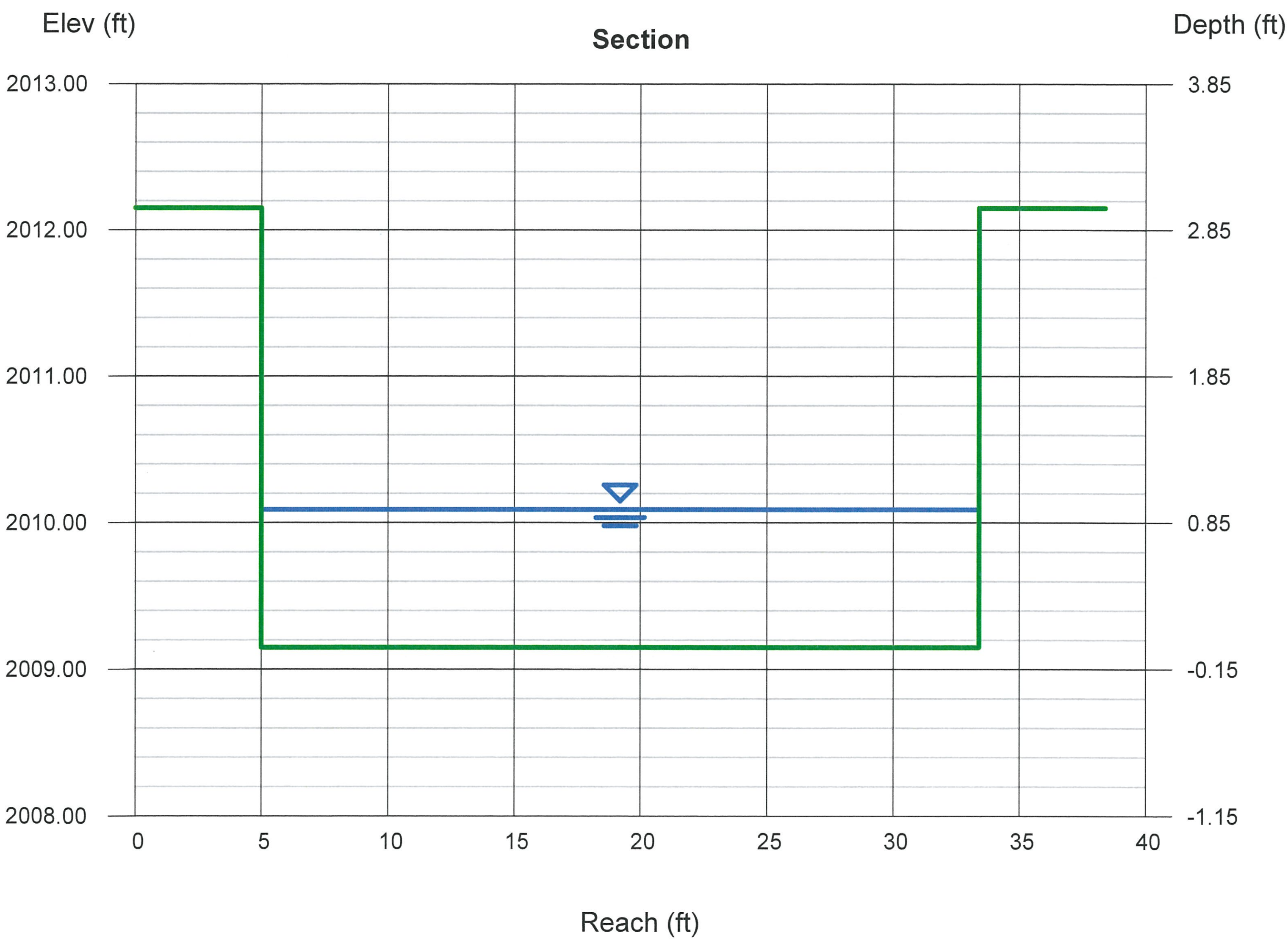
Thorpe Box Culvert

Rectangular
Bottom Width (ft) = 28.40
Total Depth (ft) = 3.00

Invert Elev (ft) = 2009.15
Slope (%) = 0.50
N-Value = 0.040

Calculations
Compute by: Known Q
Known Q (cfs) = 64.00

Highlighted
Depth (ft) = 0.94
Q (cfs) = 64.00
Area (sqft) = 26.70
Velocity (ft/s) = 2.40
Wetted Perim (ft) = 30.28
Crit Depth, Yc (ft) = 0.55
Top Width (ft) = 28.40
EGL (ft) = 1.03



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. | Friday, Apr 1 2016

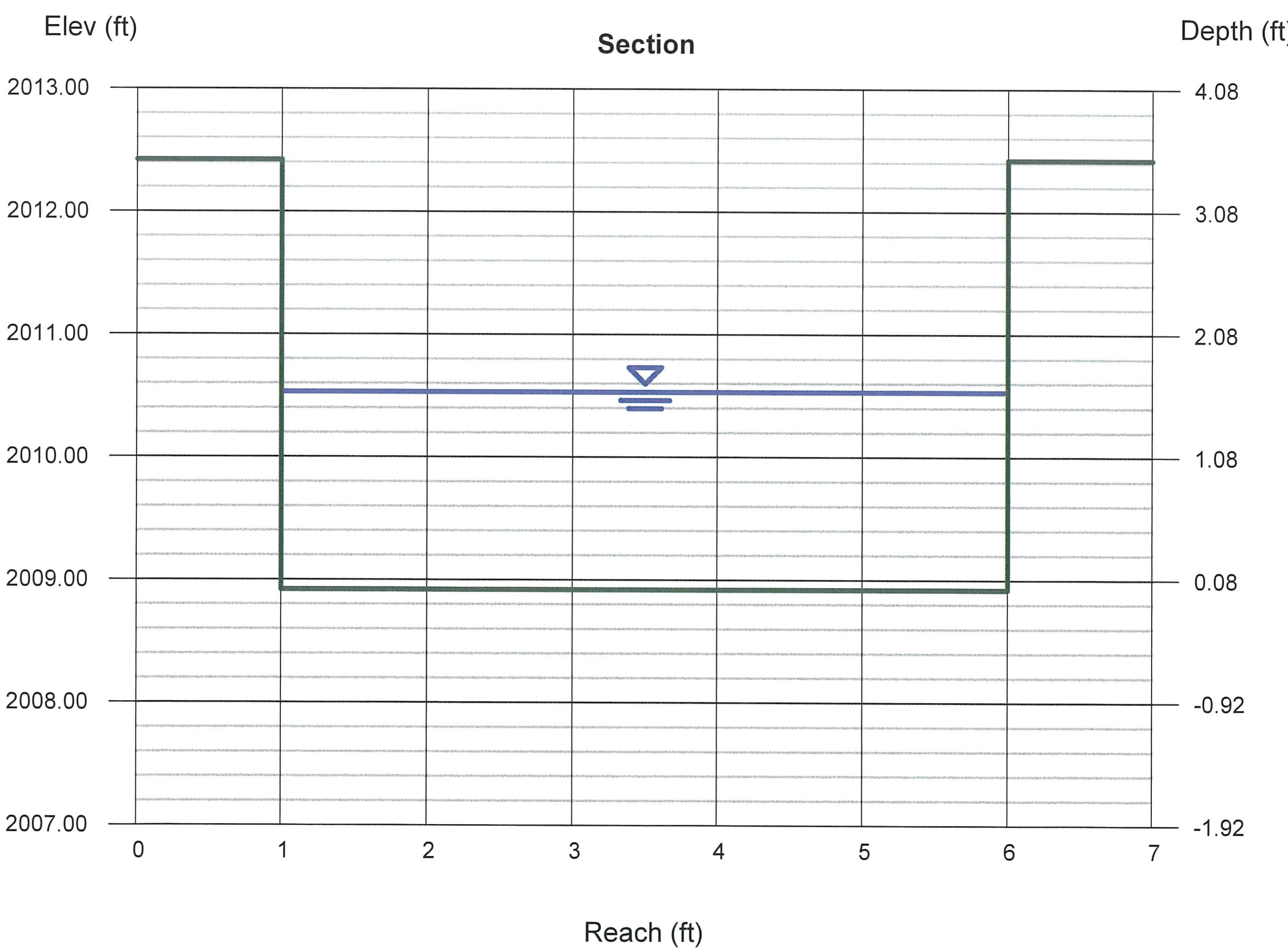
Open Channel

Rectangular
Bottom Width (ft) = 5.00
Total Depth (ft) = 3.50

Invert Elev (ft) = 2008.92
Slope (%) = 0.50
N-Value = 0.013

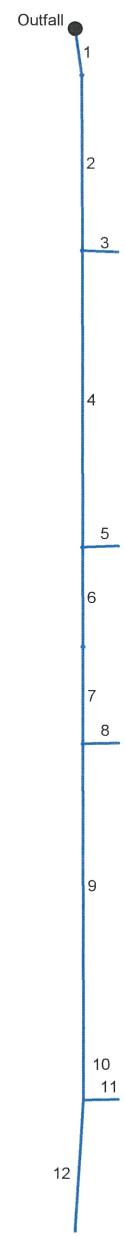
Calculations
Compute by: Known Q
Known Q (cfs) = 64.00

Highlighted
Depth (ft) = 1.61
Q (cfs) = 64.00
Area (sqft) = 8.05
Velocity (ft/s) = 7.95
Wetted Perim (ft) = 8.22
Crit Depth, Yc (ft) = 1.73
Top Width (ft) = 5.00
EGL (ft) = 2.59



PIPE SYSTEM CALCULATIONS

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Madison Pipe.stm	Number of lines: 12	Date: 10/13/2016

FL-DOT Report

Line No	To Line	Type of struc	n - Value	Len (ft)	Drainage Area C1 = 0.2, C2 = 0.5, C3 = 0.9: Incre-ment (ac)	Drainage Area: Sub-Total (ac)	Drainage Area: Sum CA	Time of conc (min)	Time of Flow in sect (min)	Inten (I) (in/hr)	Total CA	Add Q / Total Flow: Q (cfs)	Inlet elev (ft)	Elev of HGL / Elev of Crown / Elev of Invert: Up (ft)	Down (ft)	Fall (ft)	Rise / Span: Size (in)	HGL / Pipe: Slope (%)	ADD / Full Flow: Vel (ft/s)	Cap (cfs)	Date: 10/13/2016 Frequency: 100 yrs Proj: Madison Pipe.stm Line description
1	End	MH	0.013	95.291	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	10.55	0.39	0.00	0.00	0.00 79.00	2008.68	2004.73 2006.34 2001.34	2004.58 2006.24 2001.24	0.15 0.10	60 60 Cir	0.16 0.10	5.62 4.30	79.00 84.37	Pipe - (1)
2	1	MH	0.013	357.374	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	9.07	1.48	0.00	0.00	0.00 79.00	2012.87	2005.61 2006.70 2001.70	2005.25 2006.34 2001.34	0.36 0.36	60 60 Cir	0.10 0.10	4.79 4.21	79.00 82.67	Pipe - (2)
3	2	None	0.013	70.839	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00	0.23	0.00	0.00	9.00 9.00	2005.87	2007.03 2007.37 2005.87	2006.29 2006.70 2005.20	0.74 0.67	18 18 Cir	1.04 0.95	6.33 5.78	9.00 10.21	Pipe - (9)
4	2	MH	0.013	600.822	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	6.26	2.81	0.00	0.00	0.00 70.00	2008.85	2006.37 2007.29 2002.29	2005.97 2006.70 2001.70	0.40 0.59	60 60 Cir	0.07 0.10	4.00 4.16	70.00 81.63	Pipe - (3)
5	4	None	0.013	71.843	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00	2.12	0.00	0.00	1.00 1.00	2006.56	2006.93 2008.06 2006.56	2006.63 2007.29 2005.79	0.30 0.77	18 18 Cir	0.42 1.07	1.95 6.15	1.00 10.87	Pipe - (10)
6	4	MH	0.013	202.450	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	5.30	0.96	0.00	0.00	0.00 69.00	2008.95	2006.75 2007.49 2002.49	2006.63 2007.29 2002.29	0.12 0.20	60 60 Cir	0.06 0.10	3.84 4.17	69.00 81.86	Pipe - (4)
7	6	MH	0.013	197.451	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	4.37	0.94	0.00	0.00	0.00 69.00	2011.72	2006.91 2007.69 2002.69	2006.79 2007.49 2002.49	0.12 0.20	60 60 Cir	0.06 0.10	3.87 4.22	69.00 82.89	Pipe - (5)
8	7	None	0.013	71.291	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00	2.10	0.00	0.00	1.00 1.00	2007.72	2008.09 2009.22 2007.72	2007.14 2007.69 2006.19	0.95 1.53	18 18 Cir	1.33 2.15	1.88 8.71	1.00 15.38	Pipe - (11)
9	7	MH	0.013	577.952	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	1.58	2.78	0.00	0.00	0.00 68.00	2011.00	2007.49 2008.25 2003.25	2007.14 2007.69 2002.69	0.35 0.56	60 60 Cir	0.06 0.10	3.76 4.13	68.00 81.08	Pipe - (6)
10	9	MH	0.013	146.439	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.88	0.70	0.00	0.00	0.00 68.00	2011.72	2006.18 2008.86 2003.86	2007.52 2008.25 2003.25	-1.34 0.61	60 60 Cir	-0.91 0.42	5.71 8.56	68.00 168.1	Pipe - (7)

NOTES: Intensity = 127.16 / (Inlet time + 17.80) ^ 0.82 (in/hr) ; Time of flow in section is based on full flow.

Project File: Madison Pipe.stm

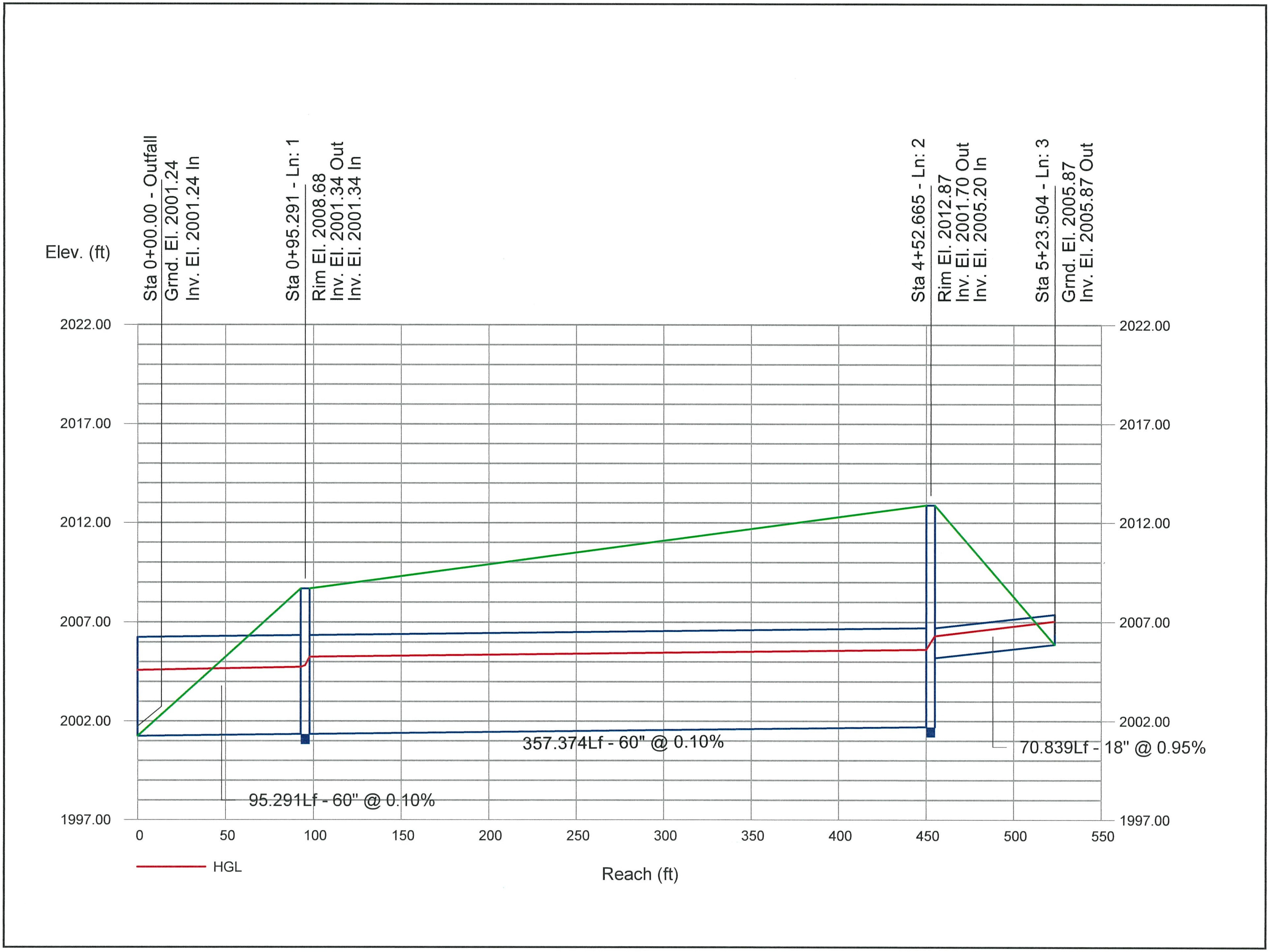
FL-DOT Report

Line No	To Line	Type of struc	n - Value	Len	Drainage Area C1 = 0.2 C2 = 0.5 C3 = 0.9			Time of conc	Time of Flow in sect	Inten (I)	Total CA	Add Q / Total Flow	Inlet elev	Elev of HGL / Elev of Crown / Elev of Invert			Rise / Span	HGL / Pipe	ADD / Full Flow		Date: 10/13/2016 / Frequency: 100 yrs / Proj: Madison Pipe.stm
				(ft)	Incre-ment (ac)	Sub-Total (ac)	Sum CA	(min)	(min)	(in/hr)		Q (cfs)	(ft)	Up (ft)	Down (ft)	Fall (ft)	Size (in)	Slope (%)	Vel (ft/s)	Cap (cfs)	Line description
11	10	None	0.013	69.575	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00	0.51	0.00	0.00	4.00 4.00	2007.72	2008.50 2009.22 2007.72	2008.14 2008.86 2007.36	0.36 0.36	18 18 Cir	0.52 0.52	4.33 4.27	4.00 7.55	Pipe - (12)
12	10	MH	0.013	268.776	0.00 0.00 0.00	0.00 0.00 0.00	0.00 0.00 0.00	0.00	0.88	0.00	0.00	64.00 64.00	2014.25	2009.46 2011.05 2007.05	2006.85 2008.86 2004.86	2.62 2.19	48 48 Cir	0.97 0.81	9.18 10.32	64.00 129.7	Pipe - (8)

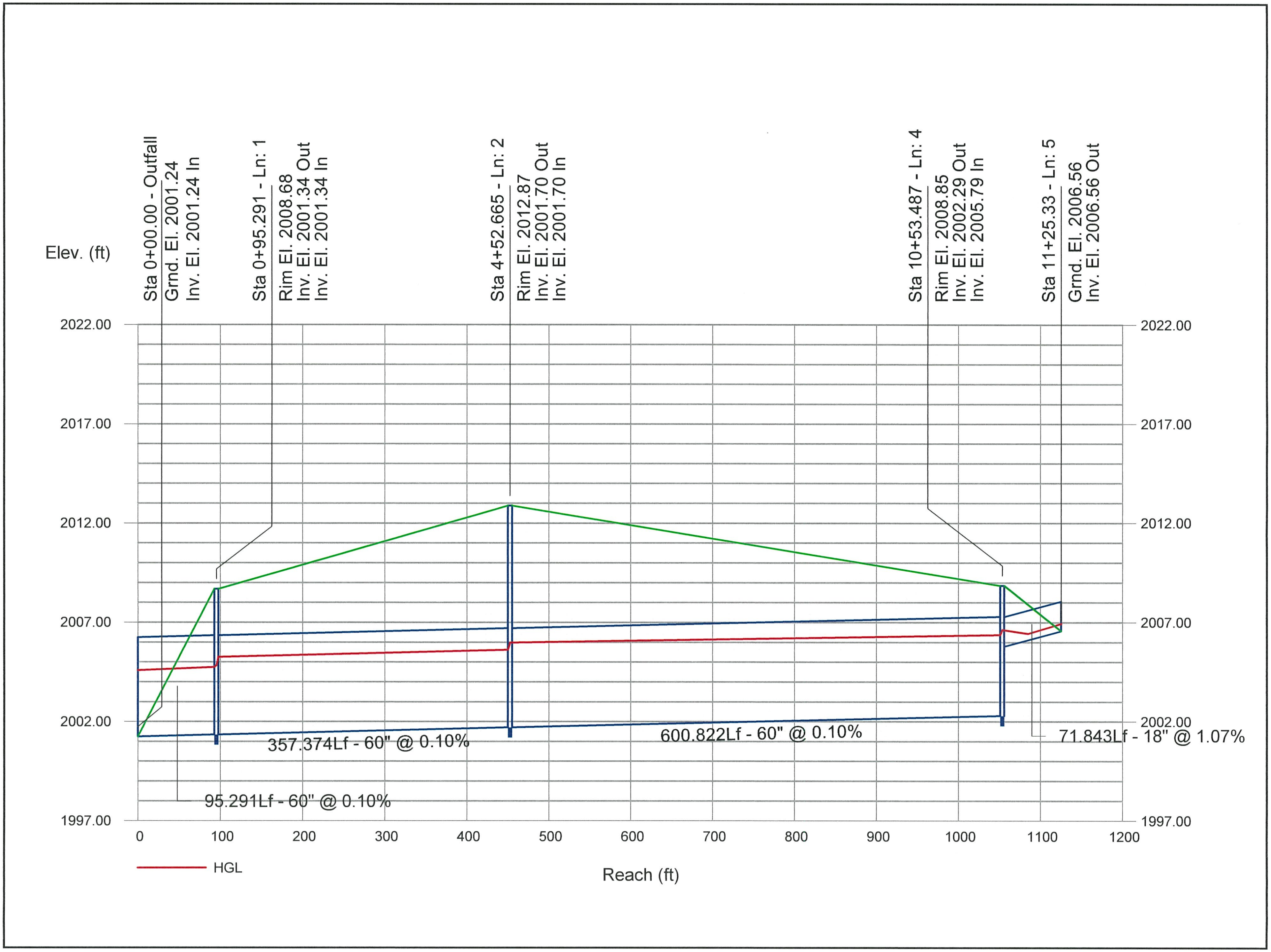
NOTES: Intensity = 127.16 / (Inlet time + 17.80) ^ 0.82 (in/hr) ; Time of flow in section is based on full flow.

Project File: Madison Pipe.stm

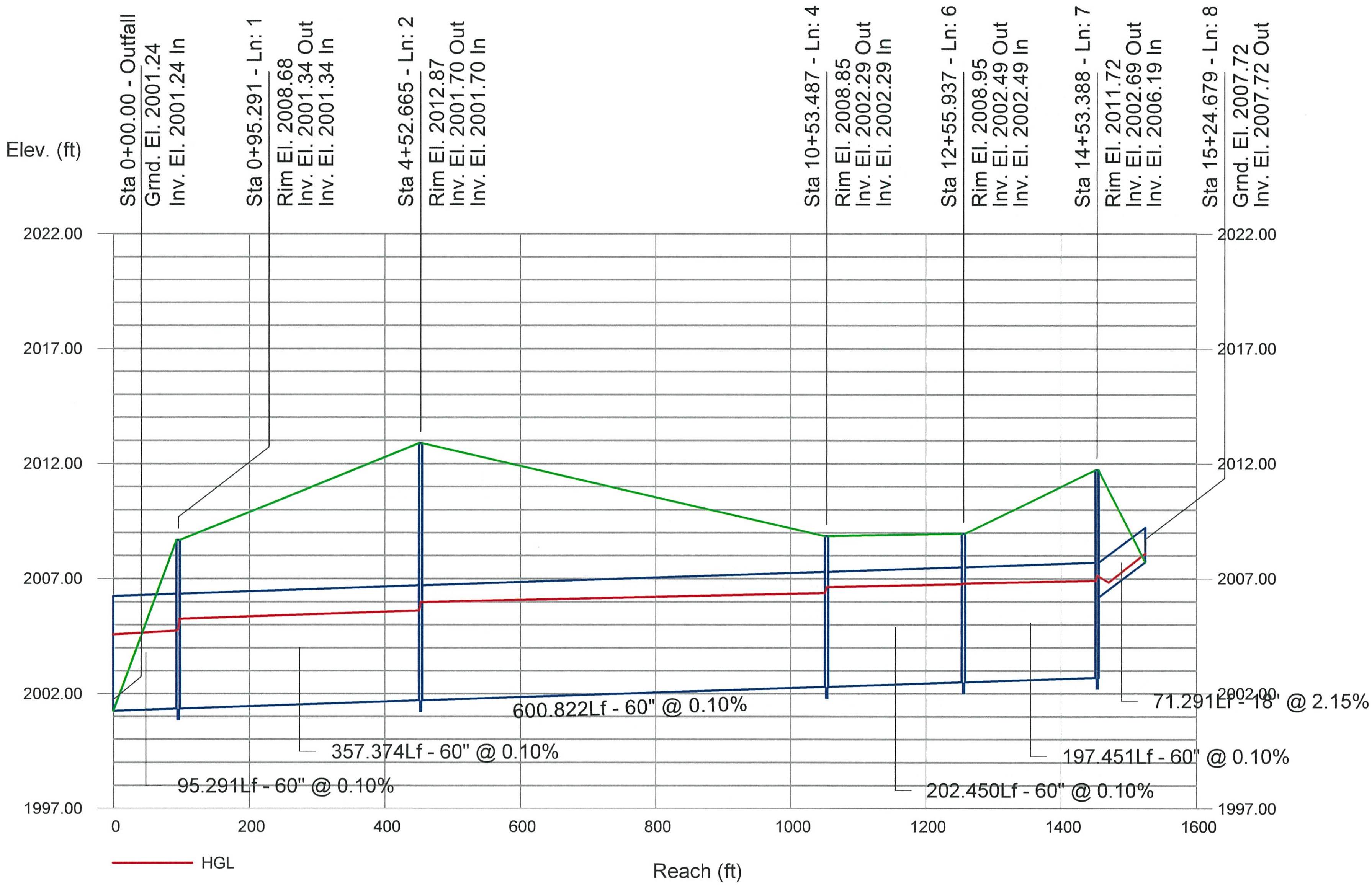
Storm Sewer Profile



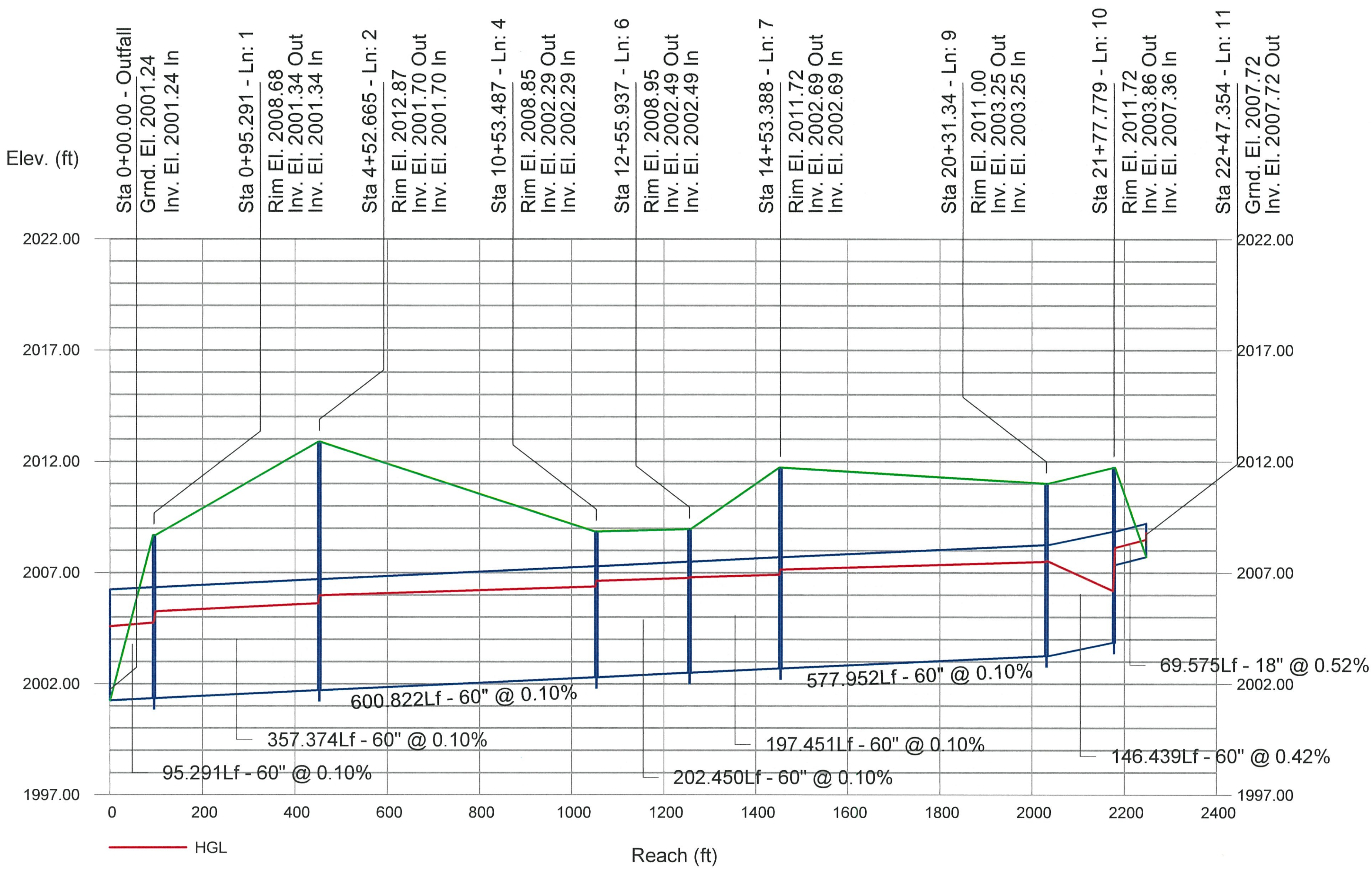
Storm Sewer Profile



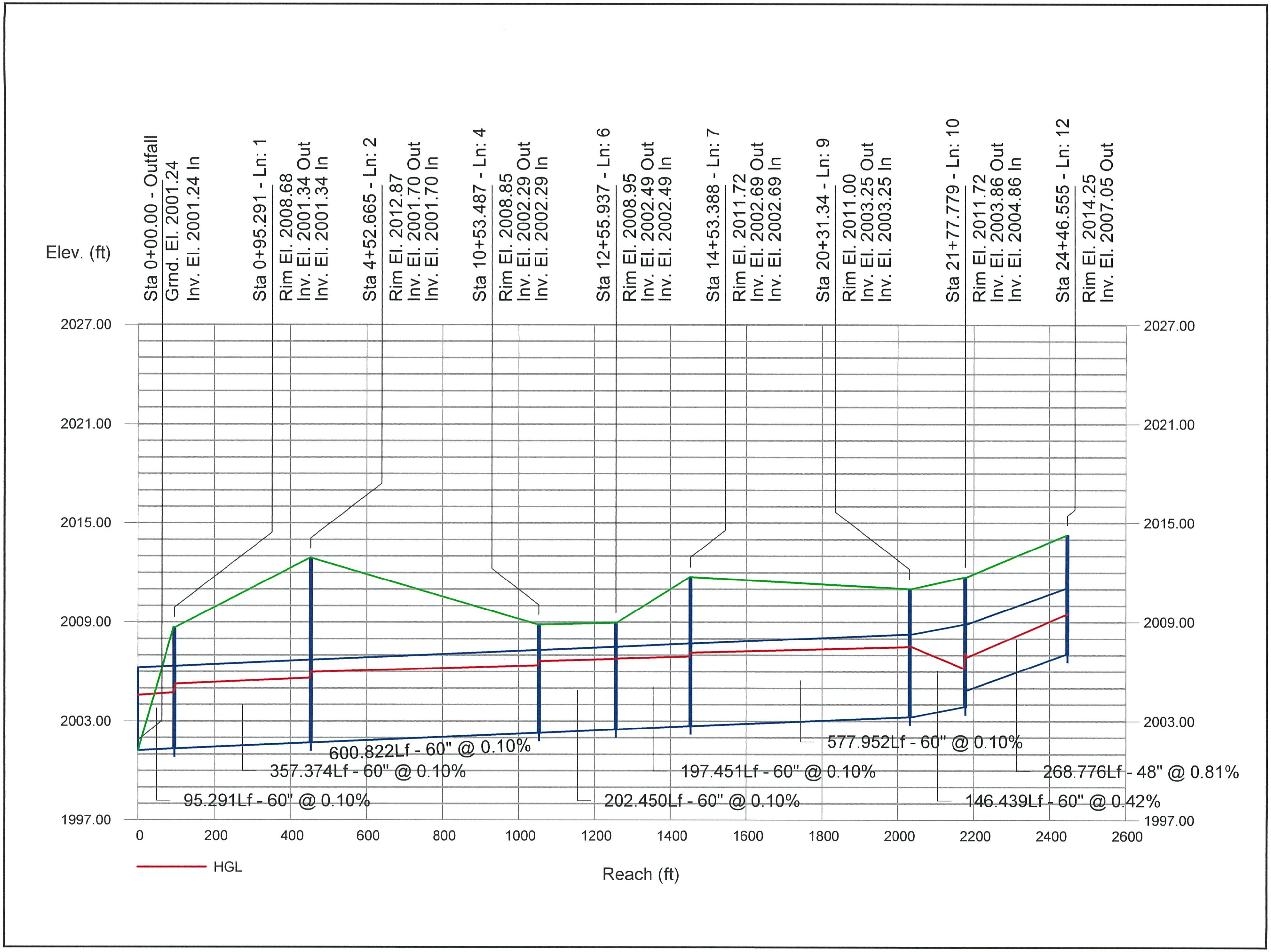
Storm Sewer Profile



Storm Sewer Profile



Storm Sewer Profile



GRAVEL GALLERY WORKSHEET - NORTH

WHIPPLE CONSULTING ENGINEERS

GRAVEL GALLERY CALC SHEET

10/13/2016

13-1166 Painted Hills PRD
ENGINEER BNG

Note: infiltration rates per IPEC Geotechnical Report Dated December 31, 2013

Gallery Depth (Min)	Porosity of Gravel (Typ)			Infiltration Rate
ft	cf/cf			cfs/sf
13	0.3			1.80E-03

Gallery		Number of Galleries	Length	Width	Ground Water EL.	Gravel Gallery Bott. EL	Volume	Storage Volume	Perimeter	Sidewall Area	Bottom Area	Outflow
			ft	ft	ft	ft	cf	cf	ft	sf	sf	cfs
A		1	450.00	10.00	-	1000.00	58,500	**17,550**	920	11,960	4,500	**29.63**
B		1	450.00	10.00	-	1000.00	58,500	**17,550**	920	11,960	4,500	**29.63**
C		1	450.00	10.00	-	1000.00	58,500	**17,550**	920	11,960	4,500	**29.63**
D		1	450.00	10.00	-	1000.00	58,500	**17,550**	920	11,960	4,500	**29.63**
Totals		4	1800	10			234,000	**70,200**	3,680	23,920	9,000	**118.51**

Storage Volume = Volume* Porosity
Sidewall Area= Perimeter*Depth
OutFlow = Sidewall Area+ Bottom Area * Infiltration Rate

Note: Outflow Assumes a Full Gallery

BIO-INFILTRATION CHANNEL WORKSHEET

Bio-filtration Swale Design - Swale A3

Based on King County 2005 Surface Water Design Manual (Section 6.2 and 6.3)

Calculation of Design Flow:

Q_{wq} = 0.64 * (2-yr peak flow rate)

$Q_{peak,\,2}$ = 79.00 cfs

Q_{wq} = 50.56 cfs

Calculation of swale bottom width:

$Q = 1.49\,A\,R^{0.67}S^{0.5}\,n^{-1}$ Manning's equation

OR

$b = Q_{wq}\,n_{wq}\,(1.49 * y^{1.67}S^{0.5})^{-1}$

OR

$y = [Q_{wq}\,n_{wq}\,(1.49 * b * S^{0.5})^{-1}]^{0.6}$

where

b	=	bottom width of swale (ft)…minimum 2 ft width required, maximum 10 ft
Q_{wq}	=	water quality design flow (cfs)
n_{wq}	=	Manning's roughness coefficient for shallow flow conditions = 0.20 (unitless)
y	=	design flow depth
S	=	longitudinal slope (along direction of flow) (ft/ft), slope shall be between 1%-6%. If less than 1.5%, underdrains must be provided. Slope less than 1% is considered a "wet biofiltration swale" and must be designed under those guidelines. Slope greater than 6% requires check dams with vertical drops of 12-inches

width known:

b = 6.00 ft

S = 0.010 ft/ft

y = 4.29 ft

Determining design flow velocity:

$V_{wq} = Q_{wq} / A_{wq}$, max 1.0 fps

$A_{wq} = b*y + Z*y^2$

where

V_{wq}	=	design flow velocity (fps)
A_{wq}	=	cross-sectional area of flow at design depth (sf)
Z	=	side slope length per unit height (e.g. for 3:1, Z = 3)

Z = 2

A_{wq} = 62.47 sf

V_{wq} = 0.81 fps

Calculate swale length to achieve a minimum hydraulic residence time of 9 minutes (540 seconds):

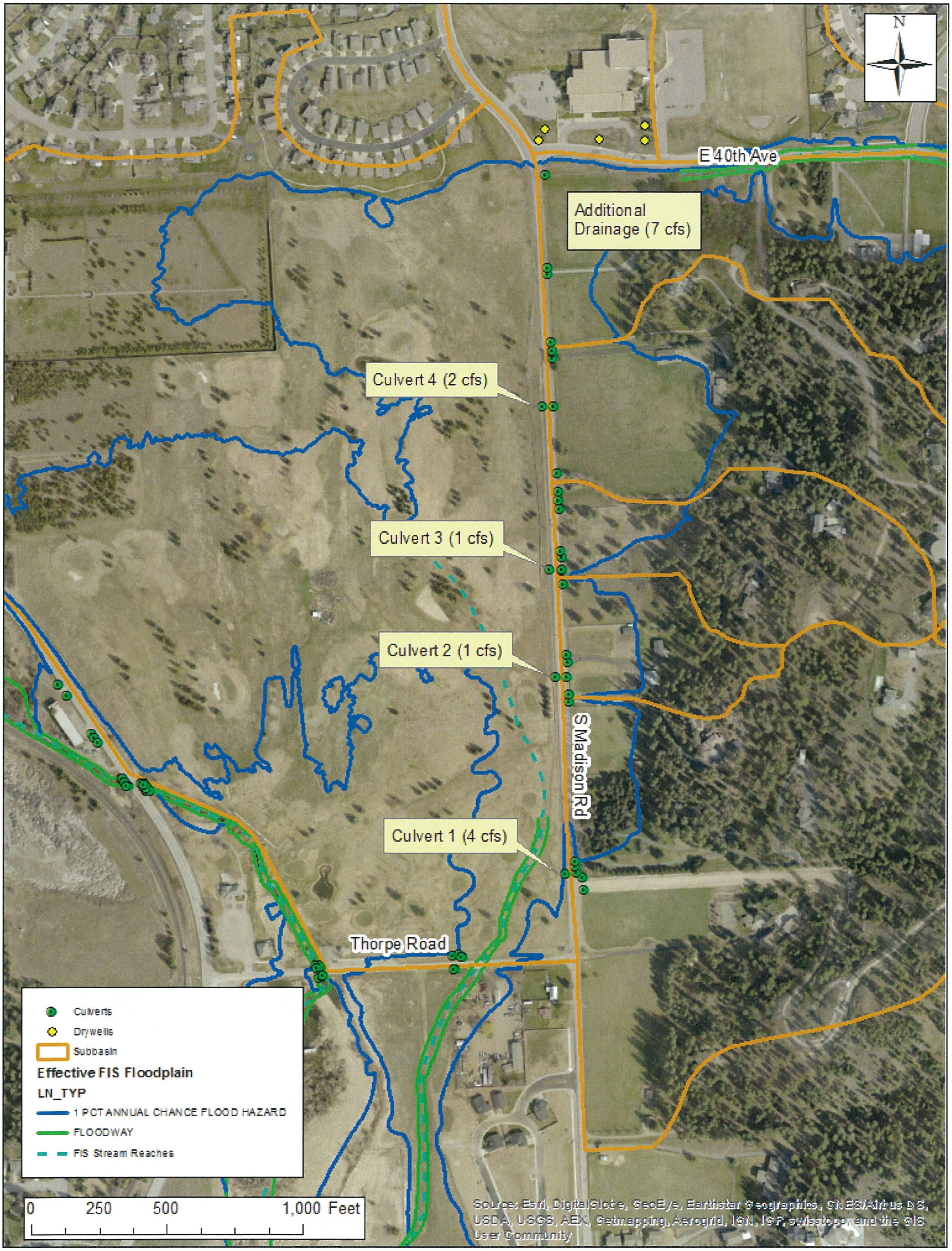
$L = 540 * V_{wq}$, minimum swale length is 100 ft

L = 437.07 ft

Conveyance of larger storms using previous steps, Velocity must not exceed 3 fps:

$Q_{peak,25}$ =	2.5	cfs	y=	**0.71**	ft	A_{25}	=	5.23	sf	V_{25} =	0.48
$Q_{peak,100}$ =	4.65	cfs	y=	**1.02**	ft	A_{100}	=	8.24	sf	V_{100} =	0.56

MADISON RD CULVERT FLOWS


N
E 40th Ave
Additional
Drainage (7 cfs)
Culvert 4 (2 cfs)
Culvert 3 (1 cfs)
Culvert 2 (1 cfs)
S Madison Rd
Culvert 1 (4 cfs)
Thorpe Road
Culverts
Drywells
Subbasin
Effective FIS Floodplain
LN_TYP
1 PCT ANNUAL CHANCE FLOOD HAZARD
FLOODWAY
FIS Stream Reaches
0 250 500 1,000 Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

V-DITCH ROCK CALCULATIONS

Hydraulic Analysis Report

Project Data

Project Title: Triangle Pond V-DITCH

Designer:

Project Date: Monday, October 03, 2016

Project Units: U.S. Customary Units

Notes:

Channel Lining Analysis: Approach Channel Lining

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 1 ft

Riprap Specific Weight: 165 lb/ft^3

Water Specific Weight: 62.4 lb/ft^3

Riprap Shape is Angular

Safety Factor: 1

Calculated Safety Factor: 1.08369

Lining Results

Angle of Repose: 41.7 degrees

Relative Flow Depth: 1.13551

Manning's n method: Bathurst

Manning's n: 0.129511

Channel Bottom Shear Results

V*: 0.812111

Reynold's Number: 66730.6

Shield's Parameter: 0.0642078

shear stress on channel bottom: 1.27808 lb/ft^2

Permissible shear stress for channel bottom: 6.58772 lb/ft^2

channel bottom is stable

Stable D50: 0.210246 ft

Channel Side Shear Results

K1: 1

K2: 0.968982

Kb: 0

shear stress on side of channel: 1.27808 lb/ft^2

Permissible shear stress for side of channel: 6.38338 lb/ft^2

Stable Side D50: 0.216977 lb/ft^2

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Report for channel

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 6.0000 ft/ft

Side Slope 2 (Z2): 6.0000 ft/ft

Channel Width: 3.0000 ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.1295

Lining Type: Rock Riprap - 300 mm (12-inch)

Depth: 2.0482 ft

Result Parameters

Flow: 38.7908 cfs

Area of Flow: 31.3156 ft^2

Wetted Perimeter: 27.9176 ft

Hydraulic Radius: 1.1217 ft

Average Velocity: 1.2387 ft/s

Top Width: 27.5785 ft

Froude Number: 0.2049

Critical Depth: 0.9907 ft

Critical Velocity: 4.3774 ft/s

Critical Slope: 0.2950 ft/ft

Critical Top Width: 14.89 ft

Calculated Max Shear Stress: 1.2781 lb/ft^2

Calculated Avg Shear Stress: 0.7000 lb/ft^2

IPEC Geotechnical Report dated June 28, 2016

Full-Scale Drywell Testing

IPEC

Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

June 28, 2016
Project No. 16-249A

NAI Black
c/o Mr. Bryan Walker
107 South Howard
Suite 500
Spokane, WA 99201

Re: **Full-Scale Drywell Testing**
Proposed Stormwater Management Facility
4403 South Dishman-Mica Road
Spokane Valley, WA

Dear Mr. Walker:

As you authorized, we have completed a full-scale drywell test on the drywell installed at the above-referenced site in Spokane Valley, Washington. The purpose of the testing was to establish a design flow rate. This report summarizes the results of our site investigation, engineering analyses and recommendations.

AVAILABLE INFORMATION

We were provided a topographic survey for the project site by Whipple Consulting Engineers, Inc. (WCE). This topographic survey showed the existing roadways, existing structures, property lines, and existing ground surface elevation contours. This plan was prepared by WCE and was dated November 7, 2013. The site was used as a golf course prior to our evaluation. The site is relatively level with some elevated golf greens and excavated areas for water hazards. The site is primarily grass-covered with scattered trees along the fairways and pine trees in the undeveloped area to the northwest. The clubhouse building is present at the southwest corner.

In addition, we performed a preliminary geotechnical evaluation for the property in December 2013. The results of that evaluation, along with our opinions and recommendations, are summarized in our Preliminary Geotechnical Evaluation dated December 31, 2013.

P.O. Box 1566, Veradale, WA 99037
Phone 509-209-6262

We also performed a geotechnical evaluation for certification of the existing levee along Chester Creek in April 2014. The results of that evaluation are summarized in our Geotechnical Evaluation report dated February 12, 2015.

Lastly, we performed a geotechnical evaluation in July 2015 consisting of ten 50-foot borings in the south half of the property. The results of that evaluation are summarized in our Geotechnical Evaluation Phase 2 report dated July 23, 2015.

FIELD EVALUATION

A geotechnical engineer from Inland Pacific Engineering Company (IPEC) performed a full-scale drywell test on the Type 2 drywell on May 6, 2016. The drywell test was performed in accordance with the Spokane Regional Stormwater Manual, Appendix 4B procedures.

ANALYSIS AND RECOMMENDATIONS

We calculated a design outflow rate for the existing drywell using the results of the recent and previous laboratory tests and the procedures described in the SRSM manual, Appendix 4B (Full-Scale Drywell Test Method). Based on the test performed, we recommend using a design flow rate of 1.05 cfs for design. This recommended design outflow rate includes a safety factor of 1.1 as required by the SRSM.

REMARKS

This report is for the exclusive use of the addressee and the copied parties to use in design of the proposed project and to prepare construction documents. In the absence of our written approval, we make no representations and assume no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other structures or purposes. We recommend that parties contemplating other structures or purposes contact us.

Services performed by the geotechnical engineers for this project have been conducted in a manner consistent with that level of care ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is intended or made.

GENERAL REMARKS

It has been a pleasure being of service to you for this project. If you have any questions or need additional information, please do not hesitate to call me at (509) 209-6262 at your convenience.

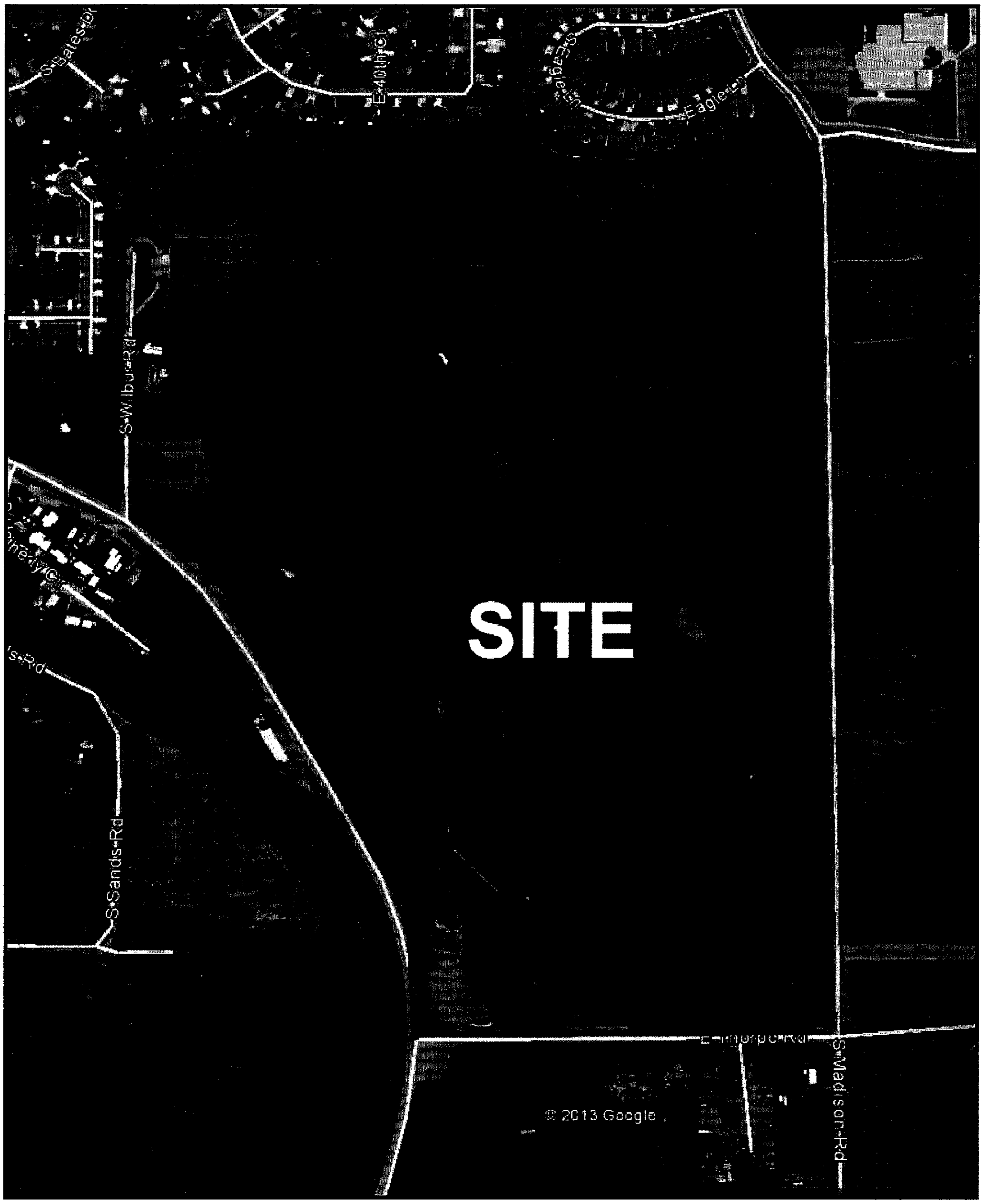
Sincerely,
Inland Pacific Engineering Company

Paul T. Nelson, P.E.
Principal Engineer

6-28-16

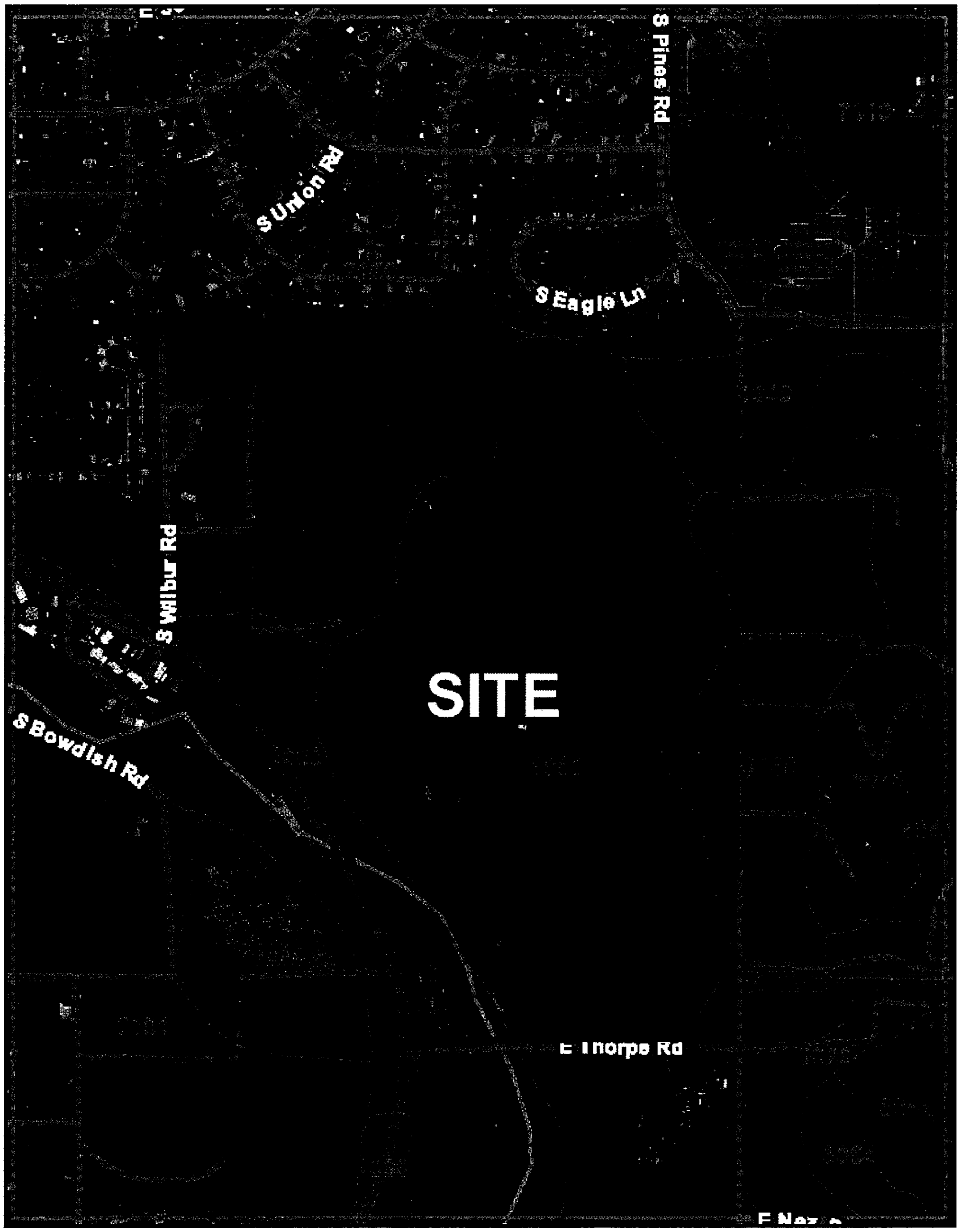
Attachments: Figure 1, Site Location Map
Figure 2, NRCS Map
Laboratory Test Results
Full-Scale Drywell Test Results

FIGURE 1



Site Location Map		
IPEC Inland Pacific Engineering Company Geotechnical Engineering and Consulting	Project No. 16-249A	June 28, 2016
	Painted Hills Golf Course 4403 South Dishman-Mica Road Spokane County, WA	

FIGURE 2



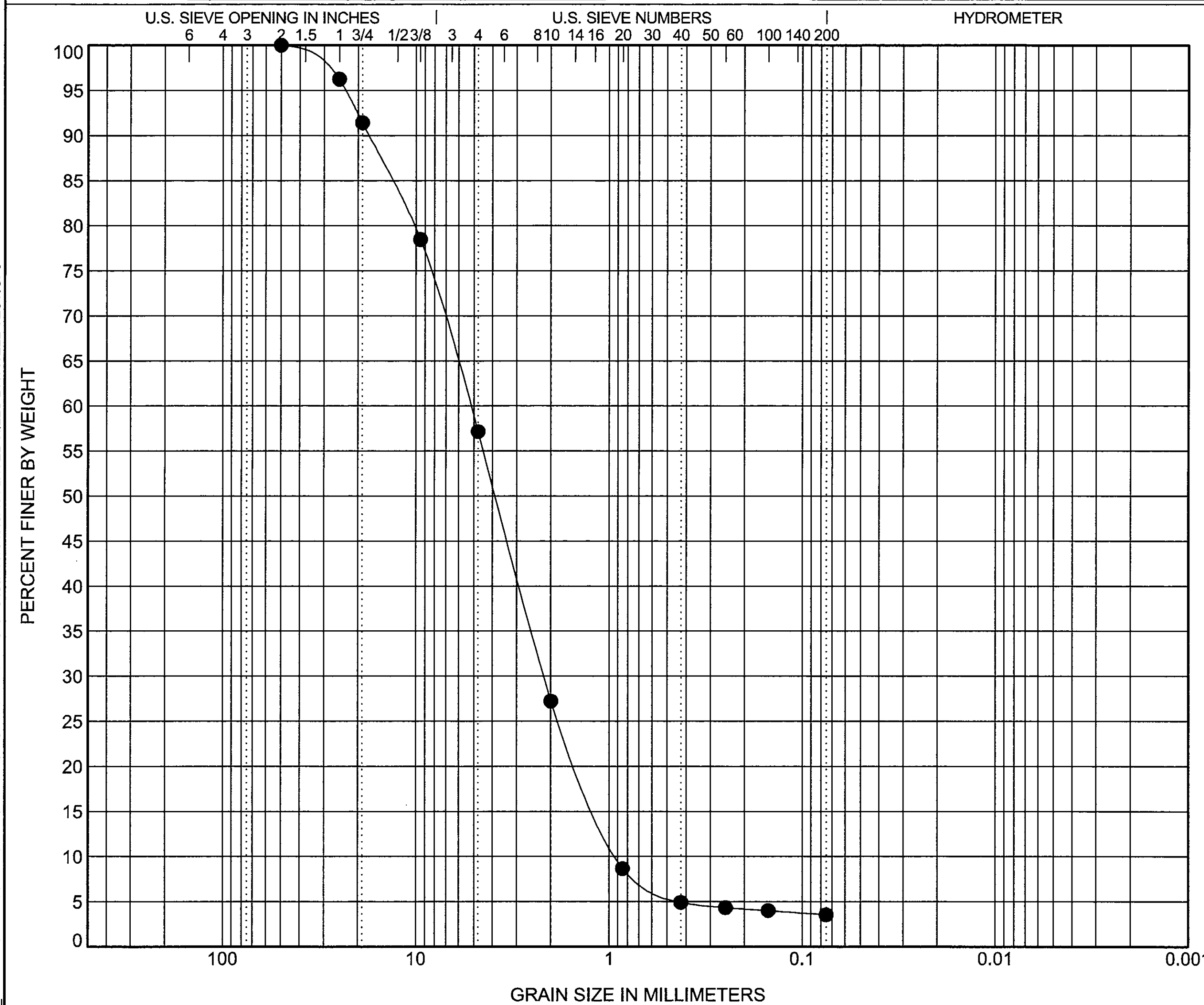
NRCS Map		
IPEC Inland Pacific Engineering Company Geotechnical Engineering and Consulting	Project No. 16-249A Painted Hills Golf Course 4403 South Dishman-Mica Road Spokane County, WA	June 28, 2016

IPEC
Inland Pacific Engineering Company
3012 North Sullivan Road, Suite C
Spokane Valley, WA 99216
Telephone: 509-209-6262
Fax: 509-290-5734

GRAIN SIZE DISTRIBUTION

CLIENT NAI Black **PROJECT NAME** Painted Hills Drywell Test

PROJECT NUMBER 16-249A **PROJECT LOCATION** 4403 South Dishman-Mica Road



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**L16-057**	**20.0**	**SP Poorly Graded Sand with Gravel**				**1.00**	**5.76**

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**L16-057**	**20.0**	**50**	**5.212**	**2.167**	**0.904**	**42.9**	**53.6**	**3.5**	

IPEC

Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

Full-Scale Drywell Test Results

Project Name: Painted Hills Drywell Test

Project Number: 16-249A

Client: NAI Black

Test Date: 5/6/2016

Test Location: Existing Drywell

Depth: 20'

Time	Elapsed Time (seconds)	Depth to Water (feet)	Flow Meter Reading (ft^3)	Volume of Water (ft^3)	Flow Rate (cfs)
10:00	0	19.5	596.6		
11:00	3600	18.2	1171.5	574.90	1.60E-01
11:10	600	18.2	1261.0	89.50	1.49E-01
11:20	600	18.2	1350.7	89.70	1.50E-01
11:30	600	18.2	1441.1	90.40	1.51E-01
11:35		18.3			
11:40		18.6			
11:45		19.1			
11:50		19.5			

Average Flow Rate: 1.50E-01