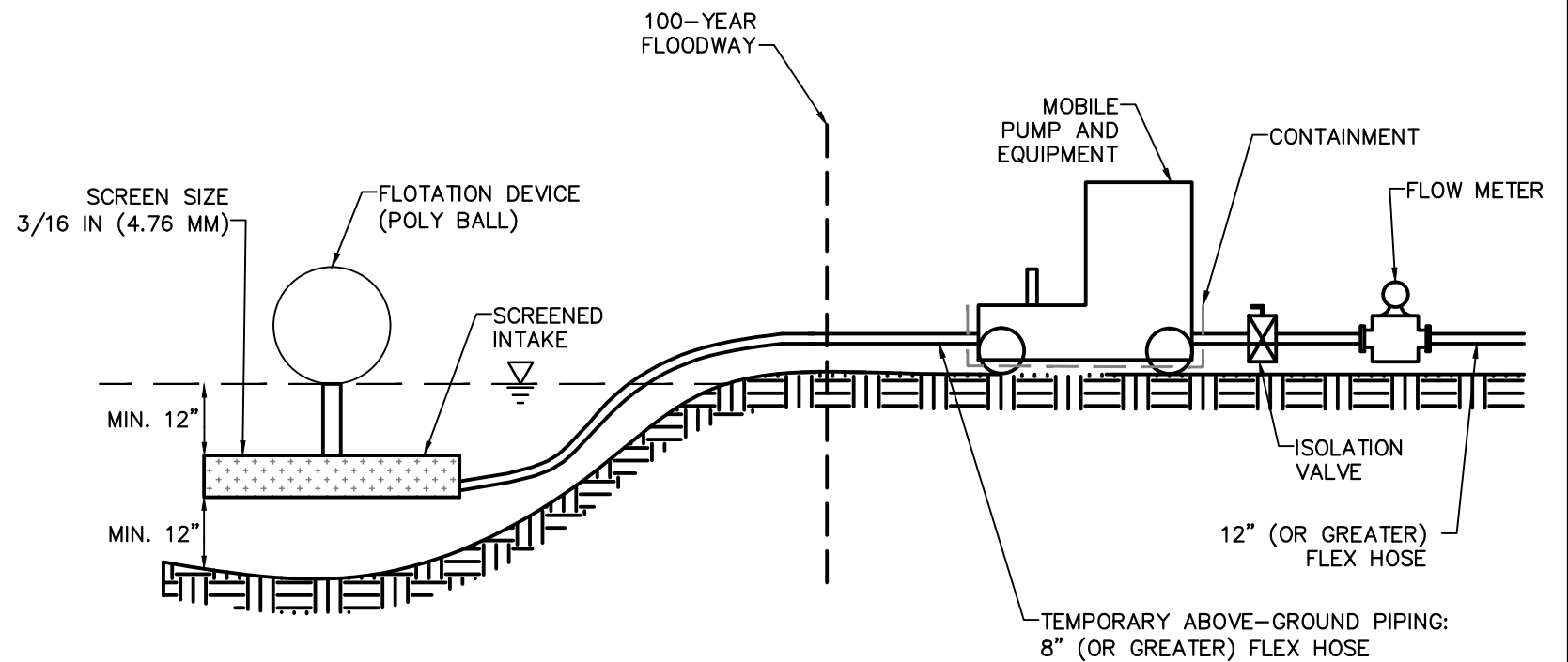


**SCHEMATIC
PLAN VIEW**

NOT TO SCALE



**INTAKE ARRANGEMENT
SECTION A-A'**

NOT TO SCALE

NOTES:

1. PUMP PAD WILL MATCH EXISTING GRADE.
2. SURFACE WATER SOURCE TO BE USED FOR TEMPORARY WATER WITHDRAWALS. TEMPORARY PUMP AND ASSOCIATED EQUIPMENT (OTHER THAN THE TEMPORARY HOSE AND INTAKE SCREEN) WILL BE LOCATED OUT OF THE 100-YEAR FLOODWAY. ALL TEMPORARY HOSES AND INTAKE SCREENS WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN THE 100-YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS.

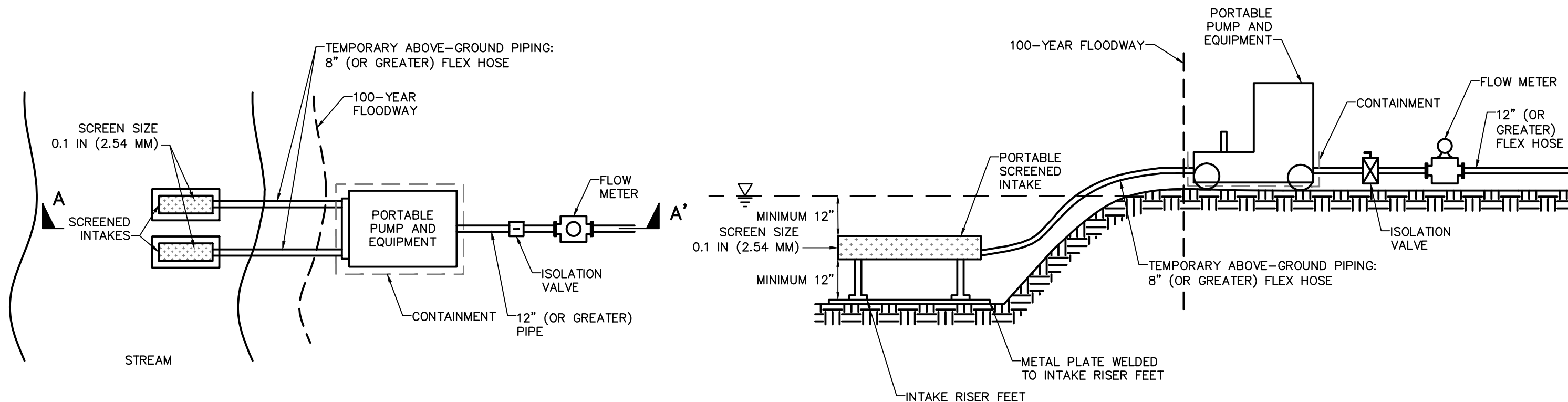
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SUNOCO PIPELINE L.P.
 SINKING SPRING, PENNSYLVANIA

**TYPICAL HYDROSTATIC TEST
 FLOATING INTAKE WITH MOBILE PUMP**

DATE:	3/17/16
PROJECT NO.:	112IC05958
DESIGNED BY:	
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SHEET:	1 OF 1

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FIGURE 1



**SCHEMATIC
PLAN VIEW**

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**INTAKE ARRANGEMENT
SECTION A-A'**

NOT TO SCALE

NOTES:

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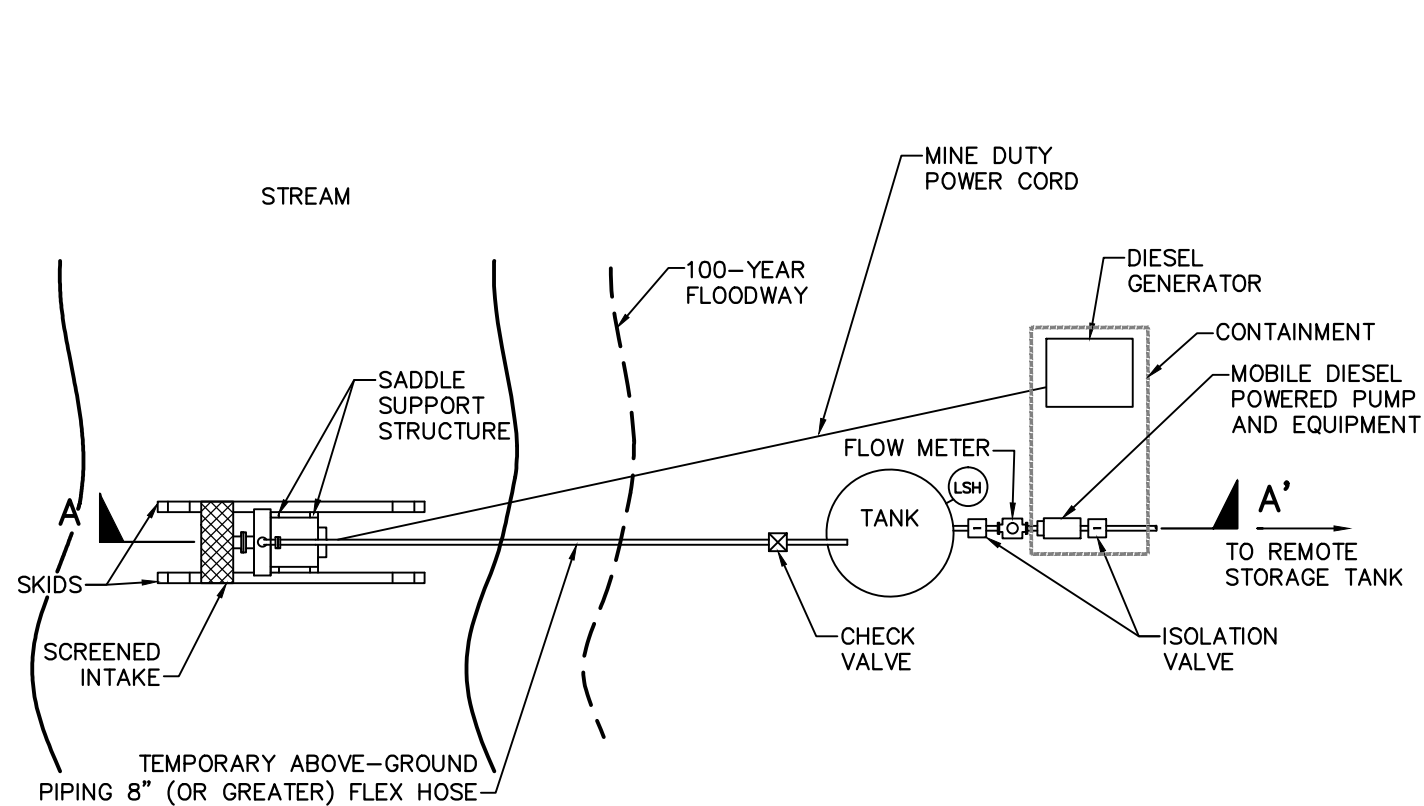
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**TYPICAL HYDROSTATIC TEST
SUBMERGED INTAKE WITH MOBILE PUMP**

DATE:	3/17/16
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DESIGNED BY:	
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SHEET:	1 OF 1

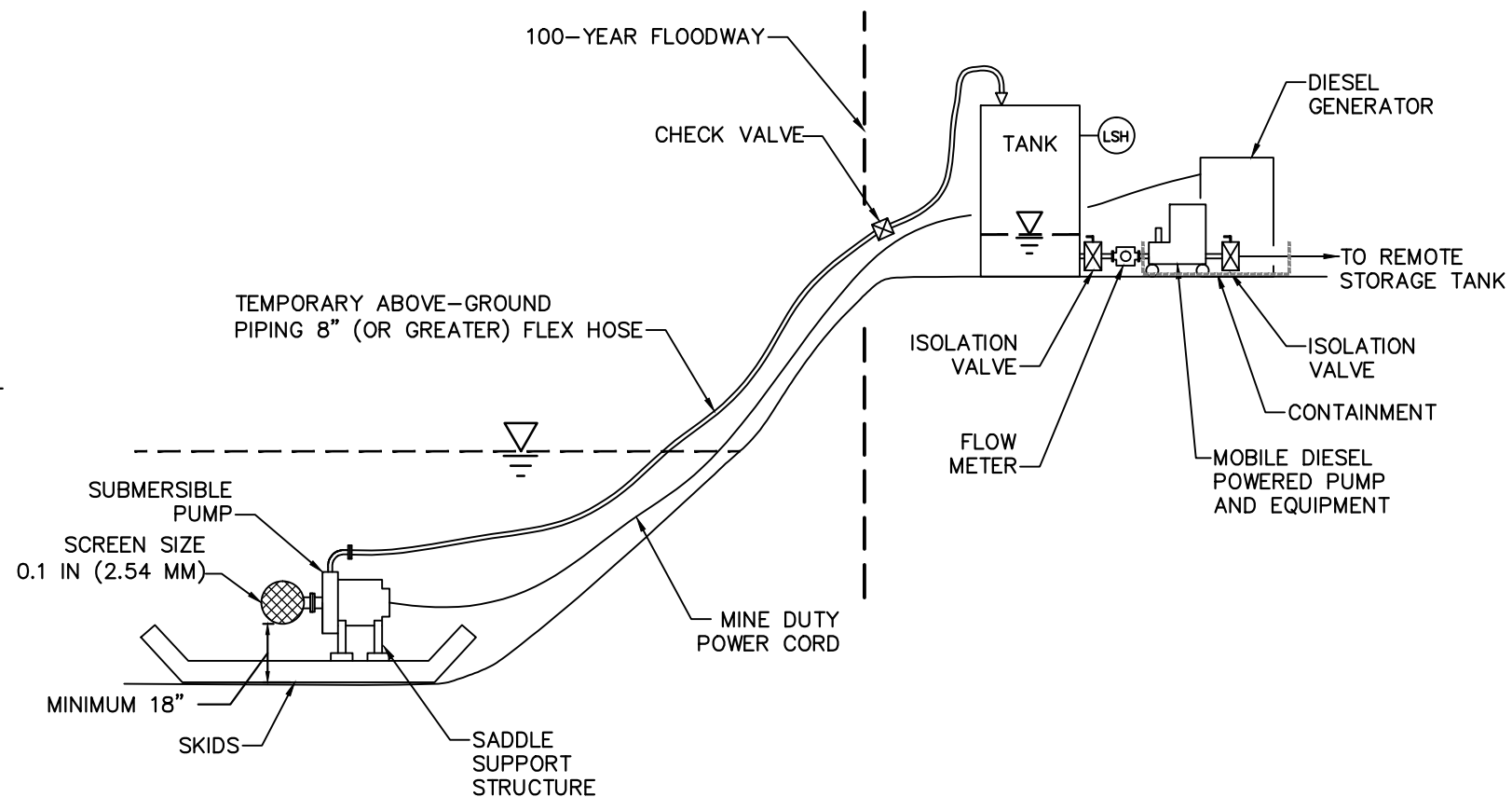
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FIGURE 2



**SCHEMATIC
PLAN VIEW**

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**INTAKE ARRANGEMENT
SECTION A-A'**

NOT TO SCALE

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3. LSH = LEVEL SWITCH HIGH



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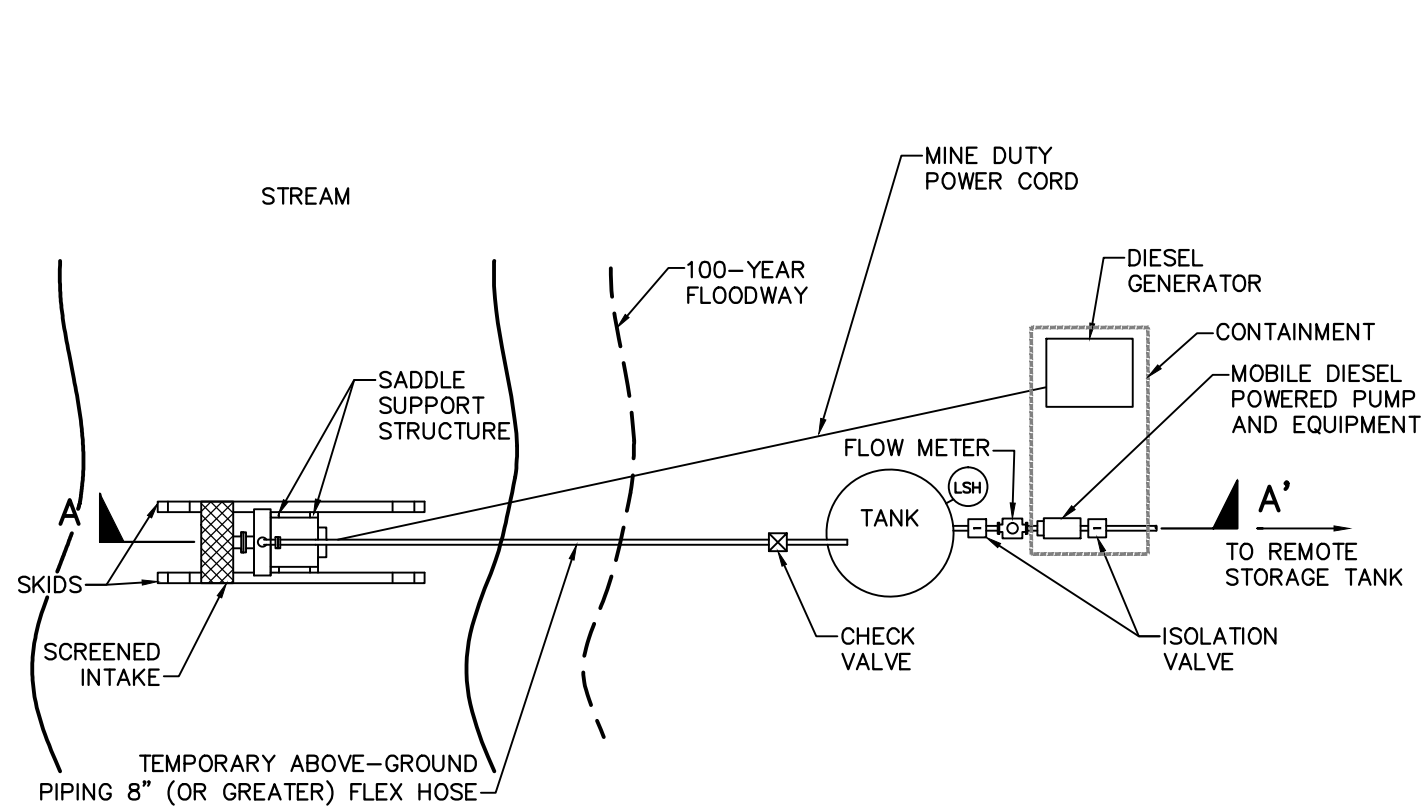
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SUNOCO PIPELINE L.P.
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TYPICAL HYDROSTATIC TEST
SUBMERGED WATER INTAKE WITH
SUBMERGED PUMP

DATE:	3/17/16
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DESIGNED BY:	
DRAWN BY:	CK
CHECKED BY:	
SHEET:	1 OF 1

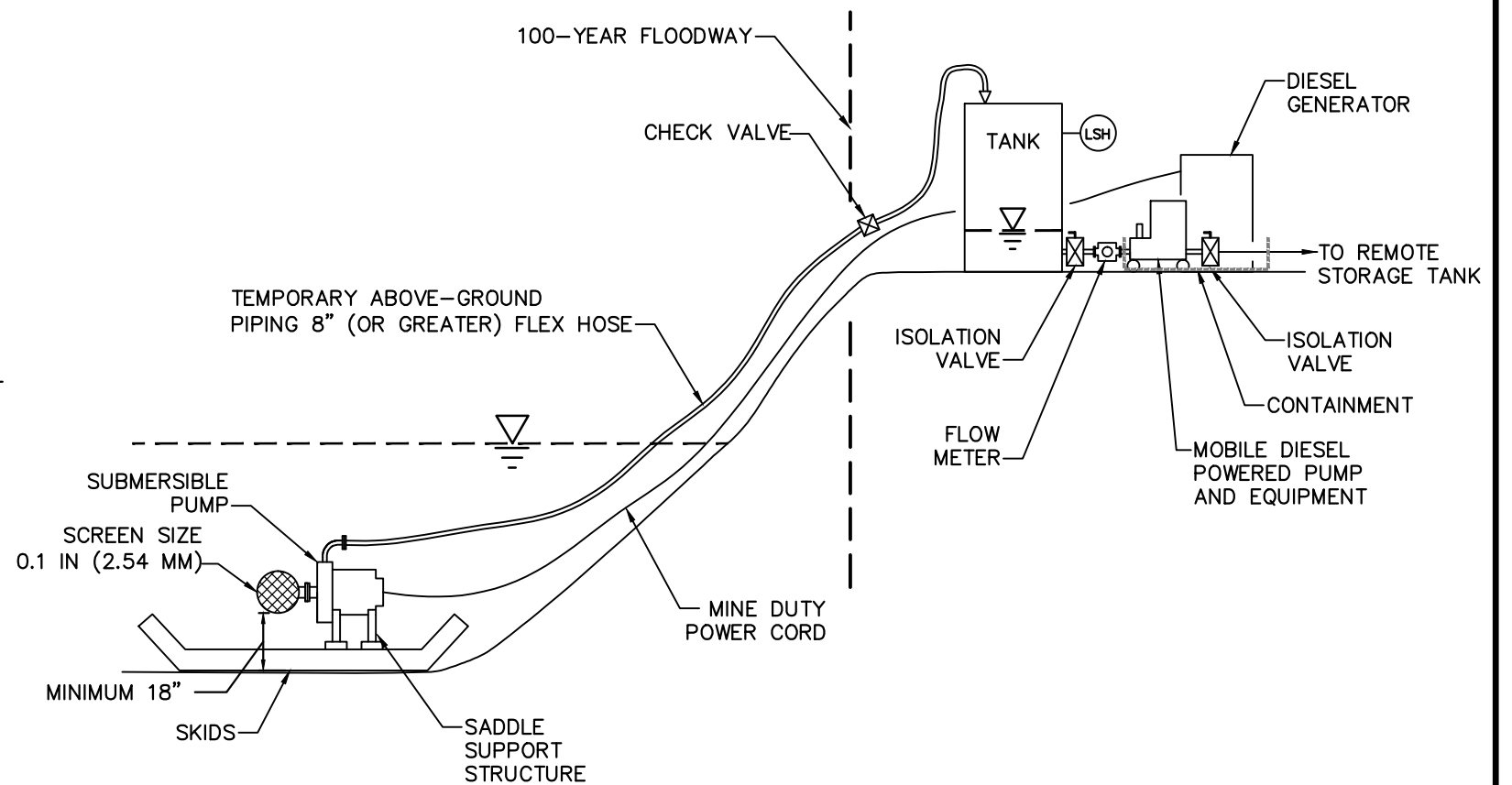
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FIGURE 3



**SCHEMATIC
PLAN VIEW**

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**INTAKE ARRANGEMENT
SECTION A-A'**

NOT TO SCALE

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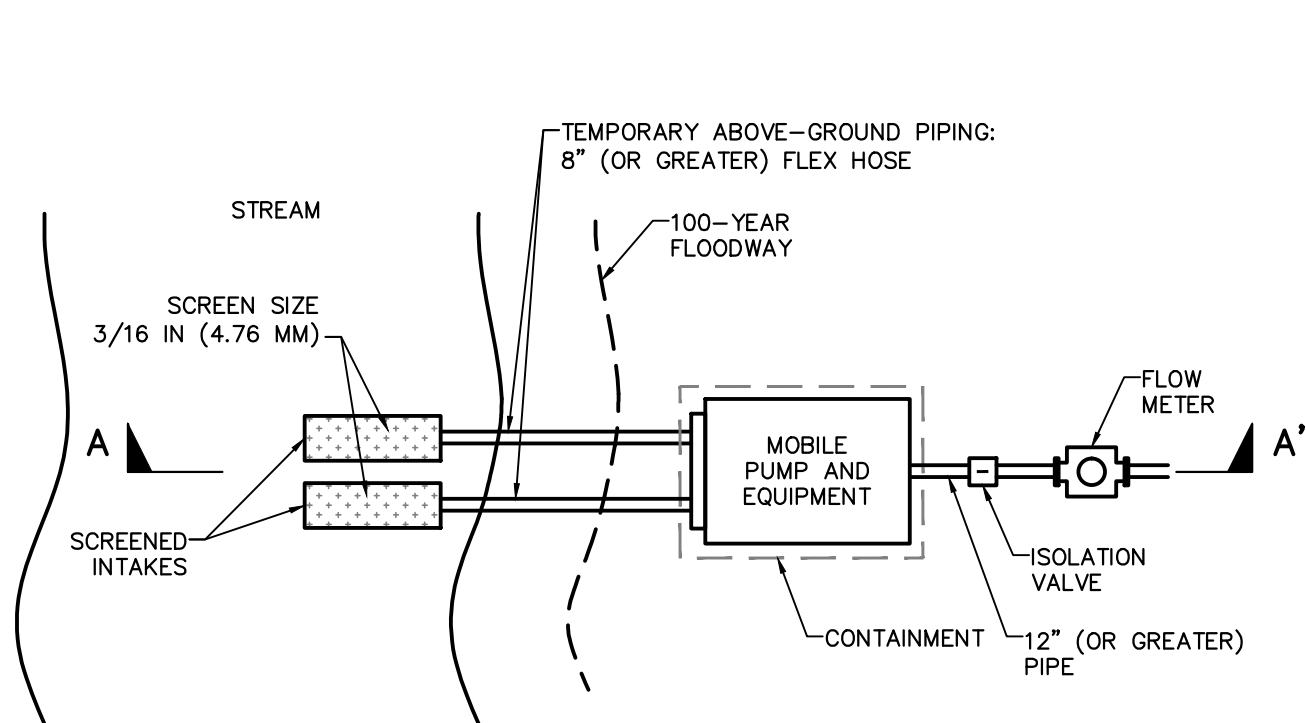
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**TYPICAL HYDROSTATIC TEST
SUBMERGED WATER INTAKE WITH
SUBMERGED PUMP**

DATE:	3/17/16
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DESIGNED BY:	
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SHEET:	1 OF 1

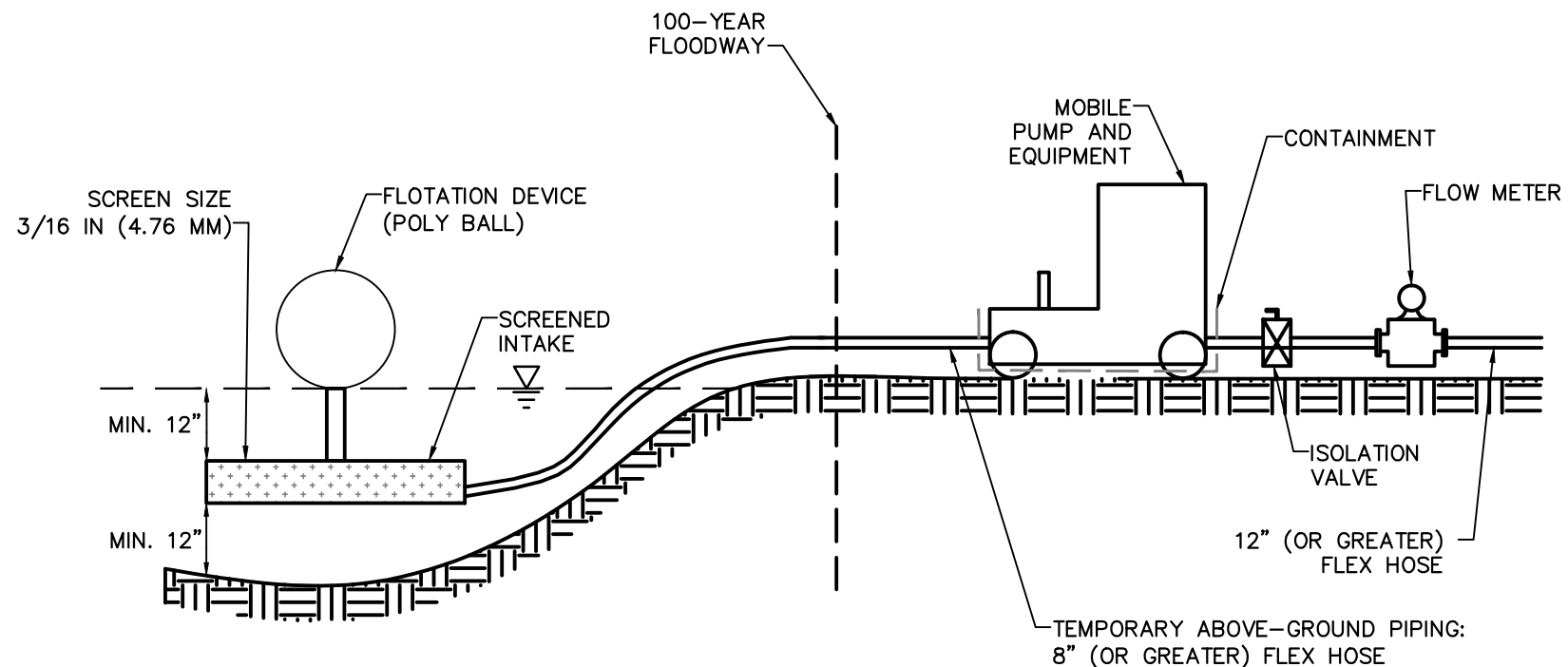
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FIGURE 3



**SCHEMATIC
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**INTAKE ARRANGEMENT
SECTION A-A'**

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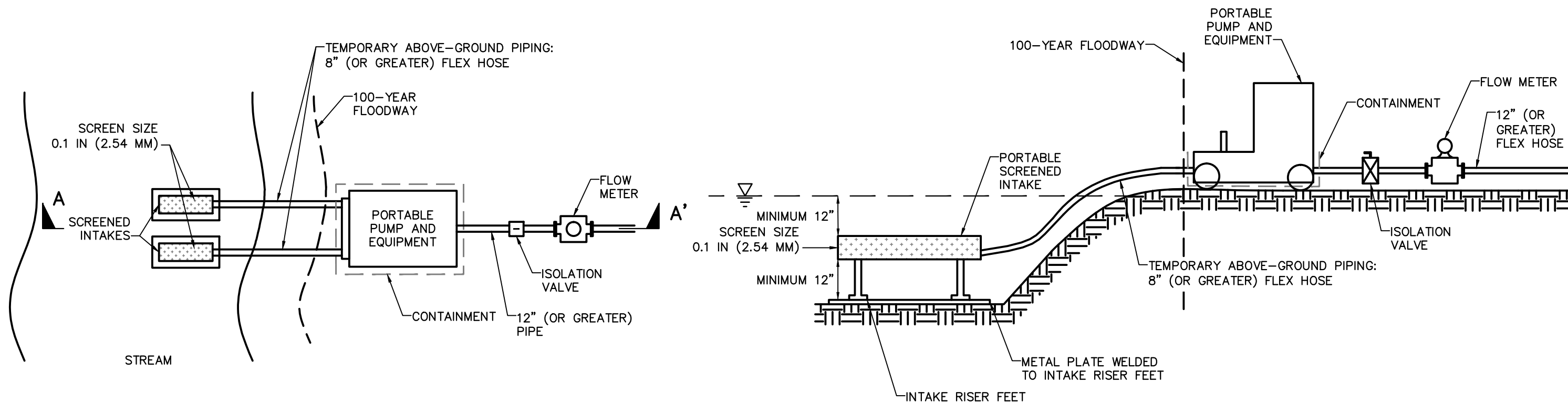
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 TYPICAL HYDROSTATIC TEST
 FLOATING INTAKE WITH MOBILE PUMP

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SHEET:	1 OF 1

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FIGURE 1



**SCHEMATIC
PLAN VIEW**

NOT TO SCALE

**INTAKE ARRANGEMENT
SECTION A-A'**

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**TYPICAL HYDROSTATIC TEST
SUBMERGED INTAKE WITH MOBILE PUMP**

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SHEET:	1 OF 1

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FIGURE 2



CLIENT: Sunoco Pipeline L.P.	PROJECT NO: 112IC05958	BY: RWD/LMH	PAGE: 1 of 3
SUBJECT: Burd Run – Evaluation of Susquehanna Withdrawal Equipment Impact on Existing Culvert		CHECKED BY: CAR 5/16/2016 DCW 5/16/2016	DATE: 5/16/2016

INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has identified a surface water withdrawal location from the Susquehanna River in Lower Swatara Township, Dauphin County, Pennsylvania, to support drilling operations and hydrostatic testing of horizontal directional drills (HDDs) and mainline test segments for the Sunoco Pipeline L.P. Mariner East 2 (ME2) pipeline project. In order to utilize the Susquehanna River withdrawal point, a temporary 12-inch intake line needs to cross a National Railroad Passenger Corporation (Amtrak) railway located in Highspire Borough in order to transport water from the river to the project workspace. Tetra Tech has identified an existing stone-arch culvert underneath the railway that conveys Burd Run beneath it as a potential location to temporarily lay the intake line (see Attachment 1, Photos 1 through 3) during water withdrawal operations. The proposed temporary piping route is shown on Figure 1 in Attachment 2 (excerpt from the Erosion and Sedimentation Control and Site Restoration Plan submission). Trico Surveying & Mapping, Inc. (Trico) obtained survey data at Burd Run culvert on April 28, 2016. Survey information is included in Attachment 3.

PURPOSE

The purpose of this calculation is to demonstrate that the existing Burd Run stone-arch culvert is adequately sized to accommodate the temporary pipeline being placed within it and convey a typical storm event (i.e., 2-year storm or greater).

METHOD

Confirm the existing capacity of a stone-arch culvert using estimated discharges for various storm events (determined via HEC-HMS modeling software). Then, using Manning's equation, calculate the effect on the capacity of the culvert when a 12-inch pipe is temporarily placed in the culvert to transfer water withdrawn from the Susquehanna River (i.e., temporarily modified culvert). Compare the calculated capacity to peak discharge rate of the 2-year storm.

The approach taken for this calculation does not take into account tailwater impacts due to rising surface water elevations in the Susquehanna River (confluence with Burd Run located approximately 200 feet downstream of the culvert outlet). Tetra Tech assumed that the entire surface water intake setup (i.e., intake screen, pump, and piping) for the Susquehanna River withdrawal point would be removed from site in the event of heavy rainfall or flooding that may cause a significant rise in the river surface elevation.

KNOWN INFORMATION

The following data was provided by Trico:

- Stone-arch culvert is 5 feet 7 inches wide and 9 feet 6 inches tall (Trico).
- Railroad Elevation: 307.679 feet
- North end of culvert (Inlet)
 - Northing: 318963.2 feet
 - Easting: 2237554 feet
 - Stream Centerline Elevation: 283.389 feet
- South end of culvert (Outlet)
 - Northing: 318875.7 feet
 - Easting: 2237514 feet
 - Stream Centerline Elevation: 282.584 feet



CLIENT: Sunoco Pipeline L.P.	PROJECT NO: 112IC05958	BY: RWD/LMH	PAGE: 2 of 3
SUBJECT: Burd Run – Evaluation of Susquehanna Withdrawal Equipment Impact on Existing Culvert		CHECKED BY: CAR 5/16/2016 DCW 5/16/2016	DATE: 5/16/2016

Therefore, length (L) and slope (s) are computed, as follows:
 $L = \sqrt{[(\Delta\text{Northing})^2 + (\Delta\text{Easting})^2]} = \sqrt{[87.5^2 + 40^2]} = 96.209 \text{ feet}$

$s = \Delta\text{Elevation}/L = (283.389 - 282.584)/96.209 = 0.00837 \text{ foot/foot}$

CALCLUATIONS

Existing Drainage Area

A hydrologic and hydraulic analysis for Burd Run was previously completed by the Dauphin County Conservation District (in conjunction with Herbert, Rowland, & Grubic, Inc.) using the U.S. Army Corps of Engineers (USACE) HEC-HMS modeling program. The calculated drainage area for Burd Run is 883.4 acres.

Further details, including existing land cover, are provided in Attachment 4 (2010 Dauphin County Act 167 Stormwater Management Plan Appendix A, Table 4: Assumed Existing and Future Land Use and Land Cover) and Attachment 5 (2010 Dauphin County Act 167 Stormwater Management Plan Appendix B, Plate 4: Laurel and Burd Watershed Release Rates).

Discharge

The Dauphin County Conservation District evaluated peak flow rates for the 2-, 10-, 25-, 50-, and 100-year storms using the USACE HEC-HMS modeling program to determine peak discharge rates at the point of interest (i.e., outlet of Burd Run). The results are summarized in Table 1. Further details are provided in Attachment 6 (2010 Dauphin County Act 167 Stormwater Management Plan Appendix C, Peak Rate Control Release Rates).

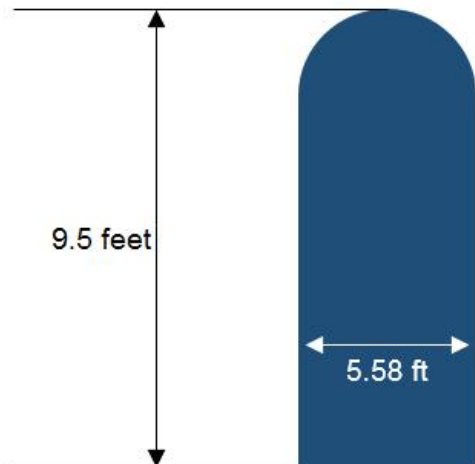
Table 1: Peak Discharge Summary

Description	Peak Discharge Rate (cubic feet per second)				
	2-Year Storm	10-Year Storm	25-Year Storm	50-Year Storm	100-Year Storm
Burd Run Outlet	235	701	987	1,214	1,462

Capacity of Existing Culvert

The culvert capacity was verified using HY-8 Culvert Hydraulic Analysis Program v7.4. HY-8 considers both inlet and outlet control. Model inputs included the arch culvert dimensions, minimum and maximum design storm discharge rates, Manning’s roughness coefficient, and upstream and downstream invert elevations.

During a 25-year storm, the headwater elevation computed for the existing culvert is 304.67 feet. The railroad elevation at the inlet to the culvert is 307.679 feet based on survey data from Trico. Therefore, the culvert can pass a 25-year storm without overtopping the railroad.





CLIENT: Sunoco Pipeline L.P.	PROJECT NO: 112IC05958	BY: RWD/LMH	PAGE: 3 of 3
SUBJECT: Burd Run – Evaluation of Susquehanna Withdrawal Equipment Impact on Existing Culvert	CHECKED BY: CAR 5/16/2016 DCW 5/16/2016	DATE: 5/16/2016	

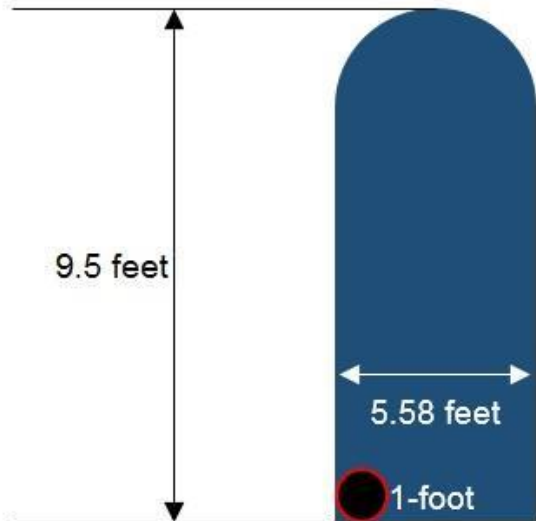
The headwater elevation computed for a typical storm event (i.e., 2-year storm) is 289.10 feet, which equates to a flow depth of approximately 4.96 feet. See Attachment 7 for full HY-8 analysis results for the existing culvert.

Capacity of Temporarily Modified Culvert

The modified culvert capacity was verified using HY-8 Culvert Hydraulic Analysis Program v7.4. The modified culvert was modeled in HY-8 by adjusting the defined shape of the culvert to block out the area occupied by the temporary 1-foot diameter pipe in the bottom corner.

During a 25-year storm, the headwater elevation computed for the existing culvert is 305.26 feet. The railroad elevation at the inlet to the culvert is 307.679 feet based on survey data from Trico. Therefore, the modified culvert can pass a 25-year storm without overtopping the railroad.

The headwater elevation computed for a typical storm event (i.e., 2-year storm) is 289.18 feet, which equates to a flow depth of approximately 4.99 feet. See Attachment 7 for full HY-8 analysis results for the modified culvert.



CONCLUSIONS

The following conclusions can be made based on the results of the culvert calculations:

- The existing culvert is capable of passing the 25-year storm.
- The temporarily modified culvert with 12-inch pipe running through it is also capable of passing the 25-year storm.
- The flow depth and headwater elevation of the temporarily modified culvert during a 2-year storm is 0.08 foot (<1 inch) higher than those of the existing culvert.
- Tetra Tech recommends that the intake line be set up to allow easy removal of the line in the event of heavy rainfall or other conditions that may cause an unexpected increase in the flow rate of surface runoff entering the culvert.

REFERENCES

Chow, Ven Te. "Open Channel Hydraulics". McGraw-Hill, Inc. 1959.

Dauphin County Act 167 Stormwater Management Plan. Dauphin County Conservation District in conjunction with Herbert, Rowland, & Grubic, Inc. April 2010.

Federal Highway Administration. HY-8 Culvert Analysis Program. Computer software. Version 7.4.

Trico Surveying & Mapping Inc. Survey Data, April 28, 2016.

ATTACHMENT 1: PHOTOS



Photo 1: Railroad Culvert Facing Upstream



Photo 2: Railroad Culvert Facing Downstream



Photo 3: Unnamed Tributary Facing Upstream from Railroad Culvert

ATTACHMENT 2: FIGURES

NOTES:

1. SEE ES-0.01 & ES-0.02 FOR GENERAL NOTES & LEGEND.
2. SEE ES-0.03 FOR STREAM & WETLAND CROSSING TABLES.
3. BMP INSTALLATION TO BE ADJUSTED AS NEEDED TO ACCOMMODATE ACTUAL CONTOURS IDENTIFIED IN FIELD DURING VARIOUS PHASES OF THE PROJECT.
4. FOR SURFACE WATER WITHDRAWALS, TEMPORARY PUMP AND ASSOCIATED EQUIPMENT (OTHER THAN THE TEMPORARY HOSES/PIPING AND INTAKE SCREEN) WILL BE LOCATED OUT OF THE 100-YEAR FLOODWAY. ALL TEMPORARY HOSES/PIPING AND INTAKE SCREENS WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN 100-YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS. TYPICAL DETAILS OF THE SURFACE WATER INTAKE AND EQUIPMENT ARE PROVIDED IN THE E&S PLAN NARRATIVE.

MATCHLINE ES-4.02

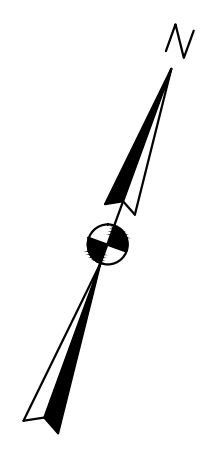
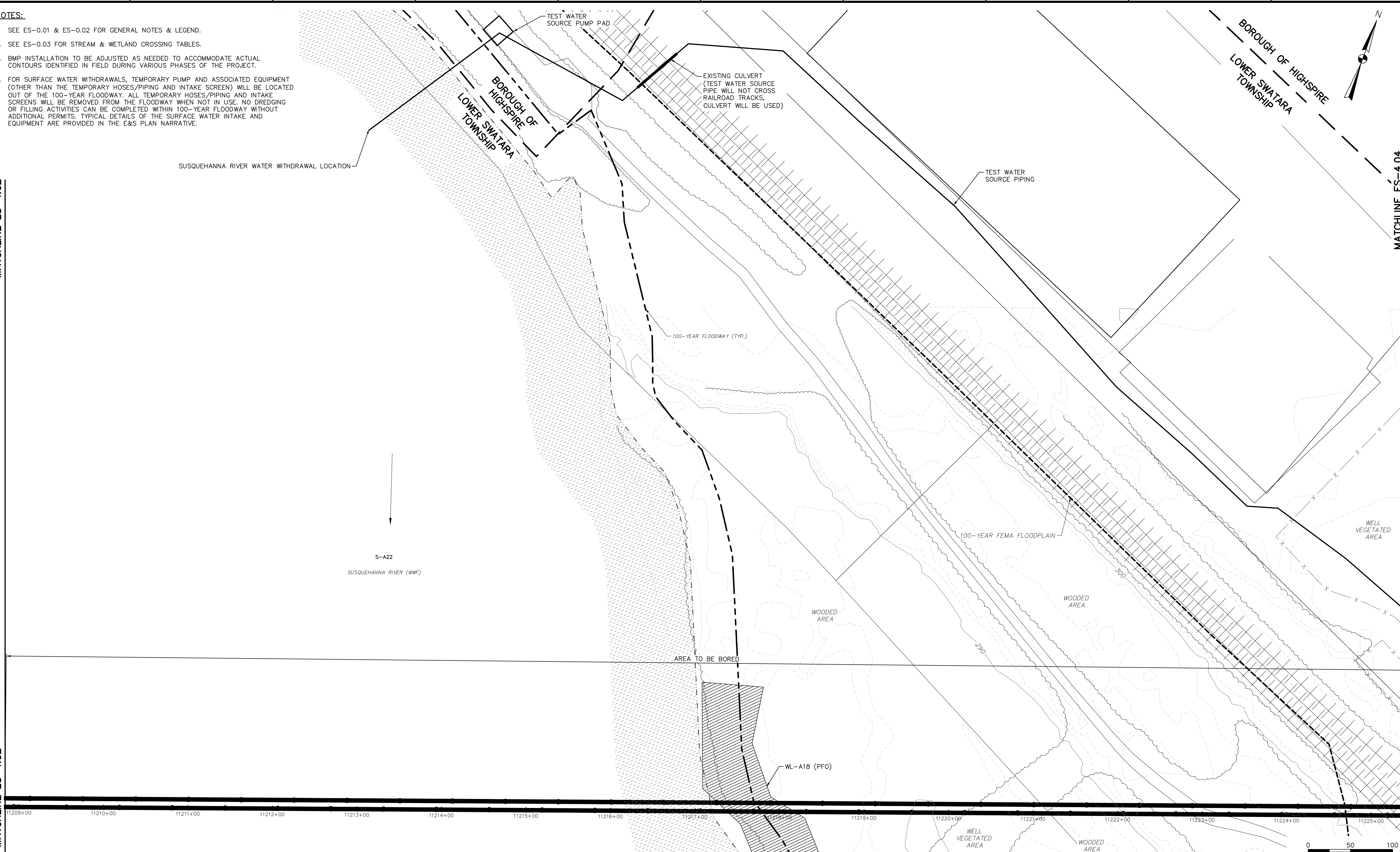
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MATCHLINE ES-4.02

MATCHLINE ES-4.04



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REVISIONS			
NO.	BY	DATE	REMARKS



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SINKING SPRING, PENNSYLVANIA
**PENNSYLVANIA PIPELINE PROJECT
CONSTRUCTION SPREAD 4**

1-20" & 1-16" PROPOSED WELDED STEEL NATURAL GAS LIQUIDS PIPELINES
DAUPHIN COUNTY CONSERVATION DISTRICT
EROSION & SEDIMENT CONTROL &
SITE RESTORATION PLAN
SHEET 3 OF 39

DATE:	3/18/16
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FIGURE 1	
SHEET 4.03 OF 49	

ATTACHMENT 3: TRICO SURVEYING & MAPPING, INC.

Burd Run Culvert Survey Data

Trico Surveying & Mapping, Inc.

April 28, 2016

Survey Point	Northing	Easting	Elevation (feet)	Notes		
658522	318875.7	2237514	282.584	CENTERLINE	STREAM	CULVERT INVERT OUT
658527	318963.2	2237554	283.389	CENTERLINE	STREAM	CULVERT INVERT IN
658521	317875.5	2241732	310.324	CHECK_POINT	CP101B	
658528	317875.5	2241732	310.271	CHECK_POINT	CP101B	
CP 100A	317789.7	2241574	312.2	CONTROL_POINT	PRIMARY CONTROL	IRON ROD
CP 101B	317875.4	2241732	310.057	CONTROL_POINT	PRIMARY CONTROL	IRON ROD
658523	318879.2	2237515	298.485	NATURAL_GROUND	TOP OF CULVERT	
658526	318958.3	2237551	298.659	NATURAL_GROUND	TOP OF CULVERT	
658524	318896.1	2237524	308.497	RAILROAD	TOP BALLAST	
658525	318930.5	2237538	307.679	RAILROAD	TOP BALLAST	

04-28-16

BASE e CP 100A HR: 5³² REBAR
 N: 317789.66 W/CAP
 E: 22471573.693
 ELV: 312.2

658,521 CK-IN e CP 101B HR: 5³² REBAR
 N: 317875.427 W/OUT
 E: 224732.098 CAP
 ELV: 310.057

CLOSURE: ΔN: -0.045 ΔE: 0.057 ΔV: -0.267

658,528 CK-OUT e CP 101B HR: 5³²
 N: 317875.427
 E: 224732.098
 ELV: 310.057

CLOSURE: ΔN: -0.042 ΔE: 0.039 ΔV: -0.214

FILE: W4042516 DA0001.0001

PNT RANGE: 658,521 - 658,528

DEL SHOTS: 0

DESC: ELEVATION DATA & ANGLES
 OF AREA COVERED

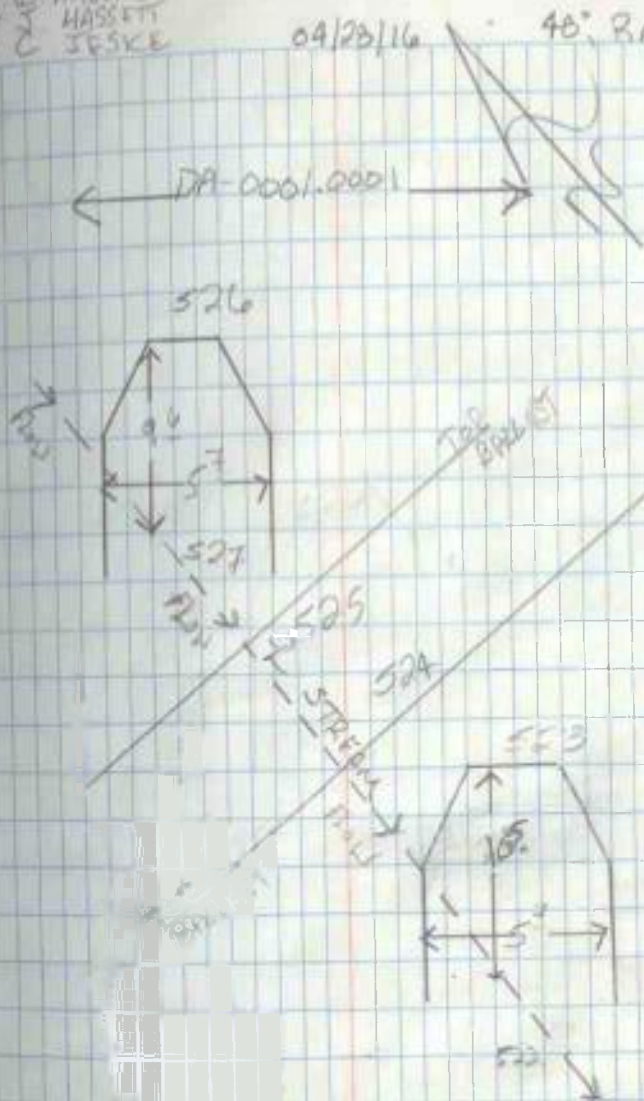
BK u 910, P 6

SUNNO-MED-SEGMENT 3

PST#	CODE	REMARKS
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658,525		RAILROAD TOP BALLAST ELV. 307.68
658,524		RAILROAD TOP BALLAST ELV. 308.50
658,523	N6	@ TOP OF CULVERT ELV. 290.49
658,522		CENTERLINE STREAM @ CULVERT ELV. 282.58

PC
PT
C
W
HAWKINS
HASSETT
JESKE

04/28/16 40° Rain



⑥ W4042816DA0001.0001

BK#96

⑥

ATTACHMENT 4: DAUPHIN COUNTY STORMWATER MANAGEMENT REPORT APPENDIX A

Table 4: Assumed Existing and Future Land Use and Land Cover

SPRING CREEK (EAST) WATERSHED	EXISTING LAND COVER		FUTURE LAND COVER		CHANGE FUTURE - EXISTING
	ACRES	%	ACRES	%	% Change
WATER	127.1	0.83%	127.1	0.83%	0.00%
LOW DENSITY RESIDENTIAL	1,829.80	11.98%	6,158.80	40.33%	28.35%
MEDIUM DENSITY RESIDENTIAL	1,065.30	6.98%	3,691.50	24.17%	17.19%
HIGH DENSITY RESIDENTIAL	415.6	2.72%	294	1.93%	-0.79%
URBAN	2,435.10	15.95%	2,744.20	17.97%	2.02%
COMMERCIAL/INDUSTRIAL	1,064.30	6.97%	2,256.10	14.77%	7.80%
OPEN SPACE	1,305.30	8.55%	0	0.00%	-8.55%
FOREST	1,372.10	8.98%	0	0.00%	-8.98%
AGRICULTURE	5,657.10	37.04%	0	0.00%	-37.04%
TOTAL	15,271.70	100.00%	15,271.70	100.00%	N/A

LAUREL RUN WATERSHED	EXISTING LAND COVER		FUTURE LAND COVER		CHANGE FUTURE - EXISTING
	ACRES	%	ACRES	%	% CHANGE
WATER	5.2	0.21%	5.2	0.21%	0.00%
LOW DENSITY RESIDENTIAL	100.2	4.09%	850.7	34.71%	30.62%
MEDIUM DENSITY RESIDENTIAL	191.1	7.80%	648.8	26.48%	18.68%
HIGH DENSITY RESIDENTIAL	304.6	12.43%	326.4	13.32%	0.89%
URBAN	63.9	2.61%	77.7	3.17%	0.56%
COMMERCIAL/INDUSTRIAL	318.2	12.98%	541.8	22.11%	9.13%
OPEN SPACE	166	6.77%	0	0.00%	-6.77%
FOREST	500	20.40%	0	0.00%	-20.40%
AGRICULTURE	801.4	32.70%	0	0.00%	-32.70%
TOTAL	2,450.6	100.00%	2,450.6	100.00%	N/A

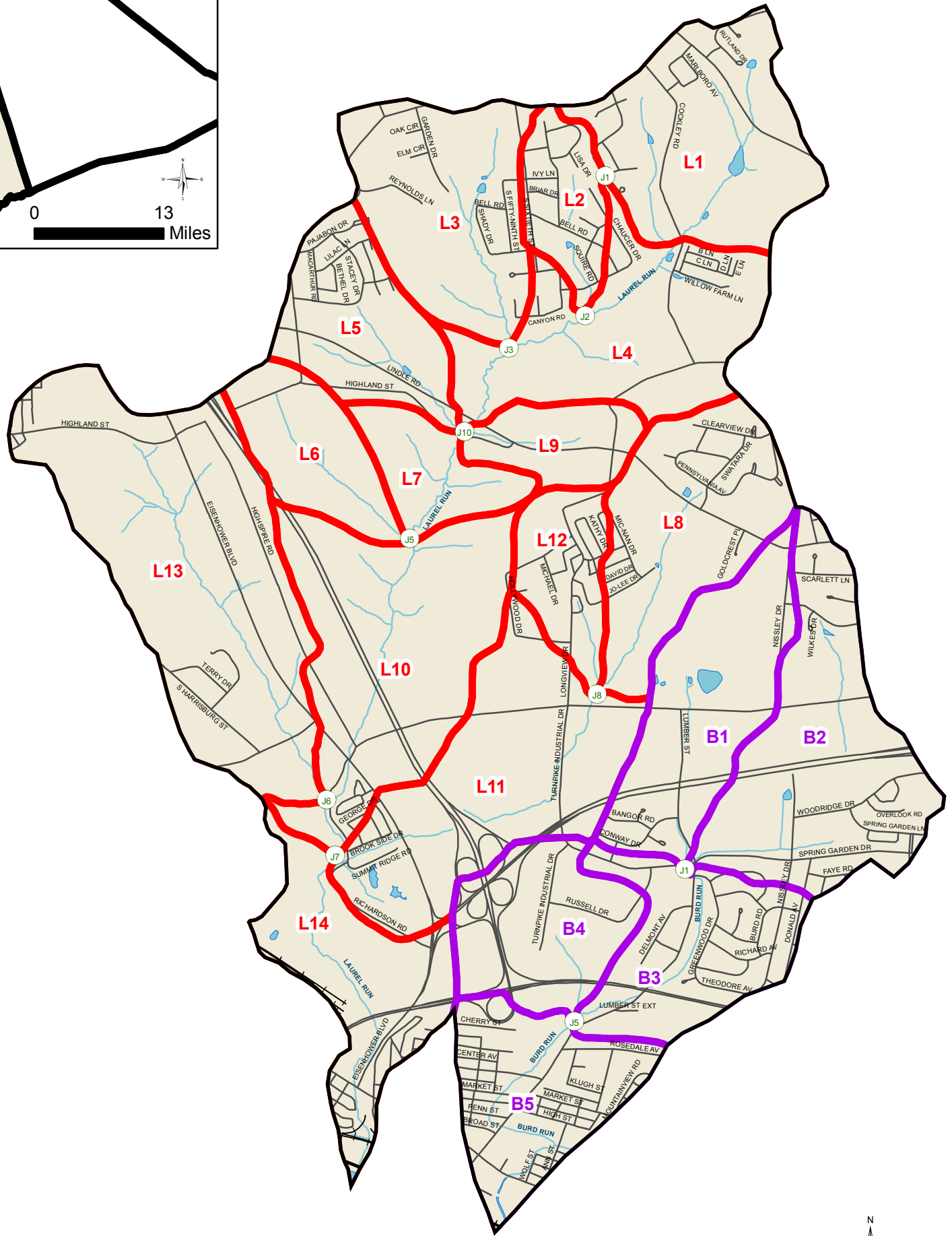
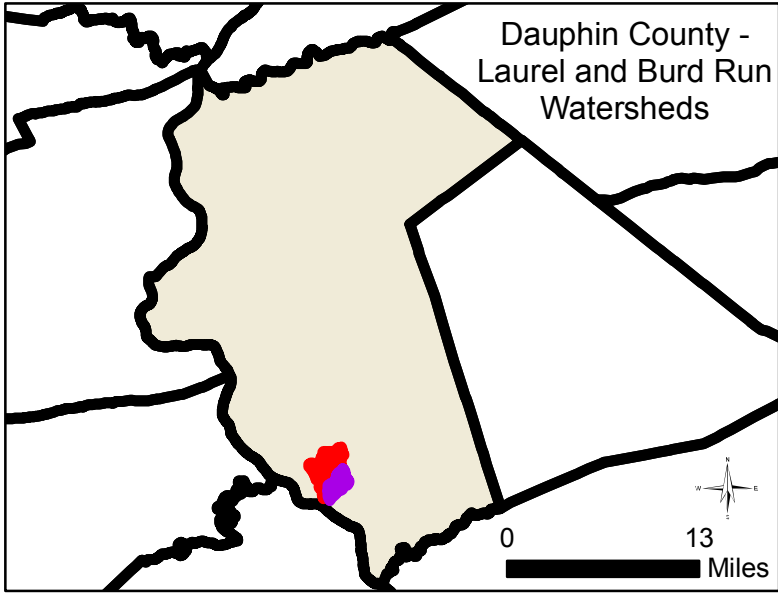
BURD RUN WATERSHED	EXISTING LAND COVER		FUTURE LAND COVER		CHANGE FUTURE - EXISTING
	ACRES	%	ACRES	%	% CHANGE
WATER	4.7	0.53%	4.7	0.53%	0.00%
LOW DENSITY RESIDENTIAL	11.4	1.29%	129.3	14.64%	13.35%
MEDIUM DENSITY RESIDENTIAL	23.9	2.71%	18.3	2.07%	-0.64%
HIGH DENSITY RESIDENTIAL	308.6	34.93%	384.1	43.48%	8.55%
URBAN	71	8.04%	114.7	12.98%	4.94%
COMMERCIAL/INDUSTRIAL	223.8	25.33%	232.3	26.30%	0.97%
OPEN SPACE	60.4	6.84%	0	0.00%	-6.84%
FOREST	42.4	4.80%	0	0.00%	-4.80%
AGRICULTURE	137.2	15.53%	0	0.00%	-15.53%
TOTAL	883.4	100.00%	883.4	100.00%	N/A

ATTACHMENT 5: DAUPHIN COUNTY STORMWATER MANAGEMENT REPORT APPENDIX B

Dauphin County Act 167 Plan

Plate 4

Laurel and Burd Watershed Release Rates

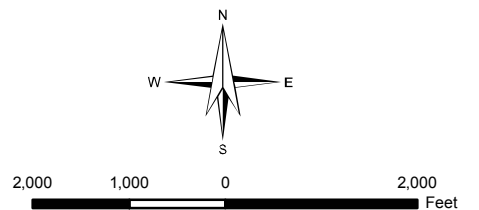


Laurel Run Watershed Release Rates

Subwatershed	1 Year	2 Year	10 Year	25 Year	50 Year	100 Year
L1	100%	80%	75%	80%	100%	100%
L2	100%	80%	75%	75%	100%	100%
L3	100%	100%	95%	95%	100%	100%
L4	100%	95%	95%	95%	100%	100%
L5	100%	90%	90%	90%	100%	100%
L6	100%	85%	80%	85%	100%	100%
L7	100%	95%	75%	75%	100%	100%
L8	100%	95%	95%	95%	100%	100%
L9	100%	80%	75%	75%	100%	100%
L10	100%	100%	95%	95%	100%	100%
L11	100%	100%	95%	95%	100%	100%
L12	100%	85%	80%	80%	100%	100%
L13	100%	100%	95%	95%	100%	100%
L14	100%	100%	95%	95%	100%	100%

Burd Run Watershed Release Rates

Subwatershed	1 Year	2 Year	10 Year	25 Year	50 Year	100 Year
B1	100%	90%	90%	95%	100%	100%
B2	100%	90%	90%	95%	100%	100%
B3	100%	90%	90%	95%	100%	100%
B4	100%	90%	90%	95%	100%	100%
B5	100%	90%	90%	95%	100%	100%



- Roads
- Railroads
- Streams
- ▭ Burd Run Subwatersheds
- ▭ Laurel Run Subwatersheds
- ▭ Rivers, Lakes, and Ponds
- HMS Junctions

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ATTACHMENT 6: DAUPHIN COUNTY STORMWATER MANAGEMENT REPORT APPENDIX C

Peak Rate Control (Release Rates)

The intent of the release rate percentage concept is to identify the general characteristics of the subwatershed interactions and their combinations and define their relative impacts on total stream flows. The release rate defines the percentage of the pre-development peak rate of runoff that can be discharged from a site after development. It applies uniformly to all land development or alterations within an individual subwatershed.

Existing Release Rates

- The 2-year, 10-year, and 25-year release rates associated with previously completed watershed wide Act 167 plans shall remain in effect. Refer to Release Rate Plates associated with existing plans.

Proposed Release Rates

- The 2-year, 10-year, and 25-year release rates associated with Laurel Run, Burd Run, and Spring Creek (East) shall be implemented as part of this Plan.
- The 1-year, 50-year, and 100-year release rate is 100% for all lands contained within Dauphin County.
- The 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year release rate is 100% for all lands contained within Dauphin County that have not had detailed modeling completed.

The general approach employed in Dauphin County was to establish release rates for each subwatershed by determining the peak rate of runoff from the subwatershed and its contribution to peak discharges in downstream reaches. This procedure was accomplished using the HEC-HMS modeling program developed by the U.S. Army Corps of Engineers. The specific steps in the approach are as follows:

1. Perform overall watershed modeling using HEC-HMS. The subwatershed peak flows and the total combined peak flows at the subwatershed junctions are shown for the 2005 Existing Land Use Condition in Table 10.
2. Identify the modeled flow contribution that a particular subwatershed contributes to each of the modeled downstream reaches.
3. Calculate the release rate percentage for each subwatershed at each downstream reach.
4. Assign a single release rate percentage for each subwatershed.
5. Compare the hydrographs of the subwatershed junctions to all points within the specific watershed to check whether peak flow increases occurred at any point within the watershed. If the full build out future condition has a greater peak

flow then the existing condition, then the release rates are modified accordingly to prevent the peak flow increase.

The final modeling of this Plan provides release rates that do not increase the full build out future peak flows above the existing condition peak flows at any point within the modeled watersheds.

Refer to Appendix B – Technical Analysis, for additional technical information regarding these release rates.

Table 10: Subwatershed and Outlet Peak Flows for Existing Land Use Conditions

BURD RUN WATERSHED AND OUTLET PEAK FLOWS FOR EXISTING CONDITIONS (CFS)					
SUBWATERSHEDS	2-YEAR	10-YEAR	25-YEAR	50-YEAR	100-YEAR
B1	36	124	182	229	280
B2	58	184	263	327	398
B3	45	133	187	229	276
B4	77	169	219	256	296
B5	49	134	185	224	267
HMS JUNCTION #1	94	307	444	555	677
HMS JUNCTION #5	198	582	819	1007	1213
BURD RUN OUTLET	235	701	987	1214	1462

LAUREL RUN WATERSHED AND OUTLET PEAK FLOWS FOR EXISTING CONDITIONS (CFS)					
SUBWATERSHEDS	2-YEAR	10-YEAR	25-YEAR	50-YEAR	100-YEAR
L1	15	90	148	198	255
L2	14	47	68	85	103
L3	8	60	103	141	186
L4	10	67	113	155	203
L5	10	52	85	113	145
L6	8	41	67	89	114
L7	2	21	38	54	72
L8	16	75	119	157	200
L9	3	24	41	56	74
L10	24	107	169	222	282
L11	42	140	204	256	314
L12	7	36	57	75	95
L13	25	125	201	268	345
L14	19	75	114	146	183
HMS JUNCTION #1	15	90	148	198	255
HMS JUNCTION #2	28	135	215	282	357
HMS JUNCTION #3	35	192	314	419	538
HMS JUNCTION #5	66	388	644	866	1121
HMS JUNCTION #6	90	502	827	1111	1438
HMS JUNCTION #7	178	856	1372	1815	2321
HMS JUNCTION #8	23	109	173	228	291
HMS JUNCTION #10	57	329	543	730	944
LAUREL RUN OUTLET	196	929	1483	1959	2501

ATTACHMENT 7: HY-8 CALCULATIONS

HY-8 Culvert Analysis Report Existing Culvert

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 235 cfs

Design Flow: 987 cfs

Maximum Flow: 987 cfs

Table 1 - Summary of Culvert Flows at Crossing: Burd Run

Headwater Elevation (ft)	Total Discharge (cfs)	Arch Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
289.10	235.00	235.00	0.00	1
290.36	310.20	310.20	0.00	1
291.43	385.40	385.40	0.00	1
292.52	460.60	460.60	0.00	1
293.93	535.80	535.80	0.00	1
295.33	611.00	611.00	0.00	1
297.08	686.20	686.20	0.00	1
298.42	761.40	761.40	0.00	1
300.38	836.60	836.60	0.00	1
302.35	911.80	911.80	0.00	1
304.67	987.00	987.00	0.00	1
307.68	1081.69	1081.69	0.00	Overtopping

Rating Curve Plot for Crossing: Burd Run

Total Rating Curve

Crossing: Burd Run

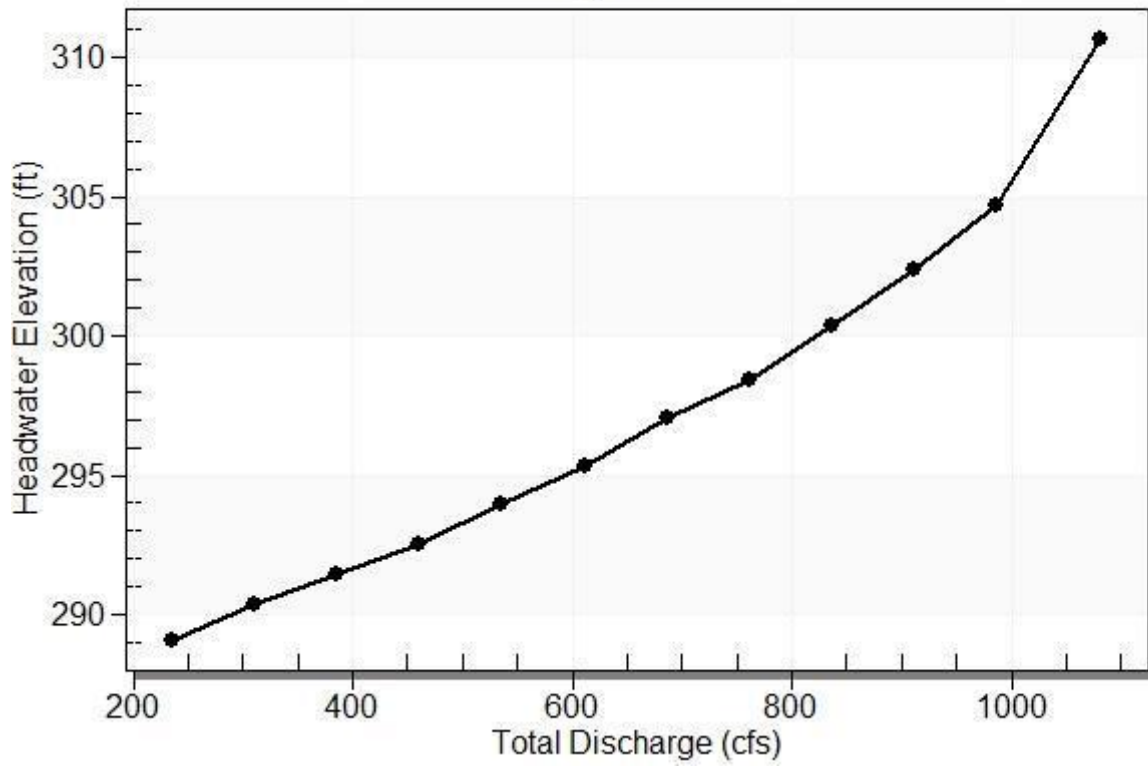


Table 2 - Culvert Summary Table: Arch Culvert

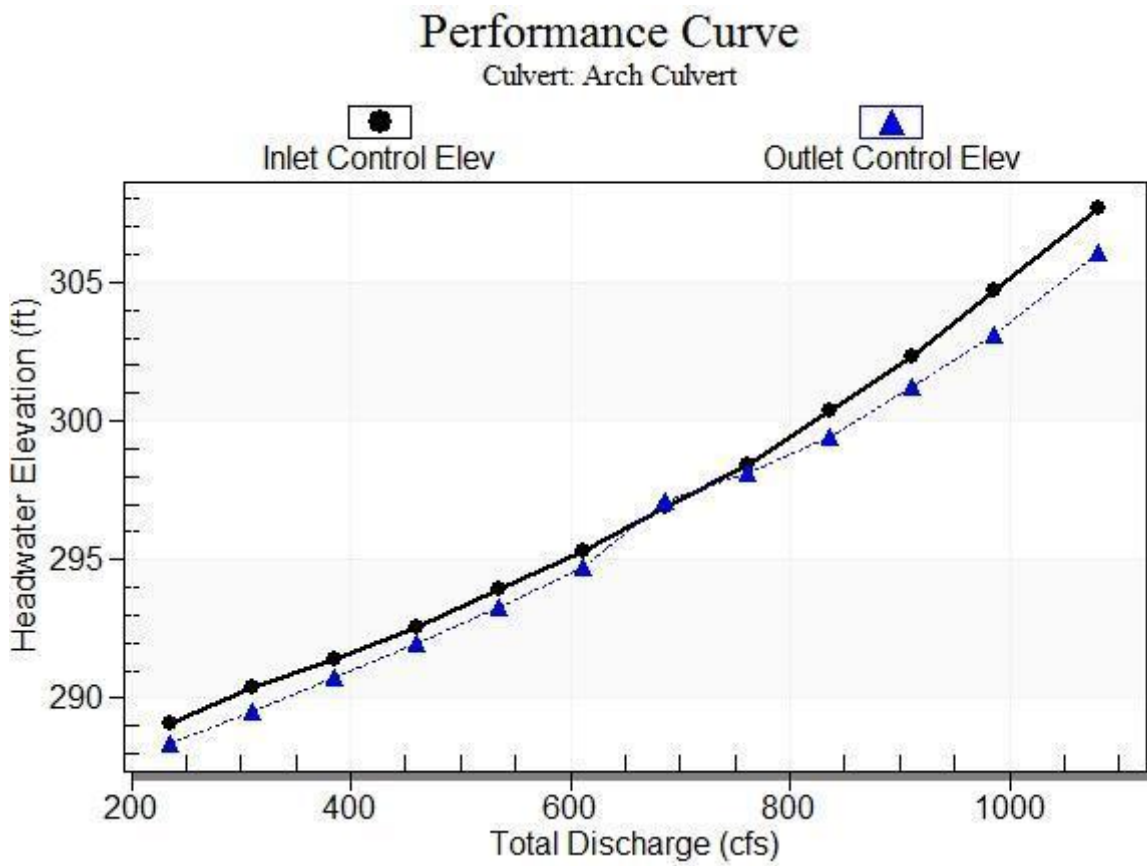
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
235.00	235.00	289.10	5.716	4.964	1-JS1t	2.741	3.813	5.170	5.170	7.400	4.956
310.20	310.20	290.36	6.968	6.139	1-JS1t	3.406	4.581	5.900	5.900	8.559	5.310
385.40	385.40	291.43	8.045	7.336	1-JS1t	4.050	5.284	6.531	6.531	9.635	5.603
460.60	460.60	292.52	9.134	8.587	1-JS1t	4.684	5.949	7.092	7.092	10.665	5.856
535.80	535.80	293.93	10.539	9.907	5-JS1t	5.310	6.582	7.600	7.600	11.685	6.078
611.00	611.00	295.33	11.945	11.309	5-JS1t	5.929	7.102	8.066	8.066	12.812	6.278
686.20	686.20	297.08	13.490	13.696	1-S1t	6.580	7.585	8.499	8.499	13.986	6.460
761.40	761.40	298.42	15.035	14.724	5-S1t	7.326	8.046	8.903	8.903	15.382	6.628
836.60	836.60	300.38	16.994	16.069	3-M2t	9.500	8.360	9.285	9.285	17.005	6.783
911.80	911.80	302.35	18.960	17.854	4-FFf	9.500	8.625	9.500	9.645	18.420	6.928
987.00	987.00	304.67	21.283	19.745	4-FFf	9.500	8.827	9.500	9.988	19.939	7.064

Straight Culvert

Inlet Elevation (invert): 283.39 ft, Outlet Elevation (invert): 282.58 ft

Culvert Length: 96.07 ft, Culvert Slope: 0.0084

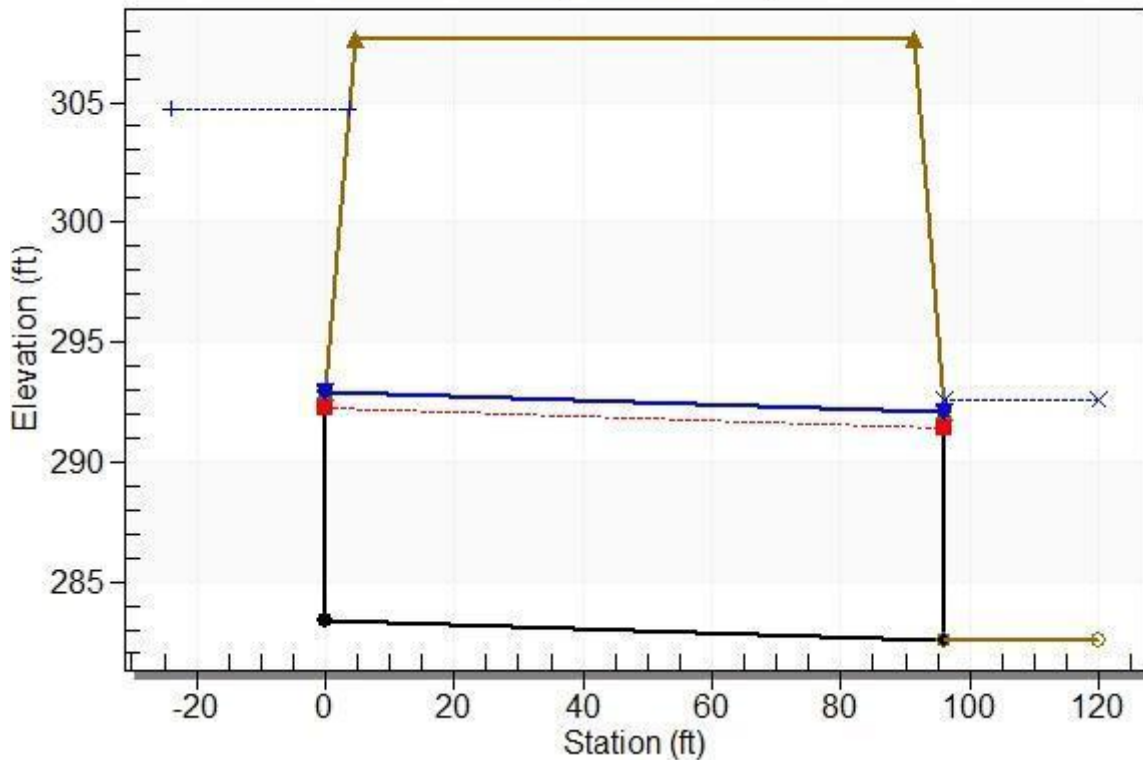
Culvert Performance Curve Plot: Arch Culvert



Water Surface Profile Plot for Culvert: Arch Culvert

Crossing - Burd Run, Design Discharge - 987.0 cfs

Culvert - Arch Culvert, Culvert Discharge - 987.0 cfs



Site Data - Arch Culvert

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 283.39 ft

Outlet Station: 96.07 ft

Outlet Elevation: 282.58 ft

Number of Barrels: 1

Culvert Data Summary - Arch Culvert

Barrel Shape: User Defined

Barrel Span: 5.58 ft

Barrel Rise: 9.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130 (top and sides)

Manning's n: 0.0120 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Burd Run)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
235.00	287.75	5.17	4.96	2.58	0.48
310.20	288.48	5.90	5.31	2.95	0.49
385.40	289.12	6.53	5.60	3.26	0.49
460.60	289.68	7.09	5.86	3.54	0.50
535.80	290.18	7.60	6.08	3.79	0.50
611.00	290.65	8.07	6.28	4.03	0.50
686.20	291.08	8.50	6.46	4.24	0.51
761.40	291.49	8.90	6.63	4.44	0.51
836.60	291.87	9.28	6.78	4.63	0.51
911.80	292.23	9.65	6.93	4.81	0.51
987.00	292.57	9.99	7.06	4.99	0.52

Tailwater Channel Data - Burd Run

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 4.00 ft

Side Slope (H:V): 1.00 (1:1)

Channel Slope: 0.0080

Channel Manning's n: 0.0500

Channel Invert Elevation: 282.58 ft

Roadway Data for Crossing: Burd Run

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 307.68 ft

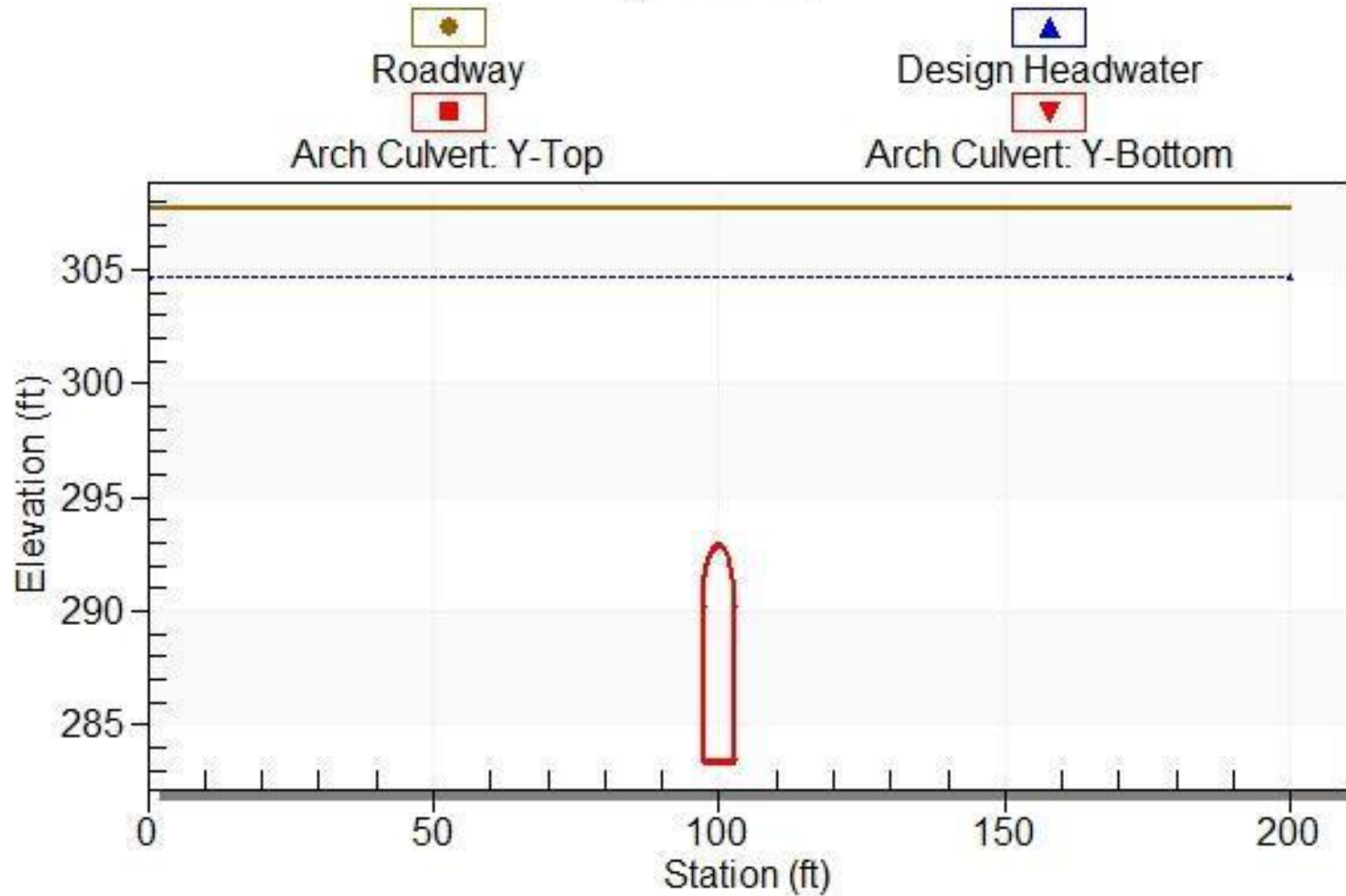
Roadway Surface: Gravel

Roadway Top Width: 86.77 ft

Crossing Front View (Roadway Profile): Burd Run

Crossing Front View

(Not to scale)



HY-8 Culvert Analysis Report Modified Culvert

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 235 cfs

Design Flow: 987 cfs

Maximum Flow: 987 cfs

Table 1 - Summary of Culvert Flows at Crossing: Burd Run

Headwater Elevation (ft)	Total Discharge (cfs)	Arch Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
289.18	235.00	235.00	0.00	1
290.44	310.20	310.20	0.00	1
291.54	385.40	385.40	0.00	1
292.69	460.60	460.60	0.00	1
294.12	535.80	535.80	0.00	1
295.57	611.00	611.00	0.00	1
297.26	686.20	686.20	0.00	1
298.79	761.40	761.40	0.00	1
300.80	836.60	836.60	0.00	1
302.87	911.80	911.80	0.00	1
305.26	987.00	987.00	0.00	1
307.68	1061.52	1061.52	0.00	Overtopping

Rating Curve Plot for Crossing: Burd Run

Total Rating Curve

Crossing: Burd Run

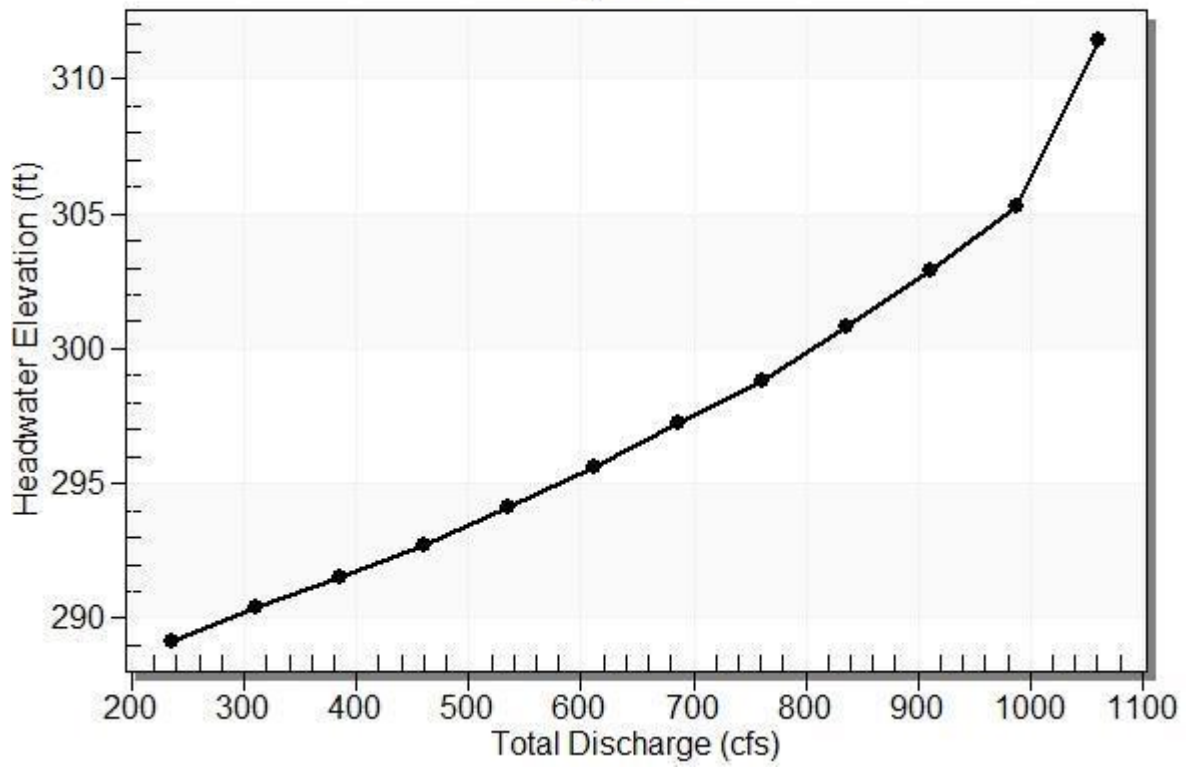


Table 2 - Culvert Summary Table: Arch Culvert

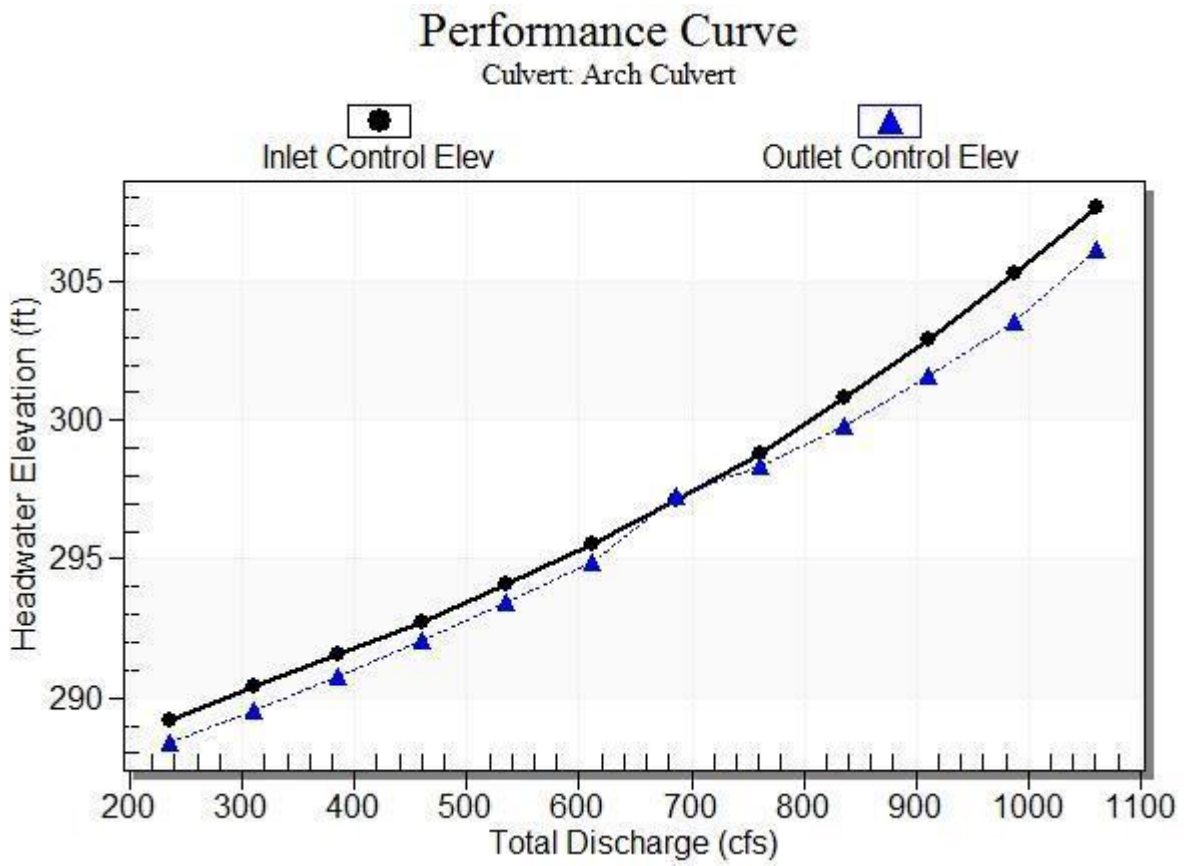
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
235.00	235.00	289.18	5.791	4.990	1-JS1t	2.974	3.974	5.170	5.170	7.621	4.956
310.20	310.20	290.44	7.052	6.183	1-JS1t	3.651	4.743	5.900	5.900	8.783	5.310
385.40	385.40	291.54	8.149	7.406	1-JS1t	4.308	5.449	6.531	6.531	9.862	5.603
460.60	460.60	292.69	9.298	8.686	1-S2n	4.947	6.115	5.576	7.092	13.820	5.856
535.80	535.80	294.12	10.729	10.041	5-S2n	5.579	6.743	6.247	7.600	14.327	6.078
611.00	611.00	295.57	12.183	11.482	5-JS1t	6.216	7.243	8.066	8.066	13.065	6.278
686.20	686.20	297.26	13.758	13.869	1-S1t	6.881	7.727	8.499	8.499	14.254	6.460
761.40	761.40	298.79	15.405	14.972	3-M2t	9.500	8.154	8.903	8.903	16.135	6.628
836.60	836.60	300.80	17.409	16.407	3-M2t	9.500	8.460	9.285	9.285	17.330	6.783
911.80	911.80	302.87	19.482	18.241	4-FFf	9.500	8.701	9.500	9.645	18.770	6.928
987.00	987.00	305.26	21.867	20.199	4-FFf	9.500	8.898	9.500	9.988	20.318	7.064

Straight Culvert

Inlet Elevation (invert): 283.39 ft, Outlet Elevation (invert): 282.58 ft

Culvert Length: 96.07 ft, Culvert Slope: 0.0084

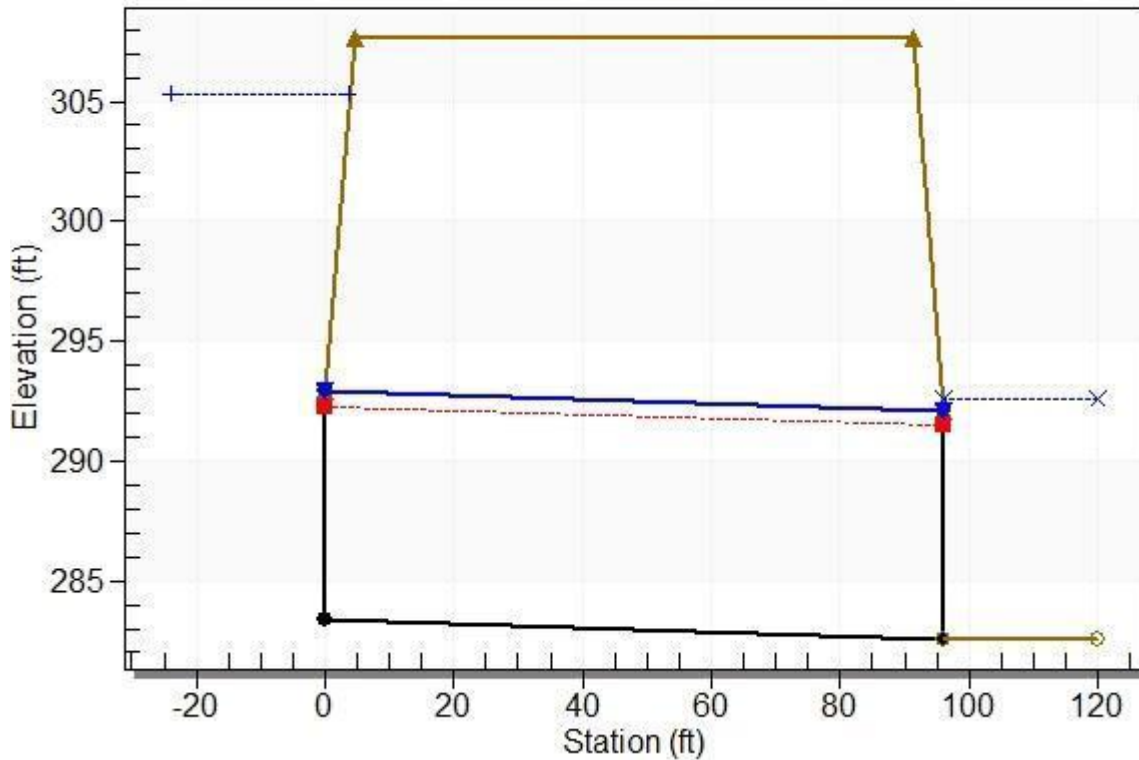
Culvert Performance Curve Plot: Arch Culvert



Water Surface Profile Plot for Culvert: Arch Culvert

Crossing - Burd Run, Design Discharge - 987.0 cfs

Culvert - Arch Culvert, Culvert Discharge - 987.0 cfs



Site Data - Arch Culvert

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 283.39 ft

Outlet Station: 96.07 ft

Outlet Elevation: 282.58 ft

Number of Barrels: 1

Culvert Data Summary - Arch Culvert

Barrel Shape: User Defined

Barrel Span: 5.58 ft

Barrel Rise: 9.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130 (top and sides)

Manning's n: 0.0120 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Burd Run)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
235.00	287.75	5.17	4.96	2.58	0.48
310.20	288.48	5.90	5.31	2.95	0.49
385.40	289.12	6.53	5.60	3.26	0.49
460.60	289.68	7.09	5.86	3.54	0.50
535.80	290.18	7.60	6.08	3.79	0.50
611.00	290.65	8.07	6.28	4.03	0.50
686.20	291.08	8.50	6.46	4.24	0.51
761.40	291.49	8.90	6.63	4.44	0.51
836.60	291.87	9.28	6.78	4.63	0.51
911.80	292.23	9.65	6.93	4.81	0.51
987.00	292.57	9.99	7.06	4.99	0.52

Tailwater Channel Data - Burd Run

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 4.00 ft

Side Slope (H:V): 1.00 (_:1)

Channel Slope: 0.0080

Channel Manning's n: 0.0500

Channel Invert Elevation: 282.58 ft

Roadway Data for Crossing: Burd Run

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 307.68 ft

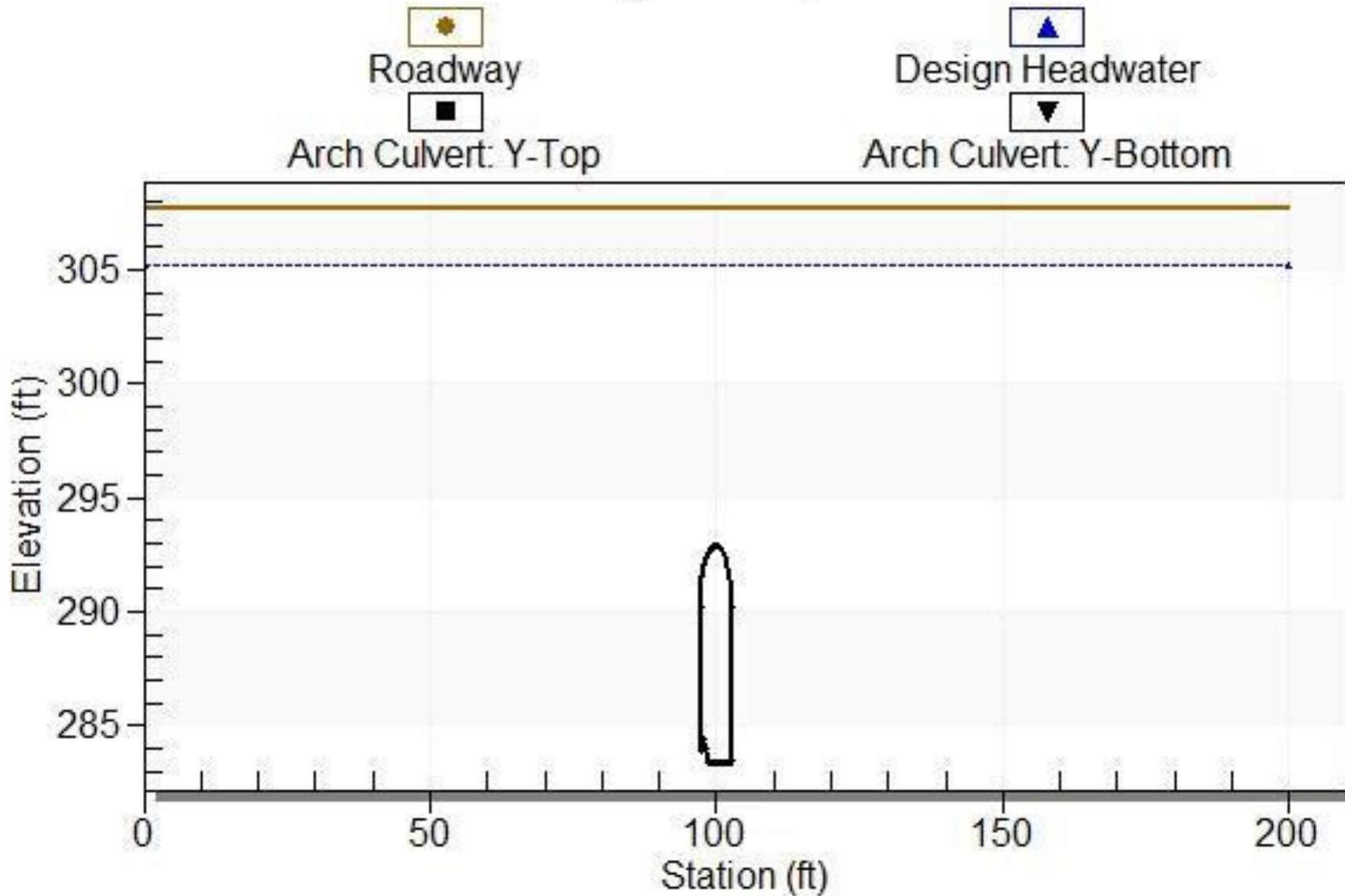
Roadway Surface: Gravel

Roadway Top Width: 86.77 ft

Crossing Front View (Roadway Profile): Burd Run

Crossing Front View

(Not to scale)



CLIENT: SUNOCO ME2 Pipeline Frankstown Branch Juniata River 2 Culvert Analysis	FILE No: 112IC05958	BY: LMH	PAGE: 1 of 4
SUBJECT: Frankstown Branch Juniata River 2 Evaluation of Withdrawal Equipment Impact on Existing Culvert.		CHECKED BY: CAR 4/5/2016 KMG 4/6/2016	DATE: 3/31/2016

INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has identified a surface water withdrawal location from Frankstown Branch Juniata River (FBJR2) in Frankstown Township, Blair County, Pennsylvania, to support drilling operations and hydrostatic testing of a horizontal directional drill (HDD) for the Sunoco Pipeline L.P. Mariner East 2 (ME2) pipeline construction project. In order to utilize the FBJR2 withdrawal, a temporary 8-inch intake line needs to cross East Loop Road/Township Route (TR) 409 at the intersection with Kearns Road (private road) in order to transport water from the river to the HDD workspace. Frankstown Township officials have indicated that it would be acceptable to lay the temporary intake line within an existing 30-inch HDPE culvert associated with an unnamed tributary to FBJR2, located along the northern edge of the ME2 project workspace (see Photos 1 through 3). The proposed temporary piping route is shown on Figure 1 (excerpt from the Erosion and Sedimentation Control submission). According to 25 Pa. Code § 105.12(a)(2), the requirements for Pennsylvania Department of Environmental Protection (PADEP) Chapter 105 permitting are waived for “[a] water obstruction in a stream or floodway with a drainage area of 100 acres or less.” Additionally, per PADEP guidance, “if a pipeline will be placed in a roadside drainage ditch or in a road culvert pipe, calculations should be submitted as part of an ESCGP NOI, or the approved E&S plan should be revised, to show that the drainage ditch or culvert pipe is adequately sized to accommodate the pipeline.”

PURPOSE

The purpose of this calculation is to show that the drainage area to the existing culvert is less than 100 acres and to demonstrate that the existing culvert pipe is adequately sized to accommodate the temporary pipeline being placed within it.

METHOD

First, delineate the drainage area to the culvert outlet using United States Geological Survey Mapping and confirm that it is less than 100 acres. Then, determine discharges for various storm events using TR-55 and confirm the existing capacity of a 30-inch culvert using CulvertMaster. Lastly, using Manning’s equation, calculate the effect on the capacity of the culvert when an 8-inch pipe is temporarily placed in the culvert to make withdrawals from FBJR2 (i.e., temporarily modified culvert). Compare to discharge capacity required to pass the 2-year storm.

KNOWN INFORMATION

- Culvert is 30-inch plastic corrugated on outside and smooth inside.
- Survey data provided by Trico Surveying and Mapping, Inc.:

North end of culvert (Outlet)
Northing: 404051.479
Easting: 1806785.339
Invert Elevation: 900.237 feet

South end of culvert (Inlet)

CLIENT: SUNOCO ME2 Pipeline Frankstown Branch Juniata River 2 Culvert Analysis	FILE No: 112IC05958	BY: LMH	PAGE: 2 of 4
SUBJECT: Frankstown Branch Juniata River 2 Evaluation of Withdrawal Equipment Impact on Existing Culvert.		CHECKED BY: CAR 4/5/2016 KMG 4/6/2016	DATE: 3/31/2016

Northing: 404020.909
 Easting: 1806753.644
 Invert Elevation: 900.391 feet

Edge of road (South):904.86 feet
 Centerline of road: 905.81 feet
 Edge of road (North): 906.25 feet

Therefore, length (L) and slope (s) are computed, as follows:

$$L = \sqrt{[(\Delta\text{Northing})^2 + (\Delta\text{Easting})^2]} = \sqrt{[31.695^2 + 30.57^2]} = 44.035 \text{ feet}$$

$$s = \Delta\text{Elevation}/L = (900.391 - 900.237)/44.035 = 0.00349 \text{ ft/ft}$$

- Culverts along township roads are typically sized for 10-year storm frequencies, according to PennDOT Highway Design Manual Part 2 Publication 13M – March 2015.

CALCUATIONS

Existing Drainage Area

A hydrologic and hydraulic analysis for the existing culvert was completed using NRCS Technical Release 55 (TR-55). The drainage areas and time of concentrations were calculated for existing conditions. Calculation results are summarized in Table 1. Full calculations are provided in Appendix A.

Figure 2 shows the drainage area to the existing culvert. Figure 3 shows the land cover within the drainage area. The culvert drainage area was delineated from a point of interest northwest of the proposed withdrawal point on Frankstown Branch Juniata River just north of East Loop Rd.

Table 1 Drainage Area Summary

Description	Area (Acres)	Tc (hours)
Culvert Drainage Area	50.16	0.507

The drainage area to the culvert outlet is less than 100 acres; therefore, a waiver is required for stream impacts per PADEP Chapter 105.

Discharge

The 1-, 2-, 10-, and 25-year storms were analyzed in TR-55 to determine peak discharge rates at the point of interest. The precipitation amounts used in the model were 2.1 inches for the 1-year storm, 2.4 inches for the 2-year storm, 3.4 inches for the 10-year storm, and 4.0 inches for the 25-year storm, based on published values for Blair County, PA [USDA, 1986]. The results are summarized in Table 2. Full calculations have been included in Appendix A.

CLIENT: SUNOCO ME2 Pipeline Frankstown Branch Juniata River 2 Culvert Analysis	FILE No: 112IC05958	BY: LMH	PAGE: 3 of 4
SUBJECT: Frankstown Branch Juniata River 2 Evaluation of Withdrawal Equipment Impact on Existing Culvert.		CHECKED BY: CAR 4/5/2016 KMG 4/6/2016	DATE: 3/31/2016

Table 2 Peak Discharge Summary

Description	Peak Discharge Rate (cfs)			
	1-Year Storm	2-Year Storm	10-Year Storm	25-Year Storm
Culvert Point of Interest	11.92	18.49	45.88	64.77

Capacity of Existing Culvert

The culvert capacity was verified using Heasted Methods Culvert Master V3.3. Culvert master considers both inlet and outlet control. Model inputs include design storm discharge rate, Manning’s roughness coefficient, upstream and downstream invert elevations, culvert length, culvert diameter, and entrance losses.

During a 10-year storm, the headwater elevation computed for the existing culvert is 904.88 ft. The road elevation is 904.56 ft at the south edge, 905.81 ft at its centerline, and 906.25 ft at the north edge. Therefore, the south edge of the road would be partially covered in water during the 10-year storm.

Capacity of Temporarily Modified Culvert

Calculate hydraulic radius of culvert with temporary 8-inch pipe through it:

$R = A/WP$

Where:

R = Hydraulic Radius (ft)

A = Area (ft²)

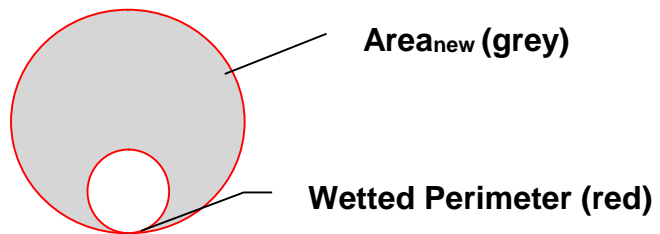
WP = Wetted Perimeter (ft)

C = Circumference (ft)

$A_{new} = A_{30\text{-inch}} - A_{8\text{-inch}}$
 $A_{30\text{-inch}} = \pi * r^2 = 4.909 \text{ ft}^2$
 $A_{8\text{-inch}} = \pi * r^2 = 0.349 \text{ ft}^2$
 $A_{new} = 4.560 \text{ ft}^2$

$WP = C_{30\text{-inch}} + C_{8\text{-inch}}$, assuming full flow
 $C_{30\text{-inch}} = 2 * \pi * r = 7.854 \text{ ft}$
 $C_{8\text{-inch}} = 2 * \pi * r = 2.094 \text{ ft}$
 $WP = 9.948 \text{ ft}$

$R = 0.458 \text{ ft}$



Calculate Average Velocity Using Manning’s Equation:

$V = 1.49 * R^{(2/3)} * S^{(1/2)} / n$

Where:

CLIENT: SUNOCO ME2 Pipeline Frankstown Branch Juniata River 2 Culvert Analysis	FILE No: 112IC05958	BY: LMH	PAGE: 4 of 4
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V = average velocity (ft/s)
R = Hydraulic Radius (ft)
S = channel slope (ft/ft)
N = Manning's roughness coefficient

$$V = 1.49 * (0.458^{(2/3)}) * (0.00350 \text{ ft/ft}^{(1/2)}) / 0.012$$

V = 4.365 ft/s

Calculate Modified Culvert Capacity:

$$Q = VA$$
$$Q = 4.365 \text{ ft/s} * 4.560 \text{ ft}^2$$

Q = 19.903 cfs

Per Table 2, the 2-year storm results in a discharge of 18.49 cfs; therefore, the modified culvert capacity is large enough to pass the 2-year storm.

CONCLUSIONS

The following conclusions can be made based on the results of the culvert calculations:

- The existing culvert is capable of passing the 10-year storm with a headwater depth of 1.49 ft.
- The temporarily modified culvert with 8-inch pipe running through it is capable of passing the 2-year storm, which is acceptable for the temporary nature of the work.
- Tetra Tech recommends that the intake line be set up to allow easy removal of the line in the event of heavy rainfall or other conditions that may cause an unexpected increase in the flow rate of surface runoff entering the culvert.

REFERENCES

Bentley CulvertMaster V3.3. Haestad Methods, Inc.

PennDOT Highway Design Manual Part 2 Publication 13M – March 2015.

Requirements for Temporary and Permanent Pipeline Stream Crossings and Intake Structures for Water Withdrawals. Pennsylvania Department of Environmental Protection Guidance. 2016.

Survey Data. Bloomington, IN: Trico Surveying and Mapping, Inc., 25 Mar. 2016.

Urban Hydrology for Small Watersheds. 210-VI-TR-55, Second Ed. TR-55. United States Department of Agriculture, June 1986.

25 Pa. Code § 105.12. Waiver of Permit Requirements. Pennsylvania Department of Environmental Protection. Accessed 04 Apr. 2016.

PHOTOS



Photo 1: E. Loop Road Culvert Inlet Looking North

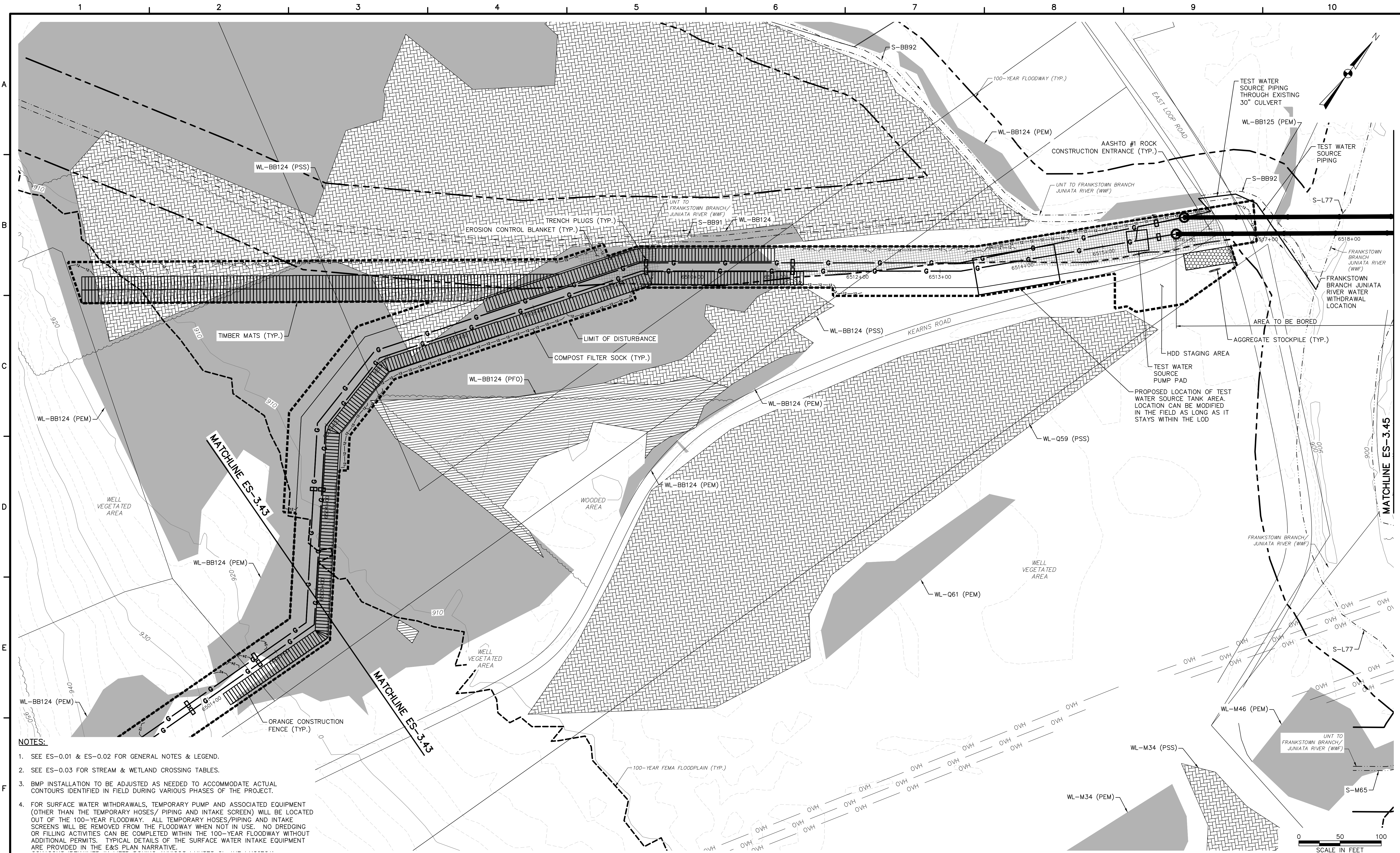


Photo 2: E. Loop Road Culvert Inlet Looking South



Photo 3: E. Loop Rd. Culvert Outlet Looking North

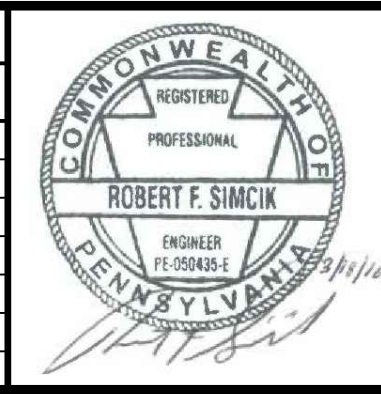
FIGURES



- NOTES:**
1. SEE ES-0.01 & ES-0.02 FOR GENERAL NOTES & LEGEND.
 2. SEE ES-0.03 FOR STREAM & WETLAND CROSSING TABLES.
 3. BMP INSTALLATION TO BE ADJUSTED AS NEEDED TO ACCOMMODATE ACTUAL CONTOURS IDENTIFIED IN FIELD DURING VARIOUS PHASES OF THE PROJECT.
 4. FOR SURFACE WATER WITHDRAWALS, TEMPORARY PUMP AND ASSOCIATED EQUIPMENT (OTHER THAN THE TEMPORARY HOSES/ PIPING AND INTAKE SCREEN) WILL BE LOCATED OUT OF THE 100-YEAR FLOODWAY. ALL TEMPORARY HOSES/PIPING AND INTAKE SCREENS WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN THE 100-YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS. TYPICAL DETAILS OF THE SURFACE WATER INTAKE EQUIPMENT ARE PROVIDED IN THE E&S PLAN NARRATIVE.

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REVISIONS			
NO.	BY	DATE	REMARKS



**SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA
PENNSYLVANIA PIPELINE PROJECT
CONSTRUCTION SPREAD 3**

1-20" & 1-16" PROPOSED WELDED STEEL NATURAL GAS LIQUIDS PIPELINES

**BLAIR COUNTY CONSERVATION DISTRICT
EROSION & SEDIMENT CONTROL &
SITE RESTORATION PLAN
SHEET 44 OF 73**

DATE:	3/18/16
PROJECT NO.:	1121C05958
DESIGNED BY:	JB
DRAWN BY:	BH
CHECKED BY:	RS
COPYRIGHT TETRA TECH INC.	
FIGURE 1	
SHEET 3.44 OF 87	

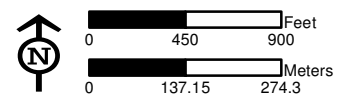
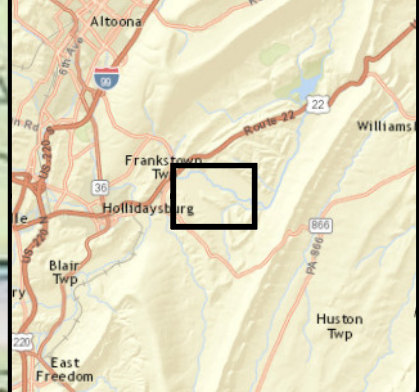


- Legend**
- Culvert Outlet
 - ▶ Time of Concentration
 - Stream
 - Drainage Area

LAT: 40° 26' 27.689" N
LON: 78° 19' 51.623" W

Drainage Area
50.166 acres

Sheet Identifier



CULVERT DRAINAGE AREA MAP
FRANKSTOWN BRANCH JUNIATA RIVER 2
FIGURE 2
SUNOCO PIPELINE, L.P.
SINKING SPRING, PENNSYLVANIA



Notes:
1) Topographic map provided by ESRI's ArcGIS Online USA Topo Maps map service (© 2013 National Geographic Society, 1-cubed).
2) Quadrangle displayed is Frankstown.
3) Coordinate system is NAD 83 State Plane Pennsylvania South.

FGH P:\GIS\SUNOCO\MARINER EAST 2\MXD\PPP\PCSM\PENNSYLVANIA_DRAINAGE_USGS.MXD 04/05/16 SP

APPENDIX A

TR-55 CALCULATIONS

WinTR-55 Current Data Description

--- Identification Data ---

User: LMH Date: 4/6/2016
Project: FBJR2 Units: English
SubTitle: Culvert Analysis Areal Units: Acres
State: Pennsylvania
County: Blair NOAA_B
Filename: S:\Marcellus_M-Z - Mark Sladic\Sunoco Logistics (SXL)\Hydrostatic Testing Source Evaluation\Per

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Drainage A		Outlet	50.17	73	0.507

Total area: 50.17 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
2.4	3.0	3.4	4.0	4.5	5.0	2.1

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

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FBJR2
Culvert Analysis
Blair NOAA_B County, Pennsylvania

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
2.4	3.0	3.4	4.0	4.5	5.0	2.1

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

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Culvert Analysis
Blair NOAA_B County, Pennsylvania

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	1-Yr (cfs)

SUBAREAS				
Drainage A	18.49	45.88	64.78	11.92
REACHES				
OUTLET	18.49	45.88	64.78	11.92

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Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	1-Yr (cfs) (hr)

SUBAREAS

Drainage A	18.49	45.88	64.78	11.92
	12.24	12.21	12.21	12.24

REACHES

OUTLET	18.49	45.88	64.78	11.92
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FBJR2
Culvert Analysis
Blair NOAA_B County, Pennsylvania

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Drainage A	50.17	0.507	73	Outlet	
Total Area:	50.17 (ac)				

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Culvert Analysis
Blair NOAA_B County, Pennsylvania

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Drainage A	Paved parking lots, roofs, driveways	D	.79	98
	Gravel (w/ right-of-way)	B	.664	85
	Gravel (w/ right-of-way)	C	.147	89
	Gravel (w/ right-of-way)	D	.26	91
	Meadow -cont. grass (non grazed)	B	.538	58
	Meadow -cont. grass (non grazed)	C	16.959	71
	Meadow -cont. grass (non grazed)	D	14.138	78
	Woods (fair)	B	7.504	60
	Woods (fair)	C	1.743	73
	Woods (fair)	D	7.423	79
	Total Area / Weighted Curve Number		50.17	73
			=====	==

CULVERTMASTER CALCULATIONS

Culvert Designer/Analyzer Report Culvert FBJR2

Analysis Component			
Storm Event	Design	Discharge	45.88 cfs

Peak Discharge Method: User-Specified			
Design Discharge	45.88 cfs	Check Discharge	45.88 cfs

Tailwater properties: Irregular Channel

Tailwater conditions for Design Storm.			
Discharge	45.88 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-30 inch Circular	45.88 cfs	904.88 ft	9.89 ft/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report

Culvert FBJR2

Component: Culvert-1

Culvert Summary			
Computed Headwater Elev:	904.88 ft	Discharge	45.88 cfs
Inlet Control HW Elev.	904.88 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	904.72 ft	Control Type	Inlet Control
Headwater Depth/Height	1.80		

Grades			
Upstream Invert	900.39 ft	Downstream Invert	900.24 ft
Length	44.04 ft	Constructed Slope	0.003497 ft/ft

Hydraulic Profile			
Profile	CompositeM2PressureProfile	Depth, Downstream	2.24 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.24 ft
Velocity Downstream	9.89 ft/s	Critical Slope	0.009421 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.012
Section Material	HDPE (Smooth Interior)	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	904.72 ft	Upstream Velocity Head	1.36 ft
Ke	0.20	Entrance Loss	0.27 ft

Inlet Control Properties			
Inlet Control HW Elev.	904.88 ft	Flow Control	Submerged
Inlet Type	Groove end projecting	Area Full	4.9 ft ²
K	0.00450	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	3
C	0.03170	Equation Form	1
Y	0.69000		