Thunder Valley PUD

Traffic Impact Study

J&T Consulting, Inc.

Weld County, Colorado

April 23, 2018

Prepared By:

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Thunder Valley PUD

Traffic Impact Study

1.0 Introduction

The Thunder Valley PUD is proposed as a residential development with 13 single family dwelling units. It will be west of WCR 21 between WCR 10 and WCR 10.5. The vicinity map is contained in Figure 1 and the site plan is contained in Figure 2.

The study has been prepared based on the Weld County traffic impact study requirements[1].

2.0 Project Description

2.1 Existing and Proposed Streets and Intersections

Two accesses are proposed from WCR 21 to the development. The road is classified as a local road by Weld County[2]. It has a rural cross section with one lane in each direction.

2.2 Study Assumptions

The following assumptions were utilized for this study.

- **Short Term Horizon.** The study assumes that the development will be completed and fully occupied by Year 2023, therefore, the short term horizon is Year 2023.
- **Long Term Horizon.** The long term horizon is assumed to be Year 2038 which is 20 years in the future.
- **Growth in Background Traffic.** An annual growth rate for WCR 21 was developed based on existing and projected volumes that are contained in Appendix A of the County's transportation plan[3].
- **Saturation Flow Rate.** The saturation flow rate was assumed to be 1,600 passenger cars / hour / lane.
- **Peak Hour Factor.** The peak hour factor for all scenarios was assumed to be 0.85 on all approaches.
- **Truck Percentage.** Based on the data collected, the truck percentage was assumed to be 22% on WCR 21. 2% trucks was assumed on the site accesses.

3.0 Existing Traffic Volumes

Daily volume data were collected by All Traffic Data on Thursday April 5, 2018. The existing and projected daily volumes are summarized in Table 1 while the existing

1 Weld County Engineering and Construction Criteria. Weld County. April 2012.

2 Weld County Functional Classification Map. Weld County Public Works. May 31, 2017.

3 Weld County 2035 Transportation Plan. Weld County Public Works Department. May 9, 2011.

peak hour volumes are summarized in Figures 3 and 4. The traffic count data are contained in Appendix A.

4.0 Site Generated Traffic Volumes

4.1 Trip Generation

In order to estimate the traffic impacts associated with the development of the Thunder Valley PUD, the amount of traffic generated by the proposed development was estimated using trip generation rates contained in the Institute of Transportation Engineers (ITE) Trip Generation manual[4]. The trip generation estimate is contained in Table 2.

4.2 Trip Distribution and Assignment

The trip distribution for the development was based on the existing traffic volumes and is contained in Figure 5. The trip assignment for the morning and evening peak hours is contained in Figures 6 and 7.

5.0 Total Traffic Volumes

The total traffic volumes were developed by combining the background traffic volumes with the trip assignment. The following figures contain the total traffic volume scenarios.

- Figures 8 and 9 contain the Year 2023 total traffic volume scenarios. These volumes were developed by inflating the existing traffic volumes to the Year 2023 level and adding the trip assignment that is contained in Figures 6 and 7.
- Figures 10 and 11 contain the Year 2038 total traffic volume scenarios. These volumes were developed by inflating the existing traffic volumes to the Year 2038 level and adding the trip assignment that is contained in Figures 6 and 7.

5.1 Level of Service Analysis

To evaluate the performance of the intersections within the study area, the level of service (LOS) was calculated using PTV VISTRO software. This software package utilizes criteria described in the Highway Capacity Manual[5]. LOS is a measure used to describe operational conditions at an intersection. LOS categories ranging from A to F are assigned based on the predicted delay in seconds per vehicle for the intersection as a whole, as well as for individual turning movements. LOS A indicates very good operations, and LOS F indicates poor, congested operations. Acceptable intersection operation in rural areas is typically considered LOS C or better.

The projected operation of the intersections is summarized in Table 3. In all total traffic volume scenarios, both intersections are projected to operate at LOS A. The level of service for stop controlled intersections is based on the lowest letter grade for the side street movements. The laneage and traffic control assumed in the analysis are contained in Figure 12.

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4 Trip Generation, 10th Edition. Institute of Transportation Engineers. September 2017.

5 Highway Capacity Manual, 6th Edition. Transportation Research Board. 2016.

Results of the analysis are summarized in Table 3 and the VISTRO analysis results are contained in Appendix B.

6.0 Auxiliary Lanes

STS reviewed the need for auxiliary lanes at the site access intersections. The evaluation was based on criteria that are contained in Section 6.6 of the Weld County Engineering and Construction Criteria. Weld County has the following thresholds for the construction of auxiliary lanes on arterial and collector roadways.

- **Left Turn Deceleration Lane.** A left turn deceleration lane is required when peak hour volumes exceed 10 vehicles per hour.
- **Right Turn Deceleration Lane.** A right turn deceleration lane is required when peak hour volumes exceed 25 vehicles per hour.
- **Right Turn Acceleration Lane.** A right turn acceleration lane is required when peak hour volumes exceed 50 vehicles per hour. A second criterion is that the right turning traffic would be turning into a single lane.

No auxiliary lanes will be required based on the County standards.

7.0 Conclusions

STS has reached the following conclusions based on the analysis performed in this report.

- **Level of Service at the Site Access.** The site accesses are expected to operate at LOS A during all of the total traffic volume scenarios.
- **Side Street Stop Control.** The development will not warrant signalization of the site accesses, therefore, they will be stop controlled.
- **Side Street Laneage.** A single outbound lane was assumed in the analysis and will be sufficient based on the results of the analysis.

Tables

Table 1. Existing and Projected Daily Traffic Volumes

Link	Year 2017	Development	Year 2023 Background	Year 2023 Total	Year 2038 Background	Year 2038 Total
WCR 21 North of North Site Access	368	55	490	550	1,120	1,180
WCR 21 South of South Site Access	368	68	490	560	1,110	1,180
North Site Access	0	58	0	58	0	58
South Site Access	0	65	0	65	0	65

Note

1. Daily volumes collected for the study are highlighted in yellow. All other volumes in the table are estimated.

Table 2. Trip Generation Estimate

Land Use	ITE Code [1]	Size	Unit	Average Daily Trips				Morning Peak Hour Trips				Evening Peak Hour Trips			
				Rate	Total	In	Out	Rate	Total	In	Out	Rate	Total	In	Out
Single-Family Detached Housing	210	13	Dwelling Unit	9.44	123	61	61	0.74	10	2	7	0.99	13	8	5
Total	---	---	---	---	123	61	61	---	10	2	7	---	13	8	5

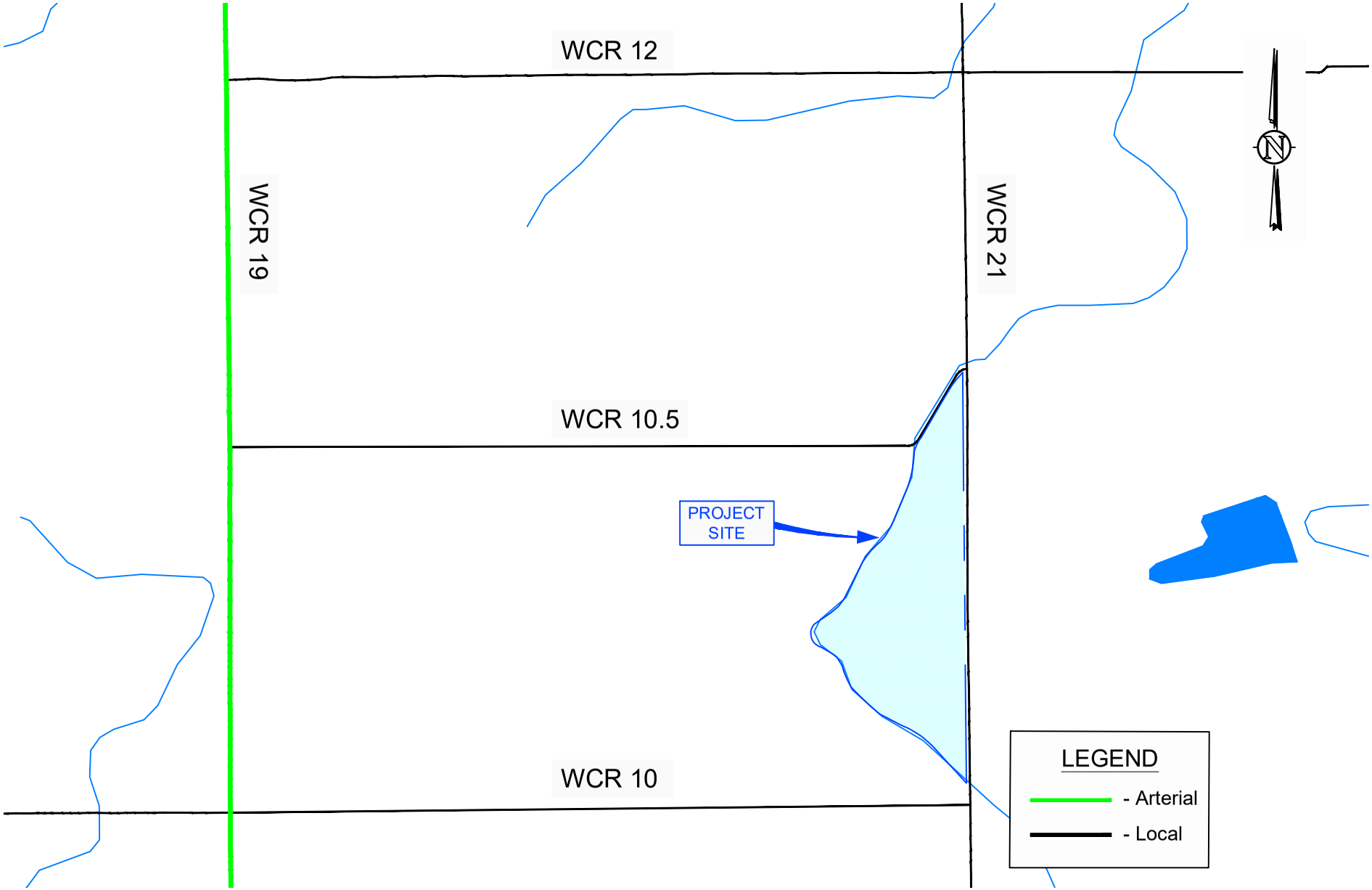
Notes:

1. The trip generation estimate is based on rates contained in Trip Generation, 10th Edition (Institute of Transportation Engineers, September 2017).

Table 3. Intersection Operational Summary

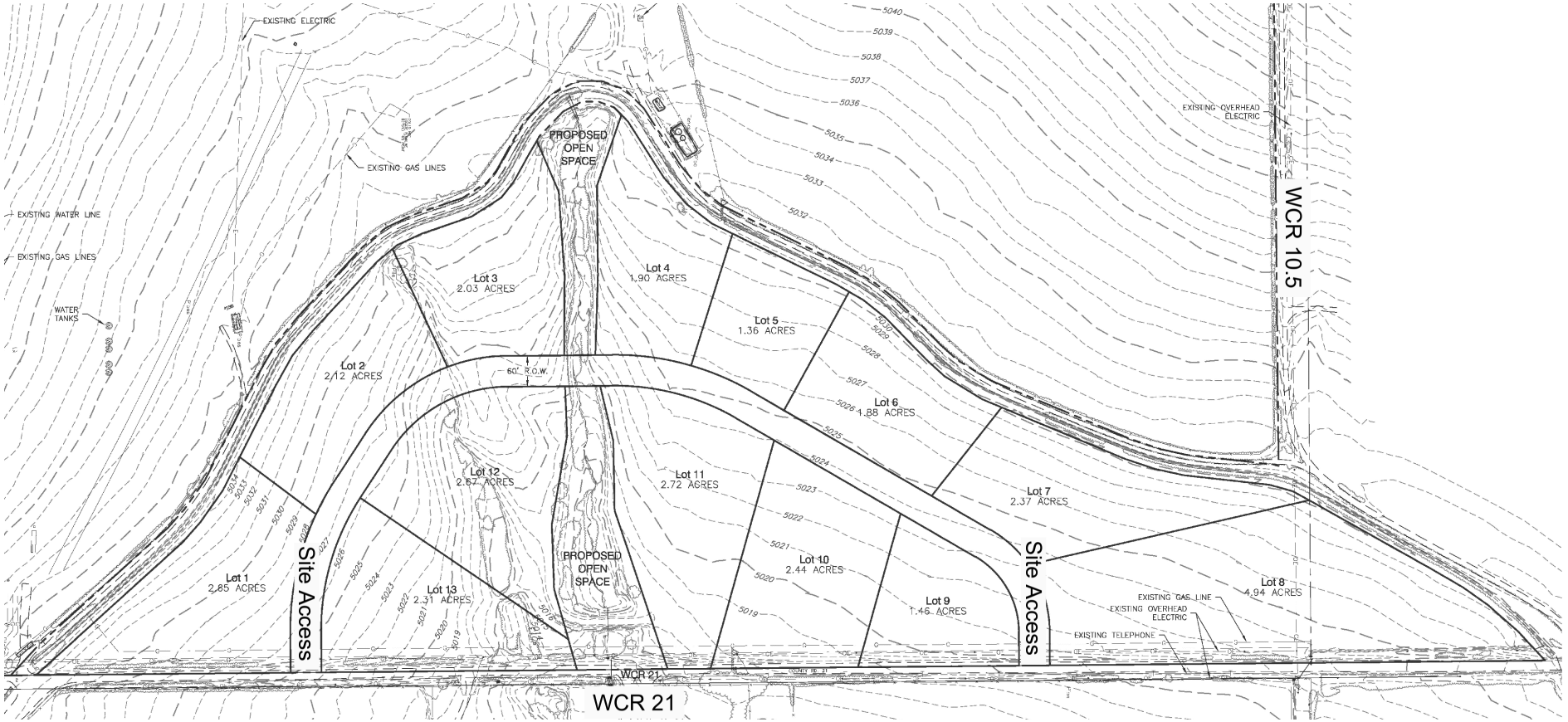
Stop Controlled Intersections	Year 2023 Total				Year 2038 Total			
	Morning		Evening		Morning		Evening	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
WCR 21 / North Site Access								
Northbound Left Turn	7.24	A	7.25	A	7.28	A	7.29	A
Eastbound Left Turn plus Right Turn	8.57	A	8.66	A	8.75	A	8.97	A
WCR 21 / South Site Access								
Northbound Left Turn	7.24	A	7.25	A	7.28	A	7.28	A
Eastbound Left Turn plus Right Turn	8.45	A	8.49	A	8.56	A	8.62	A

Figures



Thunder Valley PUD Traffic Impact Study
VICINITY MAP

Scale	1" = 1,000'	Date	April 23, 2018	Drawn by	JBH	Job #	J&T Consulting, Inc.	Figure	1



Thunder Valley PUD Traffic Impact Study
SITE PLAN

Scale	NTS	Date	April 23, 2018	Drawn by	JBH	Job #	J&T Consulting, Inc.	Figure	2

Figure 3: Existing Traffic Volumes - Morning Peak Hour

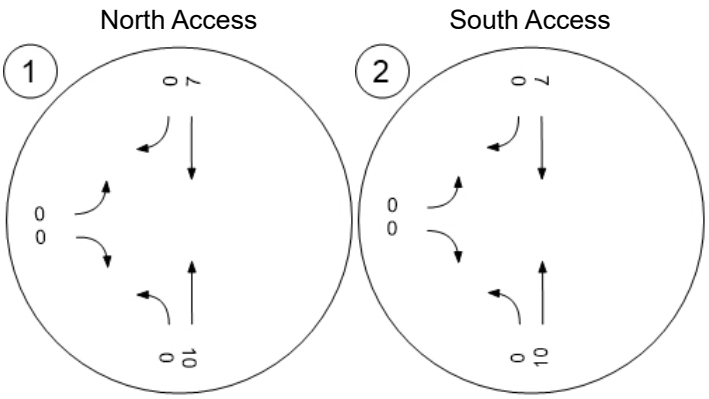
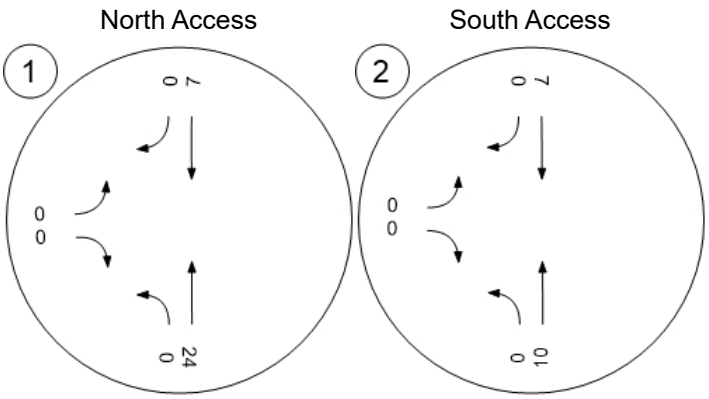
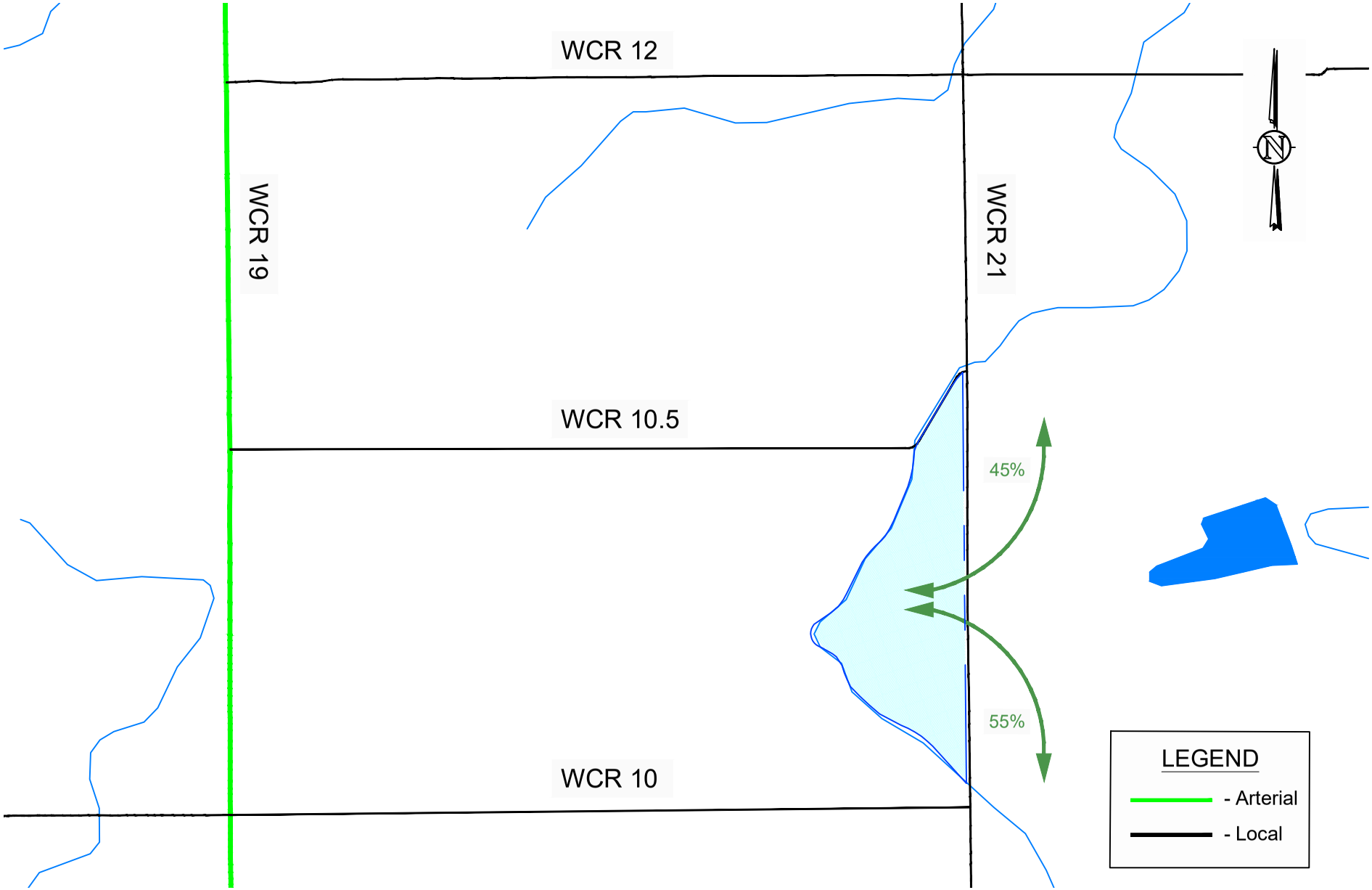


Figure 4: Existing Traffic Volumes - Evening Peak Hour





Thunder Valley PUD Traffic Impact Study
TRIP DISTRIBUTION

Scale	1" = 1,000'	Date	April 23, 2018	Drawn by	JBH	Job #	J&T Consulting, Inc.	Figure	5

Figure 6: Trip Assignment - Morning Peak Hour

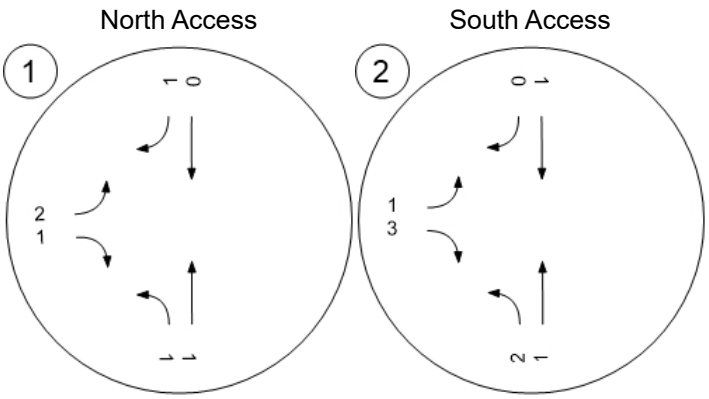


Figure 7: Trip Assignment - Evening Peak Hour

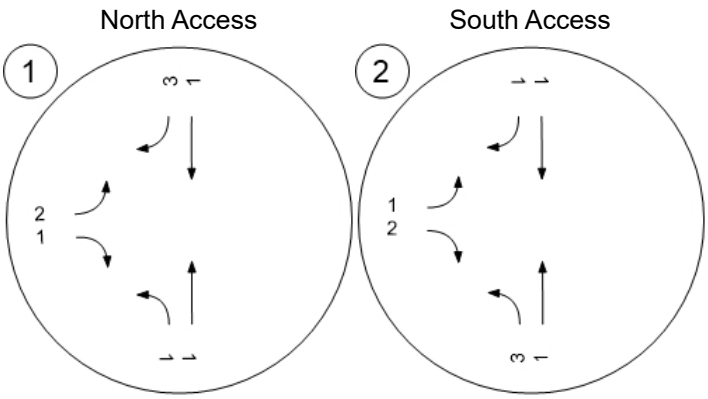


Figure 8: Year 2023 Total Traffic Volumes - Morning Peak Hour

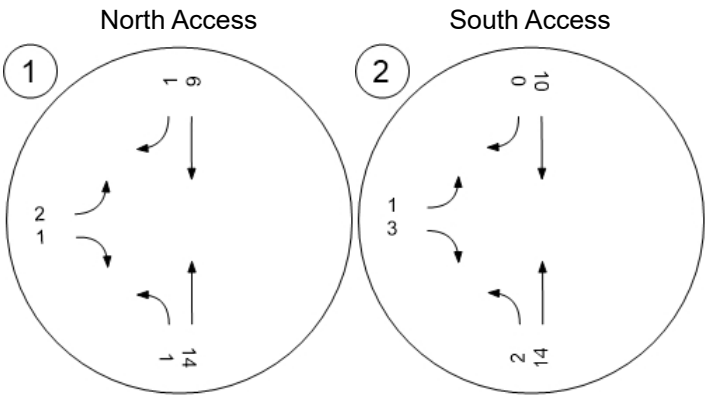


Figure 9: Year 2023 Total Traffic Volumes - Evening Peak Hour

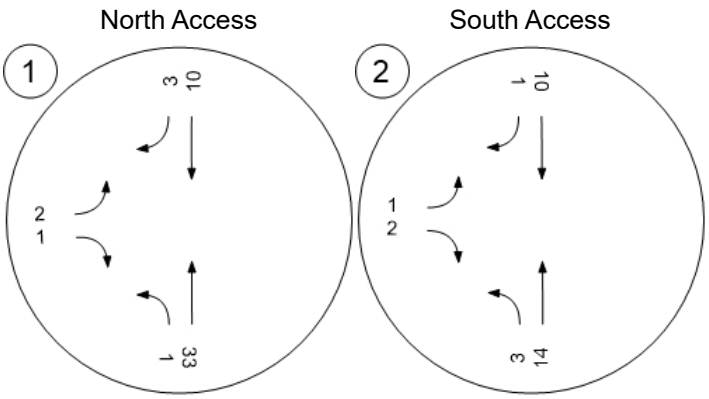


Figure 10: Year 2038 Total Traffic Volumes - Morning Peak Hour

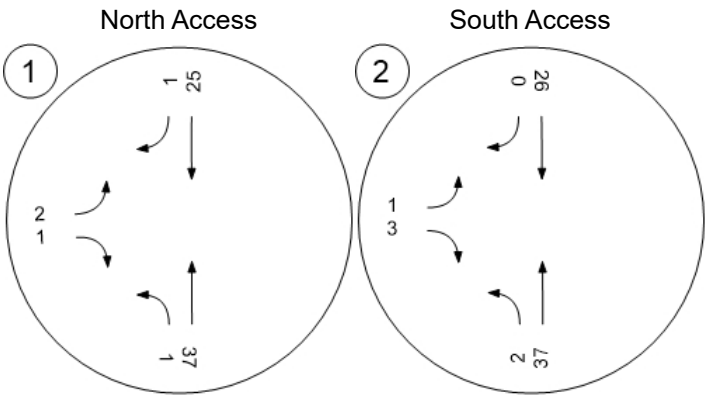


Figure 11: Year 2038 Total Traffic Volumes - Evening Peak Hour

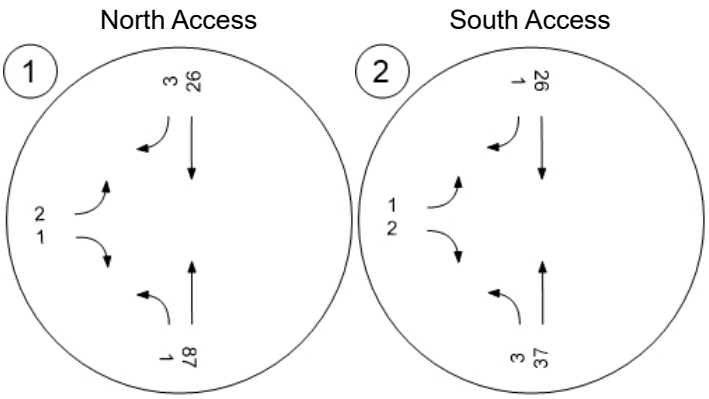
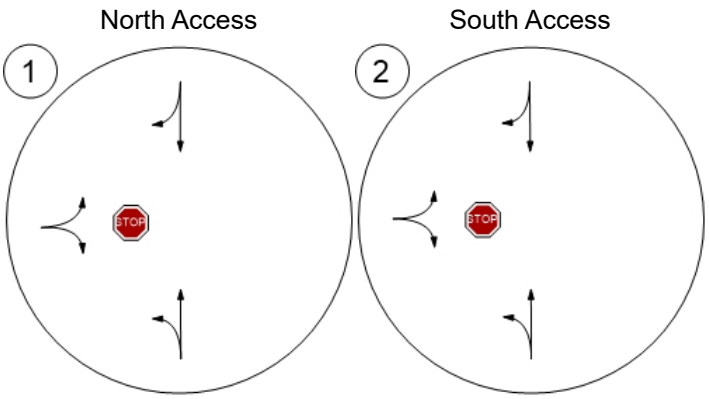


Figure 12: Laneage and Traffic Control - Future



Appendix A

Traffic Count Data

All Traffic Data

Wheat Ridge, CO 80033

Date Start: 05-Apr-18
Date End: 05-Apr-18
Site Code: 1
WCR 21 N/O WCR 10

NB

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
04/05/18	0	2	0	0	0	0	0	0	0	0	0	0	0	2
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
03:00	0	1	1	0	0	0	0	0	0	0	0	0	0	2
04:00	0	1	1	0	0	0	0	0	1	0	0	0	0	3
05:00	0	4	**4**	0	0	0	0	0	0	0	0	0	0	8
06:00	0	1	2	0	0	0	0	0	0	0	0	0	0	3
07:00	0	7	0	0	0	0	0	**1**	1	**1**	0	0	0	10
08:00	0	10	2	0	**1**	0	0	0	0	0	0	0	0	13
09:00	0	**13**	1	0	1	2	0	0	0	0	0	0	0	**17**
10:00	0	3	3	0	0	2	0	1	**2**	0	0	0	0	11
11:00	0	2	3	0	0	**3**	0	1	0	0	0	0	0	9
12 PM	0	10	1	0	**1**	**4**	**2**	0	0	**1**	0	0	**1**	20
13:00	0	6	2	0	0	2	0	**1**	**2**	0	0	0	0	13
14:00	0	9	1	0	0	1	0	1	1	1	0	0	0	14
15:00	0	8	3	0	0	1	2	0	1	0	0	0	1	16
16:00	0	**22**	**4**	0	1	0	0	1	0	0	0	0	0	**28**
17:00	0	20	3	0	0	0	0	0	0	0	0	0	1	24
18:00	0	2	1	0	0	0	0	0	0	0	0	0	0	3
19:00	0	1	1	0	0	0	0	0	0	0	0	0	0	2
20:00	0	2	0	0	0	0	0	0	0	0	0	0	0	2
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
23:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Day Total	0	127	33	0	4	15	4	6	8	3	0	0	3	203
Percent	0.0%	62.6%	16.3%	0.0%	2.0%	7.4%	2.0%	3.0%	3.9%	1.5%	0.0%	0.0%	1.5%	
AM Peak		09:00	05:00		08:00	11:00		07:00	10:00	07:00				09:00
Vol.		13	4		1	3		1	2	1				17
PM Peak		16:00	16:00		12:00	12:00	12:00	13:00	13:00	12:00			12:00	16:00
Vol.		22	4		1	4	2	1	2	1			1	28
Grand Total	0	127	33	0	4	15	4	6	8	3	0	0	3	203
Percent	0.0%	62.6%	16.3%	0.0%	2.0%	7.4%	2.0%	3.0%	3.9%	1.5%	0.0%	0.0%	1.5%	

All Traffic Data

Wheat Ridge, CO 80033

Date Start: 05-Apr-18
Date End: 05-Apr-18
Site Code: 1
WCR 21 N/O WCR 10

SB

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
04/05/18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	1	0	0	0	0	1
03:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
04:00	0	1	2	0	0	0	0	0	0	0	0	0	0	3
05:00	0	2	0	0	0	0	0	0	0	0	0	0	0	2
06:00	**1**	**10**	1	0	0	0	**1**	0	0	0	0	0	0	13
07:00	0	5	2	0	0	0	0	0	0	0	0	0	0	7
08:00	0	8	**3**	0	**2**	0	0	**1**	1	0	0	0	0	15
09:00	0	8	0	0	0	2	0	0	**2**	**1**	0	0	0	13
10:00	0	4	1	0	1	2	0	0	1	0	0	0	0	9
11:00	0	7	2	0	0	**6**	0	0	2	0	0	0	**1**	**18**
12 PM	0	**12**	1	0	0	**2**	0	0	0	**1**	0	0	0	16
13:00	**1**	7	**6**	0	0	2	**1**	0	0	0	0	0	0	**17**
14:00	0	6	1	0	0	1	0	0	**2**	1	0	0	0	11
15:00	0	4	1	0	0	2	0	0	0	0	0	0	0	7
16:00	0	12	0	0	0	0	0	**1**	0	0	0	0	0	13
17:00	1	4	1	0	**1**	0	0	0	0	0	0	0	0	7
18:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
19:00	1	2	0	0	0	0	0	0	0	0	0	0	0	3
20:00	0	3	0	0	0	0	0	0	0	0	0	0	0	3
21:00	0	3	1	0	0	0	0	0	0	0	0	0	0	4
22:00	0	0	1	0	0	0	0	0	0	0	0	0	0	1
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Day Total	4	100	23	0	4	17	2	2	9	3	0	0	1	165
Percent	2.4%	60.6%	13.9%	0.0%	2.4%	10.3%	1.2%	1.2%	5.5%	1.8%	0.0%	0.0%	0.6%	
AM Peak	06:00	06:00	08:00		08:00	11:00	06:00	08:00	09:00	09:00			11:00	11:00
Vol.	1	10	3		2	6	1	1	2	1			1	18
PM Peak	13:00	12:00	13:00		17:00	12:00	13:00	16:00	14:00	12:00				13:00
Vol.	1	12	6		1	2	1	1	2	1				17
Grand Total	4	100	23	0	4	17	2	2	9	3	0	0	1	165
Percent	2.4%	60.6%	13.9%	0.0%	2.4%	10.3%	1.2%	1.2%	5.5%	1.8%	0.0%	0.0%	0.6%	

All Traffic Data

Wheat Ridge, CO 80033

Date Start: 05-Apr-18
Date End: 05-Apr-18
Site Code: 1
WCR 21 N/O WCR 10

NB

Start Time	1 15	16 20	21 25	26 30	31 35	36 40	41 45	46 50	51 55	56 60	61 65	66 70	71 75	76 999	Total	85th Percent	95th Percent
04/05/18	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	39	39
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
02:00	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	39	39
03:00	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	43	44
04:00	0	0	**2**	0	0	1	0	0	0	0	0	0	0	0	3	37	39
05:00	1	**1**	0	1	**3**	2	0	0	0	0	0	0	0	0	8	37	38
06:00	0	0	0	0	2	1	0	0	0	0	0	0	0	0	3	37	39
07:00	2	1	1	3	1	2	0	0	0	0	0	0	0	0	10	36	38
08:00	**7**	0	0	**4**	0	2	0	0	0	0	0	0	0	0	13	35	38
09:00	3	1	1	4	3	**4**	0	**1**	0	0	0	0	0	0	**17**	38	45
10:00	0	0	1	3	3	2	**2**	0	0	0	0	0	0	0	11	40	43
11:00	0	1	1	1	1	4	1	0	0	0	0	0	0	0	9	39	42
12 PM	**1**	**2**	1	5	3	**5**	**3**	0	0	0	0	0	0	0	20	40	43
13:00	0	1	2	3	2	5	0	0	0	0	0	0	0	0	13	38	39
14:00	0	2	1	4	5	0	2	0	0	0	0	0	0	0	14	34	43
15:00	0	2	2	1	4	5	2	0	0	0	0	0	0	0	16	39	42
16:00	1	1	**3**	**12**	7	2	1	**1**	0	0	0	0	0	0	**28**	34	43
17:00	0	2	0	3	**11**	4	3	1	0	0	0	0	0	0	24	40	44
18:00	0	0	0	1	0	0	2	0	0	0	0	0	0	0	3	43	44
19:00	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	33	34
20:00	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	43	44
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
22:00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	29	29
23:00	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	34	34
Total	15	15	15	46	49	42	18	3	0	0	0	0	0	0	203		
Percent	7.4%	7.4%	7.4%	22.7%	24.1%	20.7%	8.9%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	08:00	05:00	04:00	08:00	05:00	09:00	10:00	09:00							09:00		
Vol.	7	1	2	4	3	4	2	1							17		
PM Peak	12:00	12:00	16:00	16:00	17:00	12:00	12:00	16:00							16:00		
Vol.	1	2	3	12	11	5	3	1							28		
Grand Total	15	15	15	46	49	42	18	3	0	0	0	0	0	0	203		
Percent	7.4%	7.4%	7.4%	22.7%	24.1%	20.7%	8.9%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			

15th Percentile :	20 MPH
50th Percentile :	31 MPH
85th Percentile :	38 MPH
95th Percentile :	43 MPH

Statistics

10 MPH Pace Speed :	26-35 MPH
Number in Pace :	95
Percent in Pace :	46.8%
Number of Vehicles > 55 MPH :	0
Percent of Vehicles > 55 MPH :	0.0%
Mean Speed(Average) :	30 MPH

All Traffic Data

Wheat Ridge, CO 80033

Date Start: 05-Apr-18
Date End: 05-Apr-18
Site Code: 1
WCR 21 N/O WCR 10

SB

Start Time	1 15	16 20	21 25	26 30	31 35	36 40	41 45	46 50	51 55	56 60	61 65	66 70	71 75	76 999	Total	85th Percent	95th Percent
04/05/18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
02:00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	29	29
03:00	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	24	24
04:00	0	0	0	1	1	1	0	0	0	0	0	0	0	0	3	37	39
05:00	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	33	34
06:00	0	**3**	0	2	3	3	**2**	0	0	0	0	0	0	0	13	40	43
07:00	0	1	1	2	1	1	1	0	0	0	0	0	0	0	7	39	43
08:00	2	0	**4**	**3**	3	0	2	0	**1**	0	0	0	0	0	15	41	51
09:00	**4**	3	1	0	2	2	1	0	0	0	0	0	0	0	13	37	41
10:00	0	1	1	3	2	1	1	0	0	0	0	0	0	0	9	38	42
11:00	1	0	3	3	**6**	**5**	0	0	0	0	0	0	0	0	**18**	37	39
12 PM	**2**	0	3	**5**	**5**	1	0	0	0	0	0	0	0	0	16	33	35
13:00	1	0	**4**	3	4	**3**	**2**	0	0	0	0	0	0	0	**17**	39	42
14:00	1	**1**	2	3	2	2	0	0	0	0	0	0	0	0	11	35	38
15:00	1	0	2	2	0	0	2	0	0	0	0	0	0	0	7	42	44
16:00	2	0	2	3	2	2	2	0	0	0	0	0	0	0	13	40	43
17:00	1	0	1	4	0	1	0	0	0	0	0	0	0	0	7	29	38
18:00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	29	29
19:00	0	0	1	2	0	0	0	0	0	0	0	0	0	0	3	28	29
20:00	0	0	0	0	1	1	1	0	0	0	0	0	0	0	3	42	44
21:00	0	0	0	0	1	2	0	0	**1**	0	0	0	0	0	4	52	54
22:00	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	19	19
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
Total	15	10	26	39	34	25	14	0	2	0	0	0	0	0	165		
Percent	9.1%	6.1%	15.8%	23.6%	20.6%	15.2%	8.5%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	09:00	06:00	08:00	08:00	11:00	11:00	06:00		08:00						11:00		
Vol.	4	3	4	3	6	5	2		1						18		
PM Peak	12:00	14:00	13:00	12:00	12:00	13:00	13:00		21:00						13:00		
Vol.	2	1	4	5	5	3	2		1						17		
Grand Total	15	10	26	39	34	25	14	0	2	0	0	0	0	0	165		
Percent	9.1%	6.1%	15.8%	23.6%	20.6%	15.2%	8.5%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%			

15th Percentile :	19 MPH
50th Percentile :	29 MPH
85th Percentile :	38 MPH
95th Percentile :	42 MPH

Statistics

10 MPH Pace Speed :	26-35 MPH
Number in Pace :	73
Percent in Pace :	44.2%
Number of Vehicles > 55 MPH :	0
Percent of Vehicles > 55 MPH :	0.0%
Mean Speed(Average) :	29 MPH

All Traffic Data

Wheat Ridge, CO 80033

Date Start: 05-Apr-18
Date End: 05-Apr-18
Site Code: 1
WCR 21 N/O WCR 10

Start Time	05-Apr-18 Thu	NB	SB							Total
12:00 AM		2	0							2
01:00		0	0							0
02:00		1	1							2
03:00		2	1							3
04:00		3	3							6
05:00		8	2							10
06:00		3	13							16
07:00		10	7							17
08:00		13	15							28
09:00		**17**	13							**30**
10:00		11	9							20
11:00		9	**18**							27
12:00 PM		20	16							36
01:00		13	**17**							30
02:00		14	11							25
03:00		16	7							23
04:00		**28**	13							**41**
05:00		24	7							31
06:00		3	1							4
07:00		2	3							5
08:00		2	3							5
09:00		0	4							4
10:00		1	1							2
11:00		1	0							1
Total		203	165							368
Percent		55.2%	44.8%							
AM Peak	-	09:00	11:00	-	-	-	-	-	-	09:00
Vol.	-	17	18	-	-	-	-	-	-	30
PM Peak	-	16:00	13:00	-	-	-	-	-	-	16:00
Vol.	-	28	17	-	-	-	-	-	-	41
Grand Total		203	165							368
Percent		55.2%	44.8%							
ADT		ADT 368		AADT 368						

Appendix B

VISTRO Analysis Results

Intersection Level Of Service Report
Intersection 1: North Access

Control Type:	Two-way stop	Delay (sec / veh):	8.7
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.002

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	10	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	1.34	1.34	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	1	1	0	1	2	1
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	1	14	9	1	2	1
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	0	4	3	0	1	0
Total Analysis Volume [veh/h]	1	16	11	1	2	1
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.24	0.00	0.00	0.00	8.67	8.38
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.00	0.00	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.05	0.05	0.00	0.00	0.22	0.22
d_A, Approach Delay [s/veh]	0.43		0.00		8.57	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	1.03					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 2: South Access

Control Type:	Two-way stop	Delay (sec / veh):	8.7
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.001

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	10	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	1.34	1.34	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	2	1	1	0	1	3
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	2	14	10	0	1	3
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	1	4	3	0	0	1
Total Analysis Volume [veh/h]	2	16	12	0	1	4
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.24	0.00	0.00	0.00	8.69	8.39
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.00	0.00	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.09	0.09	0.00	0.00	0.36	0.36
d_A, Approach Delay [s/veh]	0.80		0.00		8.45	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	1.62					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 1: North Access

Control Type:	Two-way stop	Delay (sec / veh):	8.8
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.002

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	24	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	1.34	1.34	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	1	1	1	3	2	1
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	1	33	10	3	2	1
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	0	10	3	1	1	0
Total Analysis Volume [veh/h]	1	39	12	4	2	1
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.25	0.00	0.00	0.00	8.79	8.39
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.00	0.00	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.05	0.05	0.00	0.00	0.23	0.23
d_A, Approach Delay [s/veh]	0.18		0.00		8.66	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	0.56					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 2: South Access

Control Type:	Two-way stop	Delay (sec / veh):	8.7
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.001

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	10	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	1.34	1.34	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	3	1	1	1	1	2
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	3	14	10	1	1	2
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	1	4	3	0	0	1
Total Analysis Volume [veh/h]	4	16	12	1	1	2
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.25	0.00	0.00	0.00	8.71	8.38
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.01	0.01	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.14	0.14	0.00	0.00	0.22	0.22
d_A, Approach Delay [s/veh]	1.45		0.00		8.49	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	1.51					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 1: North Access

Control Type:	Two-way stop	Delay (sec / veh):	8.9
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.002

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	10	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	3.60	3.60	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	1	1	0	1	2	1
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	1	37	25	1	2	1
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	0	11	7	0	1	0
Total Analysis Volume [veh/h]	1	44	29	1	2	1
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.28	0.00	0.00	0.00	8.89	8.46
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.00	0.00	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.05	0.05	0.00	0.00	0.23	0.23
d_A, Approach Delay [s/veh]	0.16		0.00		8.75	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	0.43					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 2: South Access

Control Type:	Two-way stop	Delay (sec / veh):	8.9
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.001

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	10	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	3.60	3.60	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	2	1	1	0	1	3
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	2	37	26	0	1	3
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	1	11	8	0	0	1
Total Analysis Volume [veh/h]	2	44	31	0	1	4
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.28	0.00	0.00	0.00	8.92	8.47
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.00	0.00	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.09	0.09	0.00	0.00	0.37	0.37
d_A, Approach Delay [s/veh]	0.32		0.00		8.56	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	0.70					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 1: North Access

Control Type:	Two-way stop	Delay (sec / veh):	9.2
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.002

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	24	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	3.60	3.60	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	1	1	1	3	2	1
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	1	87	26	3	2	1
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	0	26	8	1	1	0
Total Analysis Volume [veh/h]	1	102	31	4	2	1
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.29	0.00	0.00	0.00	9.22	8.47
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.00	0.00	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.05	0.05	0.00	0.00	0.25	0.25
d_A, Approach Delay [s/veh]	0.07		0.00		8.97	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	0.24					
Intersection LOS	A					

Intersection Level Of Service Report
Intersection 2: South Access

Control Type:	Two-way stop	Delay (sec / veh):	8.9
Analysis Method:	HCM 6th Edition	Level Of Service:	A
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.001

Intersection Setup

Name						
Approach	Northbound		Southbound		Eastbound	
Lane Configuration						
Turning Movement	Left	Thru	Thru	Right	Left	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Pocket	0	0	0	0	0	0
Pocket Length [ft]	100.00	100.00	100.00	100.00	100.00	100.00
Speed [mph]	30.00		30.00		30.00	
Grade [%]	0.00		0.00		0.00	
Crosswalk	Yes		Yes		Yes	

Volumes

Name						
Base Volume Input [veh/h]	0	10	7	0	0	0
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	22.00	22.00	2.00	2.00	2.00
Growth Rate	1.00	3.60	3.60	1.00	1.00	1.00
In-Process Volume [veh/h]	0	0	0	0	0	0
Site-Generated Trips [veh/h]	3	1	1	1	1	2
Diverted Trips [veh/h]	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0
Total Hourly Volume [veh/h]	3	37	26	1	1	2
Peak Hour Factor	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	1	11	8	0	0	1
Total Analysis Volume [veh/h]	4	44	31	1	1	2
Pedestrian Volume [ped/h]	0		0		0	

Intersection Settings

Priority Scheme	Free	Free	Stop
Flared Lane			No
Storage Area [veh]	0	0	0
Two-Stage Gap Acceptance			No
Number of Storage Spaces in Median	0	0	0

Movement, Approach, & Intersection Results

V/C, Movement V/C Ratio	0.00	0.00	0.00	0.00	0.00	0.00
d_M, Delay for Movement [s/veh]	7.28	0.00	0.00	0.00	8.94	8.46
Movement LOS	A	A	A	A	A	A
95th-Percentile Queue Length [veh/ln]	0.01	0.01	0.00	0.00	0.01	0.01
95th-Percentile Queue Length [ft/ln]	0.14	0.14	0.00	0.00	0.23	0.23
d_A, Approach Delay [s/veh]	0.61		0.00		8.62	
Approach LOS	A		A		A	
d_I, Intersection Delay [s/veh]	0.66					
Intersection LOS	A					

Sustainable Traffic Solutions
Joseph L. Henderson PE, PTOE
Traffic Engineer / Principal

March 8, 2020

Mr. JC York, PE
J&T Consulting, Inc.
305 Denver Avenue, Suite D
Fort Lupton, CO 80621

RE: Evaluation of SH 52 / WCR 21 Related to the Thunder Valley PUD

Dear JC,

Based on your request, I have evaluated the impact of the traffic that is expected to be generated by the Thunder Valley PUD on the intersection of SH 52 / WCR 21. The evaluation includes two tests. First, the percentage increase in traffic on WCR 21 that would result from the development was determined. Second, the need for auxiliary lanes on SH 52 was evaluated. The Thunder Valley PUD is proposed as a residential development with 13 single family dwelling units. It will be west of WCR 21 between WCR 10 and WCR 10.5. Sustainable Traffic Solutions prepared a traffic impact study for the development that is dated April 23, 2018.

The percentage increase in traffic on WCR 21 south of SH 52 as a result of the development traffic was estimated using daily volumes that were collected for the traffic impact study. On April 5, 2018, there were 368 vehicles recorded on WCR 21 north of WCR 10. The development is expected to generate 123 trips daily and 55 of those trips are expected to travel to and from SH 52. Assuming that all 368 vehicles recorded on April 5, 2018 passed through SH 52 / WCR 21, the percentage increase that would result from the development traffic will be 13%. The volume increase is less than 20% as discussed in Section 2.6(3), therefore, a CDOT access permit will not be required to construct the development.

The need for auxiliary lanes at SH 52 / WCR 21 was determined based on the requirements that are contained in the CDOT Access Code[1]. SH 52 is classified as an R-A roadway in the vicinity of WCR 21 and the speed limit is 65 MPH. Peak hour volumes collected on Wednesday March 4, 2020 (see attached) and the peak hour trip assignment from the traffic impact study were used for the analysis. The volumes are summarized in the following table.

Peak Hour	SH 52		WCR 21	
	EBRT	WBLT	NBLT	NBRT
Morning Peak Hour				
March 4, 2020	1	1	3	0
Thunder Valley PUD	1	0	2	1
Total	2	1	5	1
Evening Peak Hour				
March 4, 2020	1	2	3	6
Thunder Valley PUD	2	2	2	1
Total	3	4	5	7

[1] State Highway Access Code. State of Colorado. March 2002.

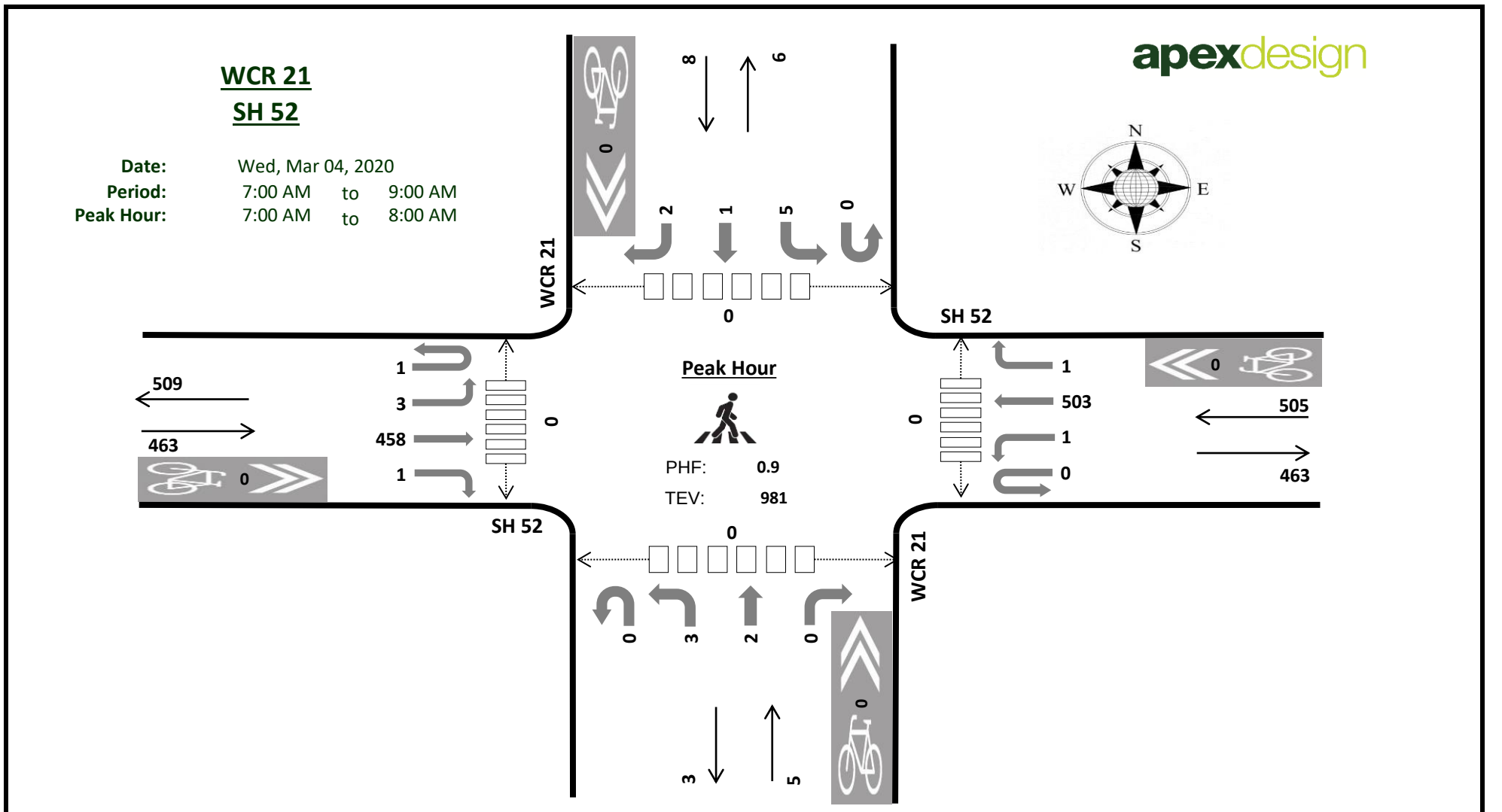
The following bullets discuss the need for auxiliary lanes on SH 52.

- **Westbound Left Turn Deceleration Lane.** A left turn deceleration lane with taper and storage length is required for any access with a projected peak hour left ingress turning volume greater than 10 vph. The taper length will be included within the required deceleration length. **The evening peak hour volume of four vehicles falls below the threshold of 10 vph, therefore, a left turn deceleration lane is not required.**
- **Eastbound Right Turn Deceleration Lane.** A right turn deceleration lane and taper length is required for any access with a projected peak hour right ingress turning volume greater than 25 vph. The taper length will be included within the required deceleration length. **The evening peak hour volume of three vehicles falls below the threshold of 25 vph, therefore, a right turn deceleration lane is not required.**
- **Northbound Right Turn Acceleration Lane.** A right turn acceleration lane and taper length is required for any access with a projected peak hour right turning volume greater than 50 vph when the posted speed on the highway is greater than 40 mph. The taper length will be included within the required acceleration length. A right turn acceleration lane may also be required at a signalized intersection if a free-right turn is needed to maintain an appropriate level of service in the intersection. **The evening peak hour volume of seven vehicles falls below the threshold of 50 vph, therefore, a right turn acceleration lane is not required.**
- **Northbound Left Turn Acceleration Lane.** A left turn acceleration lane may be required if it would be a benefit to the safety and operation of the roadway or as determined by subsection 3.5. A left turn acceleration lane is generally not required where; the posted speed is less than 45 mph, or the intersection is signalized, or the acceleration lane would interfere with the left turn ingress movements to any other access. **A left turn acceleration lane is not required based on the criteria in Section 3.5.**

Feel free to contact me with questions.

Sincerely,

Joseph L. Henderson, PE, PTOE
Project Manager / Principal
SH 52-WCR 21 Thunder Valley PUD



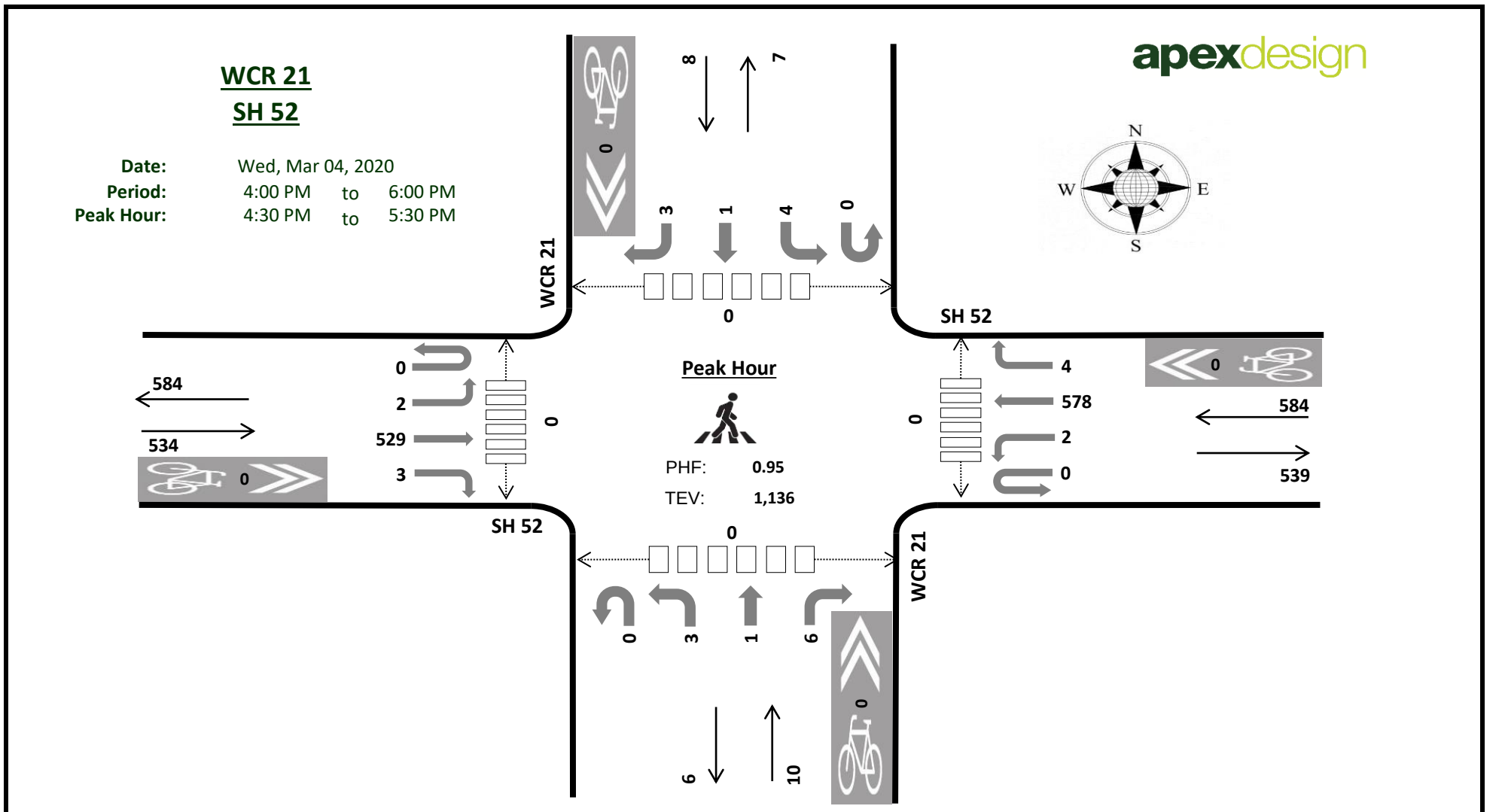
Summary

Time	SH 52 Eastbound				SH 52 Westbound				WCR 21 Northbound				WCR 21 Southbound				Total	Rolling Hour
	UT	LT	TH	RT	UT	LT	TH	RT	UT	LT	TH	RT	UT	LT	TH	RT		
7:00 AM	**0**	**1**	**103**	**0**	**0**	**0**	**123**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**231**	0
7:15 AM	**0**	**1**	**128**	**0**	**0**	**0**	**134**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**265**	0
7:30 AM	**1**	**0**	**127**	**0**	**0**	**0**	**137**	**0**	**0**	**2**	**2**	**0**	**0**	**1**	**1**	**0**	**271**	0
7:45 AM	**0**	**1**	**100**	**1**	**0**	**1**	**109**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**214**	981
8:00 AM	0	1	78	0	0	4	87	0	0	0	2	1	0	1	1	0	175	925
8:15 AM	0	0	79	0	0	2	109	1	0	0	0	0	0	1	0	1	193	853
8:30 AM	0	0	91	1	0	1	99	3	0	0	0	0	0	1	0	2	198	780
8:45 AM	0	0	68	0	0	1	96	0	0	1	0	0	0	0	0	0	166	732
Count Total	**1**	**4**	**774**	**2**	**0**	**9**	**894**	**5**	**0**	**4**	**4**	**1**	**0**	**8**	**2**	**5**	**1,713**	**0**
Peak Hour	**1**	**3**	**458**	**1**	**0**	**1**	**503**	**1**	**0**	**3**	**2**	**0**	**0**	**5**	**1**	**2**	**981**	**0**
PH HV %	**9.07%**				**10.89%**				**0.00%**				**12.50%**					
PHF	**0.90**				**0.92**				**0.31**				**0.50**					

Classifications by Approach

Time	Heavy Vehicles EB	WB	NB	SB	Total	Bicycles EB	WB	NB	SB	Total	Pedestrians East	West	North	South	Total
7:00 AM	**7**	**13**	**0**	**0**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
7:15 AM	**10**	**10**	**0**	**0**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
7:30 AM	**12**	**15**	**0**	**1**	**28**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
7:45 AM	**13**	**17**	**0**	**0**	**30**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
8:00 AM	16	15	1	0	32	0	0	0	0	0	0	0	0	0	0
8:15 AM	14	24	0	0	38	0	0	0	0	0	0	0	0	0	0
8:30 AM	19	16	0	0	35	0	0	0	0	0	0	0	0	0	0
8:45 AM	15	26	0	0	41	0	0	0	0	0	0	0	0	0	0
Count Total	**106**	**136**	**1**	**1**	**244**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Peak Hour	**42**	**55**	**0**	**1**	**98**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Nathan Warren: (720) 660-4048
nathan.warren@apexdesignpc.com



Summary

Time	SH 52 Eastbound				SH 52 Westbound				WCR 21 Northbound				WCR 21 Southbound				Total	Rolling Hour
	UT	LT	TH	RT	UT	LT	TH	RT	UT	LT	TH	RT	UT	LT	TH	RT		
4:00 PM	0	0	126	0	0	0	122	0	0	1	0	3	0	2	0	1	255	0
4:15 PM	0	0	122	3	0	1	141	1	0	0	0	1	0	1	0	0	270	0
4:30 PM	**0**	**0**	**136**	**0**	**0**	**1**	**149**	**0**	**0**	**0**	**0**	**5**	**0**	**3**	**0**	**1**	**295**	0
4:45 PM	**0**	**1**	**123**	**0**	**0**	**0**	**122**	**3**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**2**	**254**	1,074
5:00 PM	**0**	**0**	**136**	**2**	**0**	**0**	**149**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**289**	1,108
5:15 PM	**0**	**1**	**134**	**1**	**0**	**1**	**158**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**298**	1,136
5:30 PM	0	0	138	1	0	1	123	2	0	0	0	0	0	1	0	1	267	1,108
5:45 PM	0	0	117	2	0	0	106	1	0	1	0	1	0	0	0	1	229	1,083
Count Total	**0**	**2**	**1,032**	**9**	**0**	**4**	**1,070**	**8**	**0**	**5**	**1**	**11**	**0**	**8**	**1**	**6**	**2,157**	**0**
Peak Hour	**0**	**2**	**529**	**3**	**0**	**2**	**578**	**4**	**0**	**3**	**1**	**6**	**0**	**4**	**1**	**3**	**1,136**	**0**
PH HV %	**6.18%**				**3.77%**				**0.00%**				**12.50%**					
PHF	**0.97**				**0.91**				**0.50**				**0.50**					

Classifications by Approach

Time	Heavy Vehicles EB	WB	NB	SB	Total	Bicycles EB	WB	NB	SB	Total	Pedestrians East	West	North	South	Total
4:00 PM	5	6	1	1	13	0	0	0	0	0	0	0	0	0	0
4:15 PM	12	10	0	0	22	0	0	0	0	0	0	0	0	0	0
4:30 PM	**12**	**7**	**0**	**1**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
4:45 PM	**11**	**4**	**0**	**0**	**15**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
5:00 PM	**6**	**3**	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
5:15 PM	**4**	**8**	**0**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
5:30 PM	7	6	0	0	13	0	0	0	0	0	0	0	0	0	0
5:45 PM	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0
Count Total	**59**	**45**	**1**	**2**	**107**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Peak Hour	**33**	**22**	**0**	**1**	**56**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Nathan Warren: (720) 660-4048
nathan.warren@apexdesignpc.com

PHASE III DRAINAGE REPORT

THUNDER VALLEY PUD

EAST ½, SOUTHEAST ¼, SECTION 10, T1N, R67W
WELD COUNTY, CO

MARCH 2020

PREPARED FOR:

4Z INVESTMENTS, LLC
9075 WCR 10
FORT LUPTON, CO 80621

PREPARED BY:

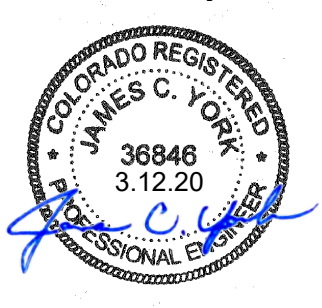
J&T Consulting, Inc.

305 DENVER AVENUE, SUITE D
FORT LUPTON, CO 80621
PHONE: 303-857-6222
FAX: 303-857-6224

Table of Contents

Standard Statement 1

"I hereby affirm that this report and plan for the Phase III drainage design of the development, Thunder Valley PUD, was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Fort Lupton Storm Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Fort Lupton does not and will not assume liability for drainage facilities designed by others. I am also aware of the provisions of the City CODE as it pertains to the City's review."



James C. York, PE
Registered Professional Engineer
State of Colorado No. 36846

Standard Statement 2

4Z Investments, LLC hereby affirms that the drainage facilities for the development, Thunder Valley PUD, shall be constructed according to the design presented in this report. I understand that the City of Fort Lupton does not and will not assume liability for drainage facilities designed and/or certified by my engineer. I understand that the City of Fort Lupton reviews drainage plans but cannot, on behalf of 4Z Investments, LLC and/or their successors and/or assigns assume future liability for improper design. I am also aware of the provisions of the City CODE as it pertains to the City's review."

Chris Zadel

Name of Developer/Owner

Chris Zadel Managing Partner

Authorized Signature/Title

Standard Form SF-3

Indemnification Statement

I am the Owner of Thunder Valley PUD, and as such am preparing to begin construction of the Thunder Valley PUD.

I hereby promise to indemnify and hold harmless the City of Fort Lupton for any liability the City may have on account of any change in the nature, direction, quantity, or quality of historical drainage flow resulting from the development of my property or from the construction of streets or storm sewers therein. In addition, I promise to reimburse the City for any and all costs including, but not limited to, attorney's fees, which the City incurs in acquiring or condemning any rights-of-way or easements which the City is required to acquire or condemn or which the City is held to have acquired or condemned, for drainage as a result of the development of my property.

I understand that I will be afforded a full opportunity to participate in the settlement and defense of any claims for which indemnity may be required under this paragraph.

Chris Zadel

By: Chris Zadel - 4 Z Investments, LLP

ATTEST:

I. GENERAL LOCATION AND DESCRIPTION

A. Introduction and Location

The purpose of this report is to describe and address the drainage impacts resulting from future development associated with Thunder Valley PUD.

The site is located in the east one-half of the southeast quarter of Section 10, Township 1 North, Range 67 West of the 6th P.M., Weld County, Colorado (see Vicinity Map in Appendix B). No streets are currently within the site. The property is on the west side of Weld County Road (WCR) 21 approximately 150 feet north of WCR 10. The site is bounded on the north by private property, the east by WCR 21, the west by private property, and the south by private property. The Bull Ditch runs adjacent to the west side of the site. There are no major drainage ways or storm drainage facilities within or adjacent to the site. There are no developments in the surrounding area. There are no existing developments adjacent to Thunder Valley PUD.

B. Description of Property

The entire site encompasses 36.27 acres. The majority of the existing vegetation within the site consists of pasture lands. The ground generally gently slopes to the east. The soil has a moderate infiltration rate. The minor drainageway through the property is centrally located from the Bull Ditch running east to WCR 21. The Bull Ditch runs along the west boundary of the PUD.

Thunder Valley PUD proposes low density single family residential lots of approximately one to four acres in size.

A portion of the development has non-jurisdictional wetlands. The area is located between the irrigation ditch and WCR 21. The area is approximately 2.1 acres.

DRAINAGE BASINS

C. Major Basin Description

There are no existing major drainageway planning studies for the area .The FEMA Flood Insurance Rate Maps (FIRM) show that the PUD is an Area of Minimal Flood Hazard. The proposed

development is located on Community Panels No. 08123C2105E and No. 08123C2115E, updated January 28, 2016. See FIRMettes National Flood Hazard Map included in Appendix A.

The existing land use is pasture land. The proposed land use is low density residential lots. The land generally slopes east and to the center of the proposed development. The water then flows under WCR 21 via a culvert to the east side of the road.

The Bull Ditch runs along the western edge of the basin. There are no lakes or ponds which may influence the drainage or may be influenced by the change in drainage in the PUD.

D. Sub-Basin Description

No Master Plan exists which encompasses the property.

The historic storm water runoff generated by this site sheet flows to the southeast or northeast, depending on the portion of the property, towards the center of the PUD to the east. It exits the site along the east to travel under WCR 21. Historic runoff is calculated using the Rational Method. See Appendix C for historic runoff calculations.

All offsite basins to the west of the property are included in overland flow for basins A, B, D, and G then will be directed to the roadside ditches and to the detention pond. There is no offsite flow from the north, south, or east. See existing and proposed basins in Figure 2 through Figure 3 in Appendix B.

The downstream drainage flow pattern will be unchanged. The runoff discharge will be limited to the existing historic site runoff rate for Hydrologic Soil Type B from Section 14 of the City of Fort Lupton Storm Drainage Design and Technical Criteria flow. It will continue to be discharged from the PUD to the same location as it has been pre-development. The proposed PUD will have no detrimental effects on the downstream drainage area under existing or fully developed conditions.

II. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference and Constraints

A Phase I drainage report was completed for the site. It found that the site can be developed in the manner proposed with no impacts to downstream property with proper management of storm flows by developing the storm water detention pond and releasing at the allowable historic

rate outlined by the City of Fort Lupton. There are no previous studies for the site that will influence or are influenced by the development of Thunder Valley PUD.

Adjacent properties have not had drainage studies completed.

Site constraints are minimal. There are no existing structures on the site. Utilities are located along WCR 21. The roadside ditches exist as does a culvert under WCR 21. The utilities for the roadway, proposed in the plan, will not be affected by the storm water drainage plan. The proposed roadway will require the use of culverts to transport the water to the detention pond located centrally on the site.

Non-jurisdictional wetlands have been identified in the center of the site. Irrigation water is transferred from the Bull Ditch, into the drainageway, and under WCR21 via an existing culvert. These flows will be conveyed along the same drainageway into the proposed detention pond and will be released via a 36” RCP pipe with a headwall and slide gate. This gate will only be open when irrigation flows are present.

B. Hydrologic Criteria

The design rainfall used for the project is from Section 5 of the City of Fort Lupton’s Storm Drainage Design and Technical Criteria.

Runoff for each proposed basin, and the off-site basins, were calculated using the Colorado Urban Hydrograph Procedure as defined in Section 6 of the City of Fort Lupton’s Storm Drainage Design and Technical Criteria.

C. Hydraulic Criteria

The existing 24” X 36” CMP culvert running under WCR 21 currently has inadequate capacity release the offsite and detained on-site flows during a 100-year storm event. The CMP culvert will need to be replaced with a box culvert. The site release will be at 0.85 cfs per acre, 30.83 cfs for the site, and a maximum flow, including off-site flows, of 186.28 cfs for the site. See Appendix E for culvert and ditch calculations.

The storm water runoff will be transported via a collection of swales, roadside ditches, and culverts. All runoff will be directed to the detention pond that will be constructed centrally in the PUD.

The allowed detention discharge for the 5-year storm is 4.72 cfs, and for the 100-year storm is 30.83 cfs. The soil type is hydrologic soil group B which the criteria states is allowed to have a runoff rate of 0.13 cfs/acre for the 5-year storm and 0.85cfs/acre for the 100-year storm. See Appendix A for the hydrologic soil group map.

Required detention storage was calculated with the Modified FAA method. The Urban Drainage and Flood Control District's provided spreadsheets were used to calculate the water quality control, 5-year, and 100-year storm volumes. Water Quality Control Volume is 0.224 acre-feet, 5-year volume is 0.494 acre-feet, and 100-year volume is 1.882 acre-feet. See Appendix F for the stage storage table.

D. Adaptations from Criteria

No adaptations have been requested from the City's Criteria.

III. DRAINAGE FACILITY DESIGN

A. General Concept

The existing drainage pattern for the property flows generally from west to east. The north portion flows southeast. The south portion flows northeast. The two areas generally flow to a swale which then enters a culvert which directs the flow to the east of WCR 21. A section of each portion is directed to roadside swales on the west side of WCR 21. This flow travels through the same culvert to the east side of WCR 21. Culverts and ditches are sized appropriately to handle the maximum flow rates determined by the Colorado Urban Hydrograph Procedure (CUHP) and EPA's storm water management model (SWMM). CUHP and SWMM results are in Appendix D.

There is off-site runoff that enters the PUD property from the property located to the west. See Figure 3 in appendix A for the offsite basin. The on-site runoff will be attenuated for all storms from existing runoff levels to a maximum of 30.83 cfs for the 100-year storm. This will improve the downstream off-site runoff. All off-site flows will pass directly through the site, matching existing flow patterns and volumes.

There are no existing drainage problems or concerns on or off site for the proposed PUD.

The anticipated drainage pattern for the PUD will be similar to the pre-development pattern. Typically, storm water runoff will flow from rooftops and combine with overland flow from yards and/or pasture. Runoff will be allowed to sheet flow and then be collected in “side lot” swales which will convey these flows to a drainage swale system. The flows will be directed to the existing low point on the property with swales and roadside ditches. A detention pond will be constructed in this area with an outlet structure that will control the runoff releases per the design criteria.

B. Specific Details

No drainage problems have been identified as being a problem for the development of the proposed PUD. All storm water appurtenances will be designed to allow for the runoff to be controlled per the City’s Drainage Policy.

The detention pond storage has been designed per the requirements laid out in the City’s Criteria. The storage will be located centrally on the PUD site. The outlet will be designed utilizing design details provided by Urban Drainage and Flood Control District. The outlet will have orifice control and weir controls for the water quality, 5-year, and 100-year detention requirements. See Appendix G for the UDFCD Outlet and Detention calculations.

The pond will be designed to provide access to maintain the bottom and sides. The sides will be no steeper than 4:1. The outlet structure will be constructed so that equipment can be used to clear any obstructions from it.

The majority of the drainage infrastructure will be located within the roadway corridor for the roadside ditches. The proposed open space tract located to the east of the proposed road between Lot 11 and Lot 12 will be the location of the detention pond. The open space tracts will be designated as drainage easements. Drainage easements will also be required along the west side of the roadway corridor and along the east boundary of the site.

The drainage downstream of the proposed PUD will not be affected by the change in the land use. The detention pond outlet structure will control the runoff of the water quality volume, 5-year, and 100-year storm per the City’s Criteria.

There are no alterations to the existing 100-year floodplain with the development of Thunder Valley PUD. The major drainage way that the PUD is located in will not be affected by the development. The flow will be controlled to release a lesser rate than pre-development in most cases do to the

requirement to release at the historic rate listed in the Criteria. The outflow culvert will be replaced and sized appropriately to handle the maximum total flow as determined by the CUHP and SWMM modeling. See Appendix D for the basin hydrographs and maximum flow rates.

IV. SUMMARY

The drainage system design for Thunder Valley PUD is within compliance of the City's Criteria and the UDFCD's Manuals. There are no major drainageway planning studies for the area.

Flows will be directed to the appropriate infrastructure for transportation to the detention pond, which is located at the current low-point on the property, where the flows currently collect.

REFERENCES

City of Fort Lupton Storm Drainage Design and Technical Criteria, City of Fort Lupton.

FIRM 08123C2105E, Federal Emergency Management Agency, access March 2018.

FIRM 08123C2115E, Federal Emergency Management Agency, access March 2018.

Soil Survey Area: Weld County, Colorado, Southern Part (CO618), Natural Resources Conservation Service, access March 2018.

Urban Storm Drainage Criteria Manual Volume 1, Urban Drainage and Flood Control District, March, 2017.

Urban Storm Drainage Criteria Manual Volume 2, Urban Drainage and Flood Control District, September, 2017.

Urban Storm Drainage Criteria Manual Volume 3, Urban Drainage and Flood Control District, March, 2015.

Software Used:

Civil 3D Hydraflow Express

Urban Drainage and Flood Control District Rational Method Spreadsheet; Version 2.00

Urban Drainage and Flood Control District Detention Spreadsheet, Version 2.35

Colorado Urban Hydrograph Procedure, Version 2.0.1

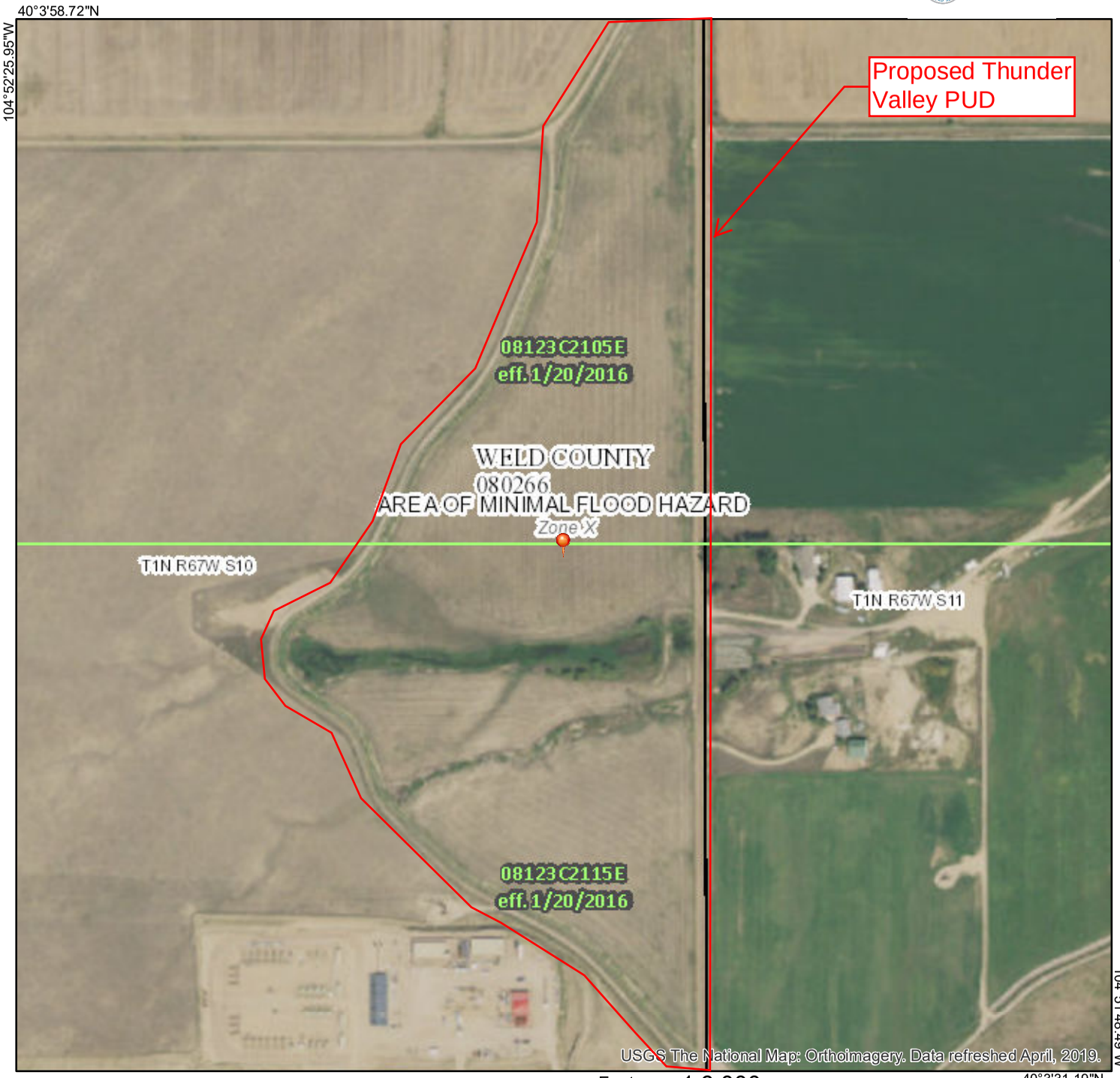
EPA Storm Water Management Model, Version 5.1

VI. Appendix A

A. **FEMA FIRMette**
B. **National Resource Conservation Service Soils Information**

National Flood Hazard Layer FIRMette

FEMA



Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A, V, A99*
	With BFE or Depth *Zone AE, AO, AH, VE, AR*
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard *Zone X*
	Effective LOMRs
	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
	Coastal Transect
	513 Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
MAP PANELS	Digital Data Available
	No Digital Data Available
	Unmapped

N

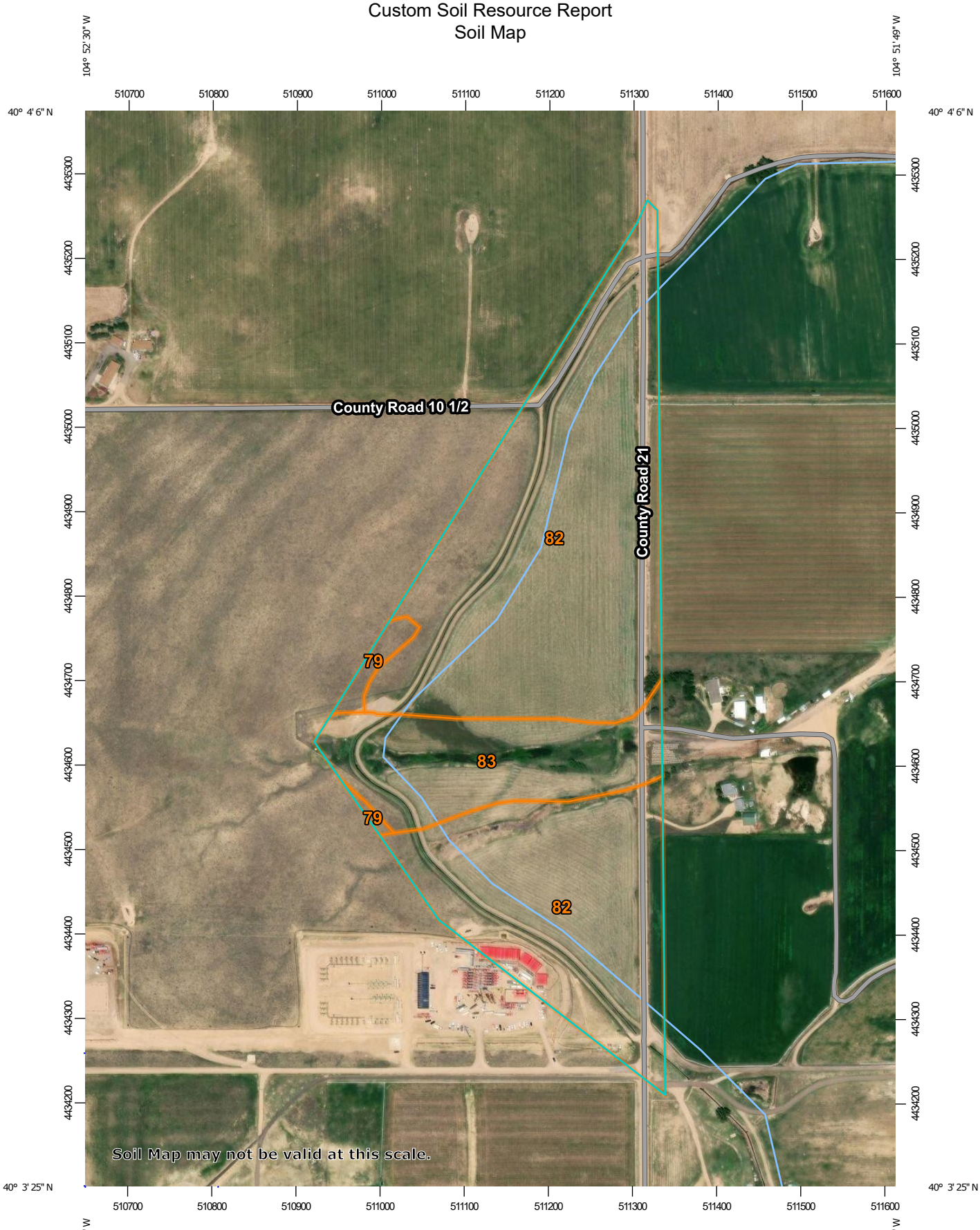
The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 3/10/2020 at 5:33:15 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Custom Soil Resource Report
Soil Map



Map Scale: 1:6,210 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 50 100 200 300

Feet
0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

Hydrologic Soil Group and Surface Runoff

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

Report—Hydrologic Soil Group and Surface Runoff

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Hydrologic Soil Group and Surface Runoff–Weld County, Colorado, Southern Part			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
79—Weld loam, 1 to 3 percent slopes			
Weld	80	Medium	C

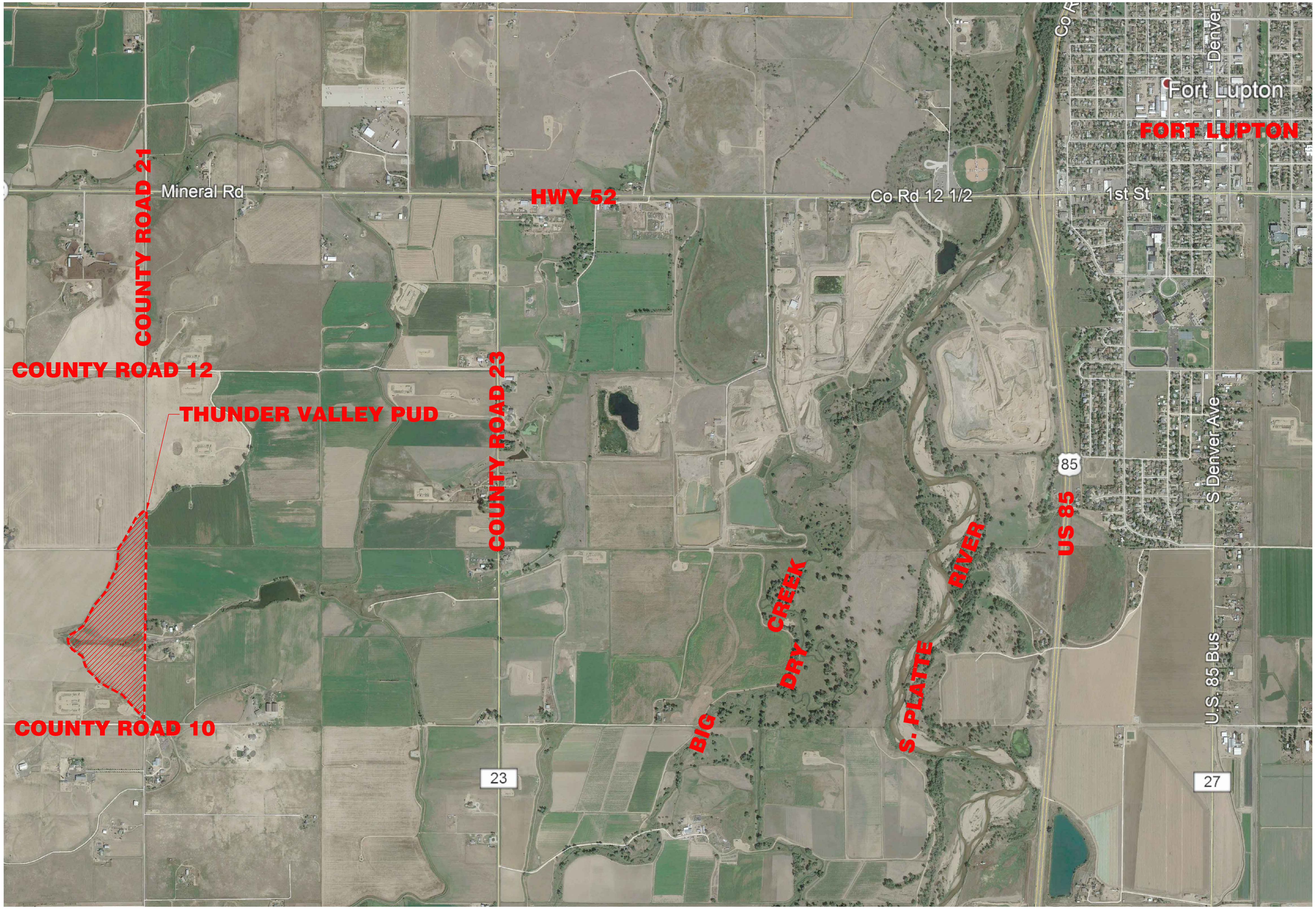
Hydrologic Soil Group and Surface Runoff–Weld County, Colorado, Southern Part			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
82—Wiley-Colby complex, 1 to 3 percent slopes			
Wiley	60	Low	B
Colby	30	Low	B
83—Wiley-Colby complex, 3 to 5 percent slopes			
Wiley	55	Low	B
Colby	30	Low	B

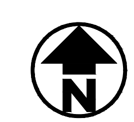
Data Source Information

Soil Survey Area: Weld County, Colorado, Southern Part
Survey Area Data: Version 18, Sep 13, 2019

VII. Appendix B

A. **Vicinity Map**
B. **Path to Major Drainageway Map**
C. **Existing Basins Map**
D. **Proposed Basins Map**
E. **Off-Site and On-Site Proposed Basins Map**





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305 Denver Avenue - Suite D
Fort Lupton, CO 80621
Ph: 303-857-6222 Fax: 303-857-6224
www.j-tconsulting.com

THUNDER VALLEY PUD

Vicinity Map

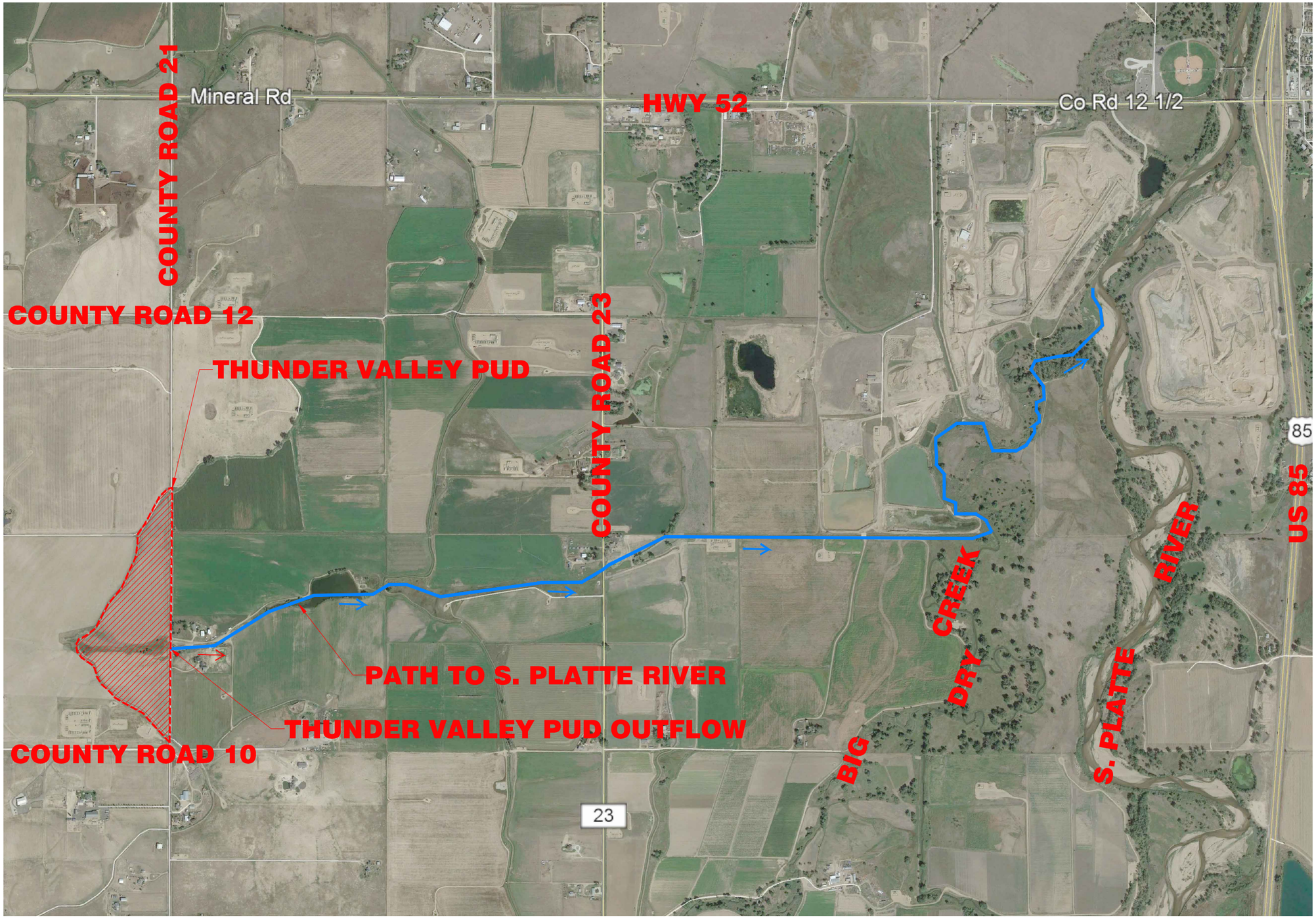
4Z Investments, LLC

REVISIONS

No	Date	By	Chk	Description

Job #	17127
Date	3.11.20
Drawn By	TWT
Designed By	TPY
Checked By	JCY
File	JT-Zadel Basin Map
Scale	As Shown

Sheet: 1 Of: 5



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www.jtconsulting.com

THUNDER VALLEY PUD

Path to Major Drainageway Map

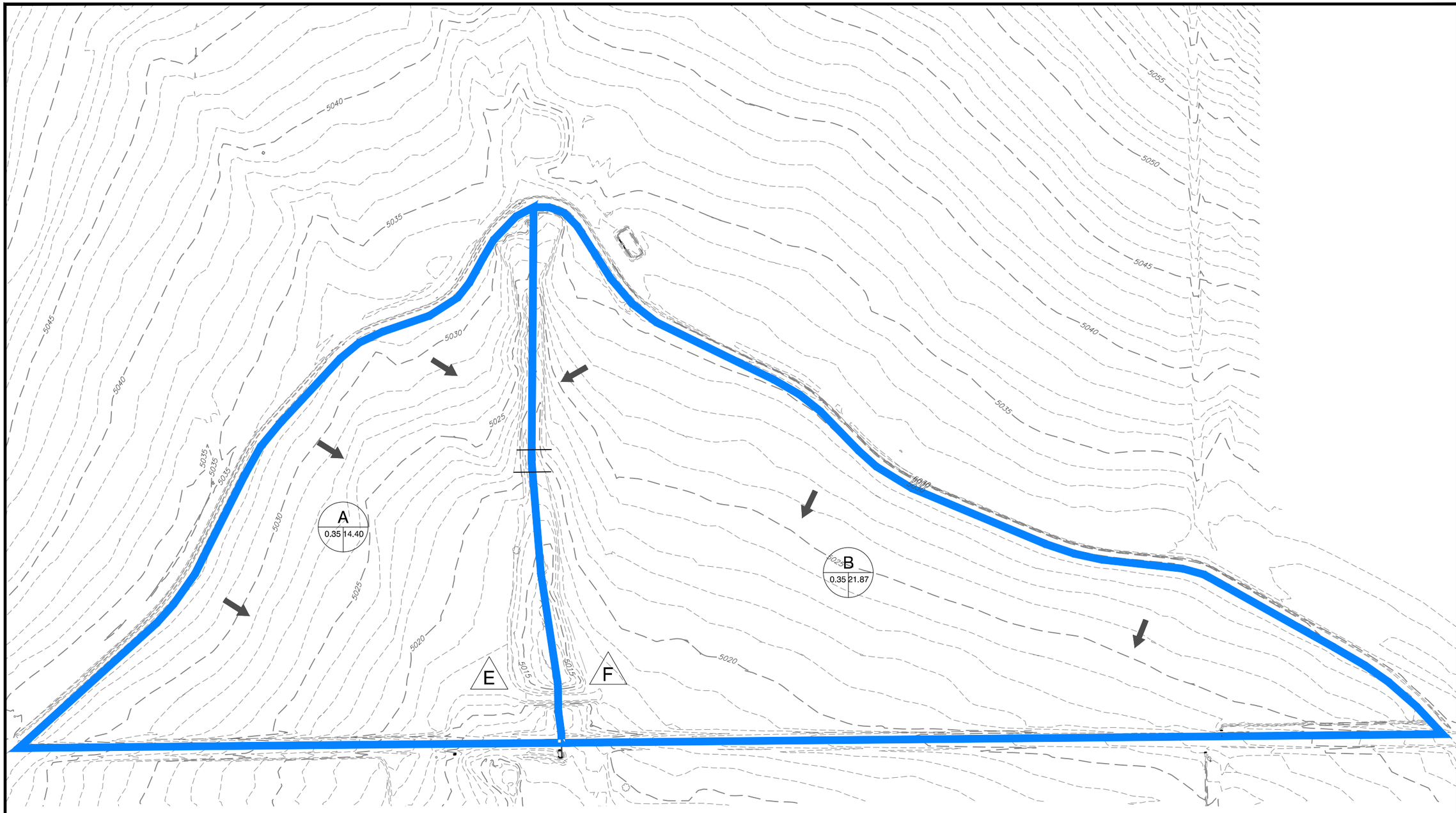
4Z Investments, LLC

REVISIONS

No	Description	Date	By	Chk.

Job #	17127
Date	3.11.20
Drawn By	TWT
Designed By	TPY
Checked By	JCY
File	JT-Zadel Basin Map
Scale	As Shown

Sheet: 2 Of: 5



LEGEND

- DRAINAGE BASIN BOUNDARY
- BASIN TRAVEL PATH
- FLOW DIRECTION
- 5280 EXISTING CONTOURS

P1 — DRAINAGE BASIN DESIGNATION
5-YR RUNOFF COEFFICIENT — BASIN AREA

A — DESIGN POINT

Summary Runoff Table for Existing Basins
Rational Method

Contributing Basin ID	5-YR Maximum Flow (cfs)	100-YR Maximum Flow (cfs)
A	5.62	35.78
B	7.27	46.22

100 50 0 100 200 300
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THUNDER VALLEY PUD

Figure #1
Existing Basins Map

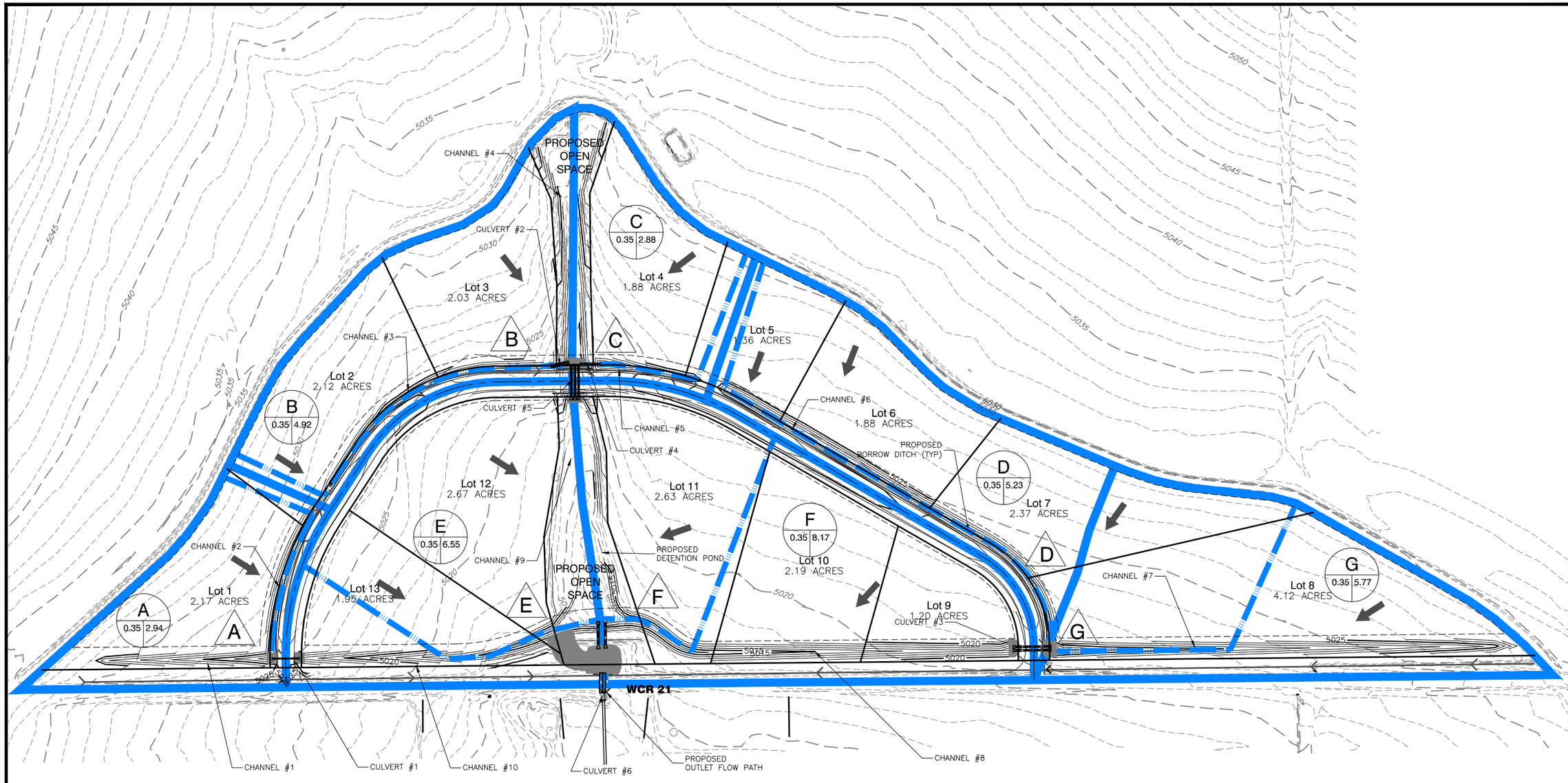
4Z Investments, LLC

REVISIONS

No	Date	By	Chk	Description

Job #	17127
Date	3.11.20
Drawn By	TWT
Designed By	TPY
Checked By	JCY
File	JT-Zadel Basin Map
Scale	As Shown

Sheet: 3 Of: 5



LEGEND

- PROPOSED DRAINAGE SWALE/CHANNEL
- PROPOSED CULVERT
- DRAINAGE BASIN BOUNDARY
- BASIN TRAVEL PATH
- FLOW DIRECTION
- 5280 EXISTING CONTOURS
- 5280 PROPOSED CONTOURS

P1 — DRAINAGE BASIN DESIGNATION
5-YR RUNOFF COEFFICIENT — BASIN AREA

A — DESIGN POINT

Proposed Basin CUHP Peak Flows

Basin ID	Design Point	5-YR Maximum Flow (cfs)	100-YR Maximum Flow (cfs)
A	A	1.06	5.41
B	B	1.49	7.73
C	C	0.84	4.39
D	D	0.97	5.42
E	E	1.87	9.82
F	F	2.34	12.28
G	G	1.51	8.04

100 50 0 100 200 300
SCALE IN FEET

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THUNDER VALLEY PUD

Figure #2
Proposed Basins Map

4Z Investments, LLC

REVISIONS

No	Date	By	Chk	Description

Job #	17127
Date	3.11.20
Drawn By	TWT
Designed By	TPY
Checked By	JCY
File	JT-Zadel Basin Map
Scale	As Shown

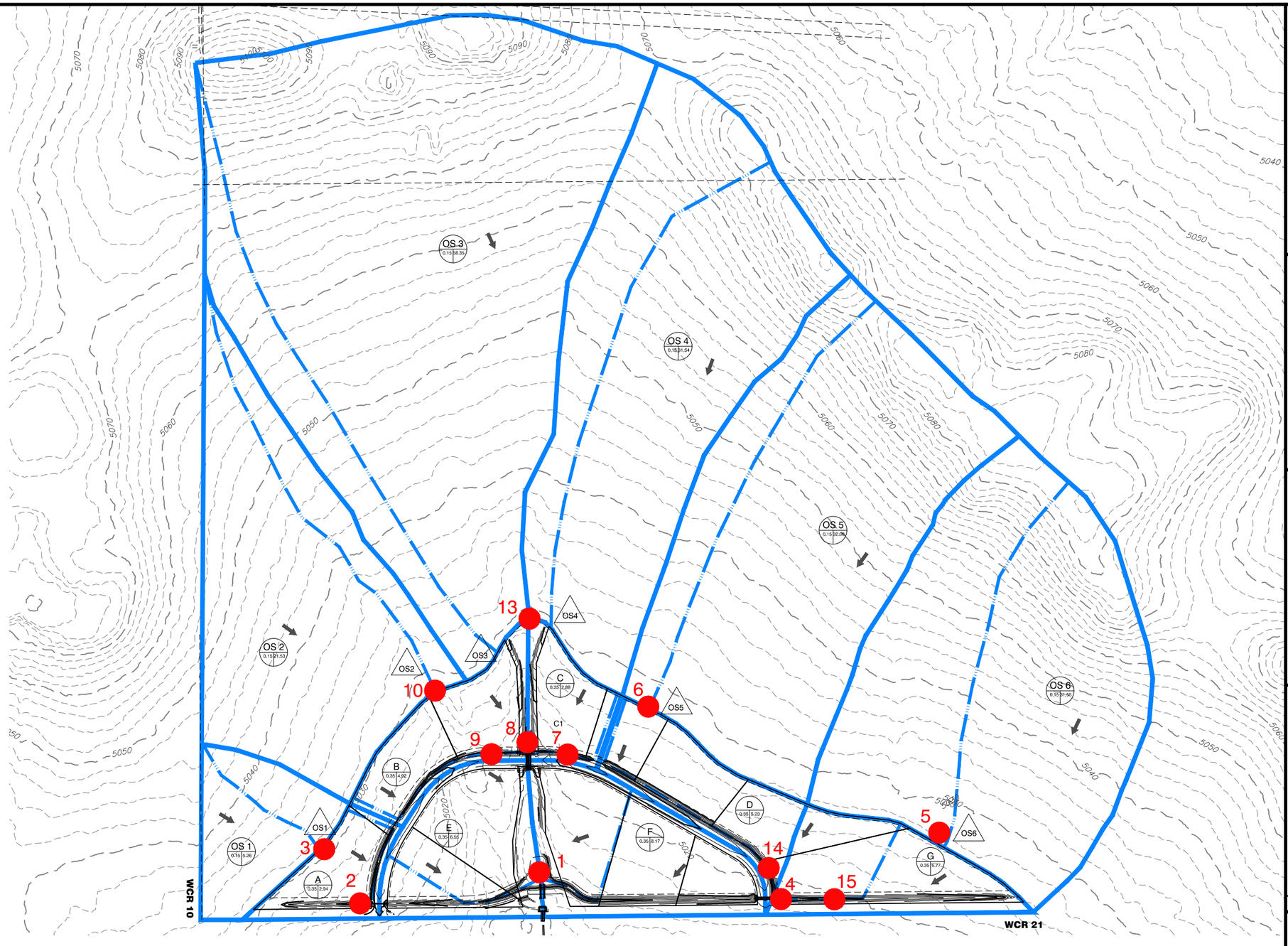
Sheet: 4 Of: 5

Off-Site Basin CUHP Peak Flows

Basin ID	Design Point	5-YR Maximum Flow (cfs)	100-YR Maximum Flow (cfs)
OS1	OS1	1.15	8.18
OS2	OS2	3.25	25.05
OS3	OS3	8.31	65.23
OS4	OS4	4.49	35.05
OS5	OS5	5.41	40.89
OS6	OS6	7.12	50.82

SWMM Routing Flows

SWMM Nodes	Contributing Basin ID	5-YR Maximum Flow (cfs)	100-YR Maximum Flow (cfs)
1	OS1, OS2, OS3, OS4, OS5, OS6, A, B, C, D, E, F, G	21.69	186.29
2	OS1, A	1.50	12.61
3	OS1	1.15	8.18
4	OS5, OS6, D, G	8.82	90.04
5	OS6	7.12	50.82
6	OS5	5.41	40.89
7	C	0.84	4.39
8	OS2, OS3, OS4, B, C	14.51	128.55
9	OS2, B	2.81	28.49
10	OS2	3.25	25.05
13	OS3, OS4	12.79	100.24
14	OS5, D	3.93	40.98
15	OS6, G	4.90	100.20
Outfall	OS1, OS2, OS3, OS4, OS5, OS6, A, B, C, D, E, F, G	21.69	186.28



LEGEND

- PROPOSED DRAINAGE SWALE/CHANNEL
- PROPOSED CULVERT
- DRAINAGE BASIN BOUNDARY
- BASIN TRAVEL PATH
- FLOW DIRECTION
- 5280 EXISTING CONTOURS

P1 — DRAINAGE BASIN DESIGNATION
5-YR RUNOFF COEFFICIENT — BASIN AREA
OS1 — DESIGN POINT
1 — SWMM NODE NUMBER

200 100 0 200 400 600
SCALE IN FEET

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THUNDER VALLEY PUD

Figure #3
On-Site & Off-Site Proposed Basins Map

4Z Investments, LLC

REVISIONS

No	Date	By	Chk	Description

Job #	17127
Date	3.11.20
Drawn By	TWT
Designed By	TPY
Checked By	JCY
File	JT-Zadel Basin Map
Scale	As Shown

Sheet: 5 Of: 5

VIII. Appendix C

A. Historic Flow Calculations

Calculation of Peak Runoff using Rational Method

Designer: Cassie Harmon
Company: J&T Consulting
Date: 7/11/2019
Project: 4Z PUD
Location: WCR 21 & WCR 10 - Historic

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Computed } t_c = t_i + t_t$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$t_{minimum}$= 5 (urban)
$t_{minimum}$= 10 (non-urban)

$$\text{Selected } t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

1-hour rainfall depth, P1 (in) =	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
	1.00	1.42	1.68		2.35	2.71	
Rainfall Intensity Equation Coefficients =	**a**	**b**	**c**				
	28.50	10.00	0.786				

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C							Overland (Initial) Flow Time					Channelized (Travel) Flow Time							Time of Concentration			Rainfall Intensity, I (in/hr)							Peak Flow, Q (cfs)						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
A	14.40	B	2.0	0.01	0.01	0.07	0.26	0.34	0.44	0.54	140.00			0.050	13.66	958.00			0.014	15	1.75	9.14	22.80	40.44	22.80	1.83	2.60	3.08		4.31	4.97		0.23	0.46	3.24		21.05	31.15	
				0.05	0.15	0.25			0.50						11.93								21.07															1.32	5.62	11.09			35.78	
B	21.87	B	2.0	0.01	0.01	0.07	0.26	0.34	0.44	0.54	50.00			0.040	8.79	1732.00			0.008	15	1.34	21.52	30.31	60.44	30.31	1.56	2.21	2.62		3.67	4.23		0.29	0.59	4.19		27.19	40.24	
				0.05	0.15	0.25			0.50						7.68								29.19															1.71	7.27	14.33			46.22	

IX. Appendix D

A. **5 – Year CUHP Calculations**
B. **5 - Year SWMM Flow Routing Calculations**
C. **100 – Year CUHP Calculations**
D. **100 - Year SWMM Flow Routing Calculations**

Colorado Urban Hydrograph Procedure

Version 2.0.1 - Release Date: 10/31/2019

Urban Drainage and Flood Control District
Denver, Colorado
email: udfcd@udfcd.org

Purpose:	This program produces hydrographs using the Colorado Unit Hydrograph Procedure (CUHP)
Functions:	
Edit Raingages	Add/Remove Raingages and change names
Edit Subcatchments	Edit subcatchment parameters
Edit Multiple Run Options	Edit the Multiple Run options (Advanced User Features)
Import CUHP 2005 File	Import an older CUHP 2005 workbook into this updated version of CUHP
Check Subcatchments	Check whether subcatchment inputs conform to UDFCD guidelines
Check SWMM Nodes	Check whether all subcatchment target nodes are included in the SWMM .inp file
Run CUHP	Calculate effective precipitation and generate hydrographs for each subcatchment

Settings:

Fill in the blue cells to begin:

Project Title:	Thunder Valley PUD
Project Comment:	5 Year Storm Event
Time Step Between Computations:	1 Minute(s); typically 5 or 1 (peak flow rate will differ slightly).
	☐ Use Relative Path Names
Output Workbook Filename:	P:\17127 Zadel Weld County PUD\Drainage\PHASE 3 Report\CUHP\17127 - CUHP_201 Release 10-31-19_5 yr Output 03.11.2020.xlsx
CUHP/SWMM Interface Filename (Optional):	P:\17127 Zadel Weld County PUD\Drainage\PHASE 3 Report\CUHP\17127 - EPA SWMM 5.0 Hydrograph_5-yr 03.11.2020.txt
EPA SWMM 5 Input Filename (Optional):	P:\17127 Zadel Weld County PUD\Drainage\PHASE 3 Report\CUHP\17127 - Thunder Valley_5-yr Storm.inp
EPA SWMM 5 Application File (Optional):	C:\Program Files (x86)\EPA SWMM 5.1\swmm5.exe
SWMM Hydrograph Start Time (Optional):	3/11/2020 12:00 AM

Acknowledgements: Thanks to Ben Urbonas, P.E., D.WRE and James C.Y.Guo, PhD, P.E., for the development of the CUHP project.

CUHP SUBCATCHMENTS

Columns with this color heading are for required user-input
Columns with this color heading are for optional override values
Columns with this color heading are for program-calculated values

								Maximum Depression Storage (Watershed inches)		Horton's Infiltration Parameters			DCIA
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (mi^2)	Length to Centroid (mi)	Length (mi)	Slope (ft/ft)	Percent Imperviousness	Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)	Level 0, 1, or 2
A	2	5 Year	0.0045938	0.041477273	0.0823864	0.03	12	0.4	0.05	4.5	0.0018	0.6	0
B	9	5 Year	0.0076875	0.06155303	0.1460227	0.031	12	0.4	0.05	4.5	0.0018	0.6	0
C	7	5 Year	0.0045	0.053977273	0.088447	0.02	12	0.4	0.05	4.5	0.0018	0.6	0
D	14	5 Year	0.0081719	0.110227273	0.2244318	0.019	12	0.4	0.05	4.5	0.0018	0.6	0
E	1	5 Year	0.0102344	0.102083333	0.119697	0.025	12	0.4	0.05	4.5	0.0018	0.6	0
F	1	5 Year	0.0127656	0.102083333	0.1278409	0.019	12	0.4	0.05	4.5	0.0018	0.6	0
G	15	5 Year	0.0090156	0.096590909	0.1339015	0.023	12	0.4	0.05	4.5	0.0018	0.6	0
OS1	3	5 Year	0.0082188	0.061174242	0.1145833	0.024	2	0.4	0.05	4.5	0.0018	0.6	0
OS2	10	5 Year	0.0336406	0.172348485	0.34375	0.021	2	0.4	0.05	4.5	0.0018	0.6	0
OS3	13	5 Year	0.0911719	0.356628788	0.4668561	0.019	2	0.4	0.05	4.5	0.0018	0.6	0
OS4	13	5 Year	0.0492813	0.241477273	0.3844697	0.019	2	0.4	0.05	4.5	0.0018	0.6	0
OS5	6	5 Year	0.050125	0.211742424	0.3323864	0.023	2	0.4	0.05	4.5	0.0018	0.6	0
OS6	5	5 Year	0.0492969	0.140340909	0.2774621	0.029	2	0.4	0.05	4.5	0.0018	0.6	0

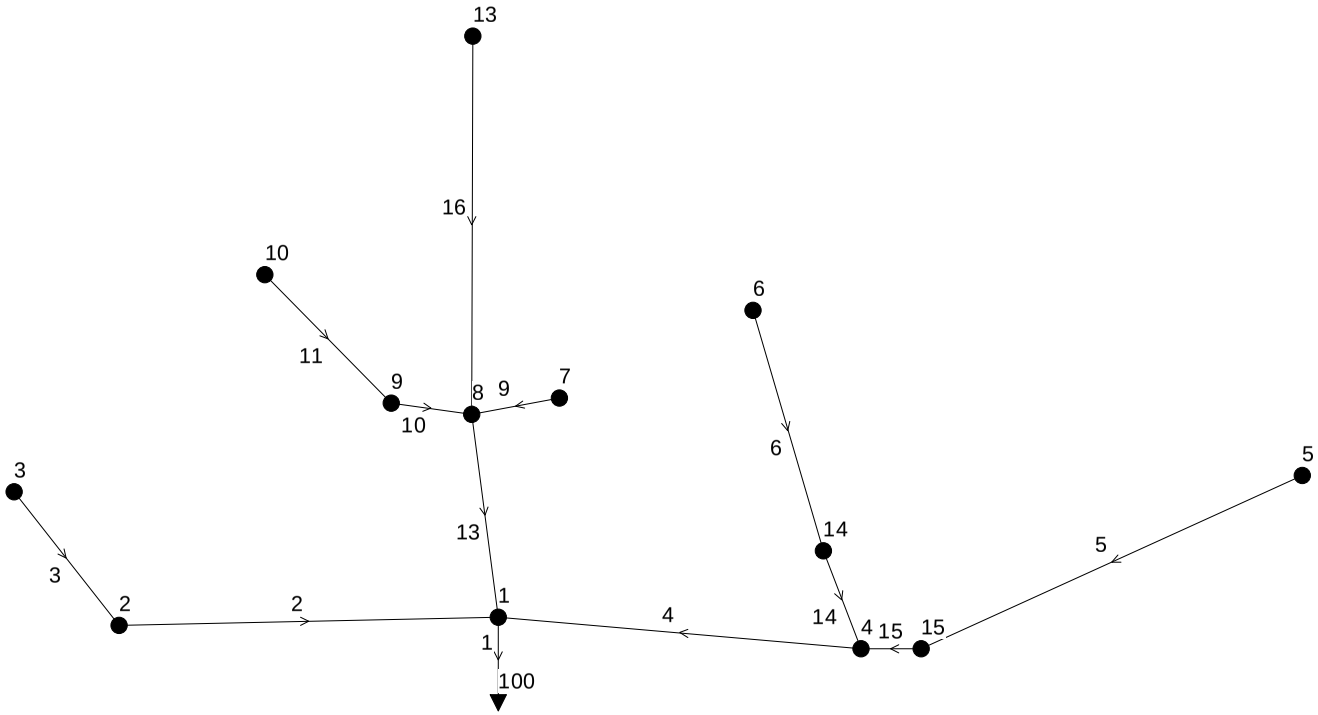
Comment	5 Year Storm		
1Hr Depth	1.42	NOAA Atlas 14 Point Precipitation Frequency Estimates: CO (Note: Use 60-minute recurrence interval depth)	
Return Period	5	Years	
Time	Depth	CurveValue	
0:05	0.028		0.02
0:10	0.053		0.037
0:15	0.124		0.087
0:20	0.217		0.153
0:25	0.355		0.25
0:30	0.185		0.13
0:35	0.082		0.058
0:40	0.062		0.044
0:45	0.051		0.036
0:50	0.051		0.036
0:55	0.043		0.03
1:00	0.043		0.03
1:05	0.043		0.03
1:10	0.043		0.03
1:15	0.036		0.025
1:20	0.031		0.022
1:25	0.031		0.022
1:30	0.031		0.022
1:35	0.031		0.022
1:40	0.021		0.015
1:45	0.021		0.015
1:50	0.021		0.015
1:55	0.021		0.015
2:00	0.018		0.013
2:05	0		

Summary of Unit Hydrograph Parameters Used By Program and Calculated Results (Version 2.0.1)

		Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment Name/ID	User Comment for Catchment	CT	Cp	W50 (min.)	W50 Before Peak	W75 (min.)	W75 Before Peak	Time to Peak (min.)	Peak (cfs)	Volume (c.f)	Excess (inches)	Excess (c.f.)	Time to Peak (min.)	Peak Flow (cfs)	Total Volume (c.f.)	Runoff per Unit Area (cfs/acre)
A		0.126	0.034	26.2	0.99	13.6	0.70	1.7	5	10,672	0.28	3,006	35.0	1	3,004	0.36
B		0.126	0.043	32.8	1.39	17.0	0.98	2.3	7	17,860	0.28	5,031	36.0	1	5,031	0.30
C		0.126	0.034	34.2	1.19	17.8	0.84	2.0	4	10,454	0.28	2,945	36.0	1	2,945	0.29
D		0.126	0.045	58.3	2.29	30.3	1.62	3.8	4	18,985	0.28	5,348	41.0	1	5,348	0.18
E		0.126	0.049	35.2	1.63	18.3	1.15	2.7	9	23,777	0.28	6,698	36.0	2	6,697	0.29
F		0.126	0.054	35.1	1.77	18.2	1.25	2.9	11	29,657	0.28	8,354	36.0	2	8,353	0.29
G		0.126	0.047	39.0	1.69	20.3	1.20	2.8	7	20,945	0.28	5,900	37.0	2	5,899	0.26
OS1		0.157	0.054	30.8	1.58	16.0	1.12	2.6	8	19,094	0.16	3,127	36.0	1	3,127	0.22
OS2		0.157	0.102	46.9	3.98	24.4	2.82	6.6	22	78,154	0.16	12,808	41.0	3	12,807	0.15
OS3		0.157	0.160	50.4	6.50	26.2	4.59	10.8	54	211,811	0.16	34,711	44.0	8	34,711	0.14
OS4		0.157	0.121	50.2	4.98	26.1	3.52	8.3	29	114,490	0.16	18,763	43.0	4	18,762	0.14
OS5		0.157	0.122	41.7	4.22	21.7	2.98	7.0	36	116,450	0.16	19,084	41.0	5	19,083	0.17
OS6		0.157	0.121	29.9	3.09	15.5	2.18	5.1	49	114,527	0.16	18,769	38.0	7	18,767	0.23

Summary of CUHP Input Parameters (Version 2.0.1)

								Depression Storage		Horton's Infiltration Parameters			DCIA Level and Fractions			
Catchment Name/ID	SWMM Node/ID	Raingage Name/ID	Area (sq.mi.)	Dist. to Centroid (miles)	Length (miles)	Slope (ft./ft.)	Percent Imperv.	Pervious (inches)	Imperv. (inches)	Initial Rate (in./hr.)	Final Rate (in.hr.)	Decay Coeff. (1/sec.)	DCIA Level	Dir. Con'ct Imperv. Fraction	Receiv. Perv. Fraction	Percent Eff. Imperv.
A	2	5 YEAR	0.005	0.041	0.082	0.030	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
B	9	5 YEAR	0.008	0.062	0.146	0.031	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
C	7	5 YEAR	0.005	0.054	0.088	0.020	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
D	14	5 YEAR	0.008	0.110	0.224	0.019	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
E	1	5 YEAR	0.010	0.102	0.120	0.025	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
F	1	5 YEAR	0.013	0.102	0.128	0.019	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
G	15	5 YEAR	0.009	0.097	0.134	0.023	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	9.90
OS1	3	5 YEAR	0.008	0.061	0.115	0.024	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.00	0.02	1.55
OS2	10	5 YEAR	0.034	0.172	0.344	0.021	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.56
OS3	13	5 YEAR	0.091	0.357	0.467	0.019	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.56
OS4	13	5 YEAR	0.049	0.241	0.384	0.019	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.56
OS5	6	5 YEAR	0.050	0.212	0.332	0.023	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.56
OS6	5	5 YEAR	0.049	0.140	0.277	0.029	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.56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5 - Year Node Flow

Node Inflow Summary

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Day of Maximum Inflow	Hour of Maximum Inflow	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
1	JUNCTION	4.20	21.69	0	01:29	0.113	1.09	0.000
2	JUNCTION	1.06	1.50	0	00:52	0.0225	0.0257	0.000
3	JUNCTION	1.15	1.15	0	00:37	0.0234	0.0234	0.000
4	JUNCTION	0.00	8.82	0	01:23	0	0.363	0.000
5	JUNCTION	7.12	7.12	0	00:39	0.14	0.14	0.000
6	JUNCTION	5.41	5.41	0	00:42	0.143	0.143	0.000
7	JUNCTION	0.84	0.84	0	00:37	0.022	0.022	0.000
8	JUNCTION	0.00	14.51	0	00:50	0	0.516	0.000
9	JUNCTION	1.49	2.81	0	01:16	0.0376	0.117	0.000
10	JUNCTION	3.25	3.25	0	00:42	0.0958	0.0958	0.000
14	JUNCTION	0.97	3.93	0	01:23	0.04	0.17	0.000
15	JUNCTION	1.51	4.90	0	01:22	0.0441	0.199	0.000
13	JUNCTION	12.79	12.79	0	00:45	0.4	0.4	0.000
100	OUTFALL	0.00	21.69	0	01:30	0	1.09	0.000

5 - Year Link Flow

Link Flow Summary

Link	Type	Maximum |Flow| CFS	Day of Maximum Flow	Hour of Maximum Flow	Maximum |Velocity| ft/sec	Max / Full Flow	Max / Full Depth
3	CONDUIT	0.74	0	00:52	0.17	0.00	0.00
2	CONDUIT	1.79	0	00:53	1.67	0.01	0.18
1	CONDUIT	21.69	0	01:30	2.67	0.00	0.00
6	CONDUIT	3.28	0	01:28	0.21	0.00	0.00
5	CONDUIT	4.11	0	01:23	0.23	0.00	0.00
4	CONDUIT	8.60	0	01:35	2.73	0.21	0.55
9	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
10	CONDUIT	2.81	0	01:17	1.34	0.00	0.00
11	CONDUIT	2.11	0	01:24	0.17	0.00	0.00
13	CONDUIT	11.22	0	01:28	0.22	0.06	0.23
14	CONDUIT	3.93	0	01:23	1.02	0.00	0.01
15	CONDUIT	4.90	0	01:23	1.10	0.00	0.01
16	CONDUIT	12.70	0	00:48	1.64	0.00	0.04

5 - Year Event
Printouts for Storm Hydrographs

flow in cfs

time in minutes	A	B	C	D	E	F	G	OS1	OS2	OS3	OS4	OS5	OS6
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
12	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
13	0.01	0.02	0.01	0.01	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
14	0.02	0.02	0.01	0.01	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
15	0.02	0.03	0.02	0.01	0.03	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00
16	0.03	0.03	0.02	0.02	0.04	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.01
17	0.03	0.04	0.02	0.02	0.05	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.01
18	0.04	0.05	0.03	0.03	0.06	0.07	0.05	0.00	0.00	0.01	0.00	0.01	0.01
19	0.04	0.06	0.03	0.03	0.07	0.09	0.06	0.00	0.00	0.01	0.00	0.01	0.01
20	0.06	0.07	0.04	0.04	0.09	0.11	0.07	0.00	0.01	0.01	0.01	0.01	0.01
21	0.12	0.13	0.08	0.06	0.15	0.18	0.12	0.01	0.01	0.02	0.01	0.02	0.04
22	0.18	0.22	0.13	0.10	0.26	0.31	0.20	0.03	0.03	0.04	0.03	0.05	0.11
23	0.25	0.32	0.18	0.16	0.37	0.45	0.29	0.05	0.07	0.09	0.07	0.10	0.20
24	0.32	0.41	0.24	0.21	0.49	0.60	0.38	0.07	0.11	0.15	0.12	0.17	0.31
25	0.39	0.50	0.29	0.27	0.60	0.74	0.48	0.09	0.16	0.23	0.17	0.25	0.43
26	0.48	0.62	0.36	0.33	0.74	0.91	0.59	0.17	0.24	0.37	0.27	0.39	0.68
27	0.60	0.77	0.45	0.41	0.93	1.14	0.73	0.32	0.42	0.62	0.46	0.67	1.21
28	0.73	0.94	0.54	0.51	1.14	1.39	0.90	0.51	0.70	1.03	0.76	1.12	2.04
29	0.85	1.11	0.64	0.61	1.35	1.66	1.07	0.70	1.09	1.63	1.20	1.73	3.09
30	0.98	1.28	0.73	0.71	1.56	1.93	1.24	0.89	1.55	2.41	1.73	2.48	4.25
31	1.02	1.38	0.78	0.80	1.70	2.11	1.35	1.01	2.00	3.30	2.31	3.23	5.28
32	1.03	1.41	0.79	0.84	1.75	2.18	1.40	1.05	2.38	4.20	2.85	3.88	5.99
33	1.04	1.43	0.81	0.87	1.79	2.23	1.43	1.08	2.65	5.06	3.30	4.36	6.43
34	1.05	1.46	0.82	0.89	1.82	2.27	1.46	1.11	2.84	5.82	3.64	4.70	6.69
35	1.06	1.48	0.84	0.92	1.85	2.31	1.49	1.14	2.97	6.47	3.91	4.94	6.88
36	1.05	1.49	0.84	0.93	1.87	2.34	1.50	1.15	3.07	7.00	4.10	5.11	7.03
37	1.04	1.48	0.84	0.95	1.87	2.34	1.51	1.14	3.14	7.41	4.23	5.23	7.11
38	1.03	1.47	0.83	0.95	1.86	2.33	1.50	1.13	3.19	7.71	4.32	5.31	7.12
39	1.01	1.46	0.83	0.96	1.85	2.31	1.50	1.13	3.22	7.93	4.39	5.37	7.09
40	0.99	1.45	0.82	0.96	1.84	2.30	1.50	1.11	3.24	8.07	4.44	5.40	7.03
41	0.97	1.43	0.81	0.97	1.82	2.28	1.49	1.10	3.25	8.18	4.47	5.41	6.94
42	0.95	1.40	0.80	0.97	1.79	2.24	1.47	1.07	3.25	8.26	4.49	5.40	6.81
43	0.92	1.38	0.78	0.96	1.76	2.21	1.45	1.04	3.24	8.30	4.49	5.37	6.65
44	0.90	1.35	0.77	0.96	1.73	2.17	1.43	1.01	3.22	8.31	4.48	5.32	6.46
45	0.88	1.32	0.75	0.96	1.70	2.13	1.41	0.98	3.19	8.30	4.45	5.25	6.27
46	0.86	1.30	0.74	0.95	1.67	2.09	1.38	0.96	3.15	8.27	4.42	5.18	6.09
47	0.84	1.27	0.73	0.95	1.64	2.05	1.36	0.93	3.11	8.22	4.38	5.09	5.92
48	0.82	1.25	0.71	0.94	1.61	2.01	1.34	0.91	3.07	8.16	4.34	5.00	5.76
49	0.80	1.23	0.70	0.93	1.58	1.98	1.32	0.89	3.02	8.09	4.28	4.90	5.61
50	0.78	1.21	0.69	0.93	1.56	1.95	1.30	0.87	2.97	8.00	4.23	4.80	5.46
51	0.76	1.18	0.68	0.92	1.53	1.92	1.28	0.84	2.92	7.90	4.17	4.69	5.31
52	0.74	1.16	0.66	0.91	1.50	1.88	1.26	0.82	2.87	7.79	4.11	4.58	5.17
53	0.72	1.14	0.65	0.90	1.48	1.85	1.24	0.80	2.81	7.68	4.04	4.48	5.02
54	0.70	1.11	0.64	0.89	1.45	1.81	1.22	0.78	2.75	7.56	3.97	4.38	4.88

55	0.69	1.09	0.63	0.88	1.42	1.78	1.20	0.76	2.69	7.42	3.89	4.29	4.74
56	0.67	1.07	0.62	0.87	1.40	1.75	1.18	0.74	2.64	7.29	3.82	4.21	4.60
57	0.66	1.05	0.60	0.86	1.37	1.71	1.16	0.72	2.59	7.14	3.74	4.13	4.46
58	0.64	1.03	0.59	0.85	1.34	1.68	1.14	0.70	2.55	6.99	3.67	4.05	4.33
59	0.63	1.01	0.58	0.84	1.32	1.65	1.12	0.68	2.51	6.85	3.60	3.98	4.21
60	0.61	0.99	0.57	0.83	1.29	1.62	1.11	0.66	2.47	6.72	3.54	3.90	4.10
61	0.60	0.97	0.56	0.83	1.27	1.59	1.09	0.65	2.43	6.60	3.49	3.83	4.00
62	0.59	0.95	0.55	0.82	1.25	1.56	1.07	0.63	2.39	6.49	3.43	3.75	3.90
63	0.57	0.94	0.54	0.81	1.23	1.53	1.05	0.62	2.35	6.38	3.38	3.68	3.81
64	0.56	0.92	0.53	0.80	1.21	1.51	1.04	0.60	2.31	6.28	3.33	3.60	3.72
65	0.54	0.91	0.52	0.80	1.19	1.49	1.02	0.59	2.27	6.18	3.27	3.53	3.63
66	0.53	0.89	0.52	0.79	1.17	1.46	1.00	0.58	2.23	6.09	3.22	3.46	3.54
67	0.52	0.88	0.51	0.78	1.15	1.44	0.99	0.56	2.19	5.99	3.17	3.39	3.46
68	0.50	0.86	0.50	0.77	1.14	1.42	0.98	0.55	2.15	5.90	3.12	3.32	3.37
69	0.49	0.85	0.49	0.77	1.12	1.40	0.96	0.54	2.12	5.80	3.08	3.25	3.29
70	0.48	0.83	0.48	0.76	1.10	1.38	0.95	0.52	2.08	5.71	3.03	3.18	3.20
71	0.46	0.82	0.48	0.75	1.08	1.36	0.94	0.51	2.04	5.62	2.98	3.11	3.12
72	0.45	0.80	0.47	0.75	1.07	1.33	0.92	0.50	2.00	5.52	2.93	3.05	3.03
73	0.43	0.78	0.46	0.74	1.05	1.31	0.91	0.48	1.97	5.43	2.88	2.99	2.95
74	0.42	0.77	0.45	0.73	1.03	1.29	0.90	0.47	1.93	5.34	2.83	2.94	2.86
75	0.41	0.75	0.44	0.72	1.01	1.26	0.88	0.46	1.89	5.25	2.78	2.89	2.77
76	0.39	0.74	0.43	0.71	0.99	1.24	0.87	0.44	1.86	5.15	2.73	2.84	2.69
77	0.38	0.72	0.42	0.71	0.97	1.21	0.85	0.43	1.82	5.06	2.68	2.79	2.60
78	0.37	0.70	0.41	0.70	0.95	1.19	0.84	0.42	1.79	4.97	2.63	2.75	2.51
79	0.36	0.68	0.40	0.69	0.93	1.16	0.82	0.40	1.76	4.87	2.58	2.70	2.43
80	0.35	0.67	0.39	0.68	0.91	1.14	0.81	0.39	1.74	4.78	2.54	2.65	2.34
81	0.34	0.65	0.39	0.67	0.89	1.11	0.80	0.37	1.71	4.70	2.49	2.60	2.25
82	0.33	0.63	0.38	0.66	0.87	1.08	0.78	0.36	1.68	4.62	2.45	2.56	2.17
83	0.33	0.61	0.37	0.65	0.85	1.06	0.77	0.35	1.66	4.54	2.42	2.51	2.08
84	0.32	0.60	0.36	0.65	0.83	1.03	0.75	0.34	1.63	4.47	2.38	2.47	2.00
85	0.31	0.58	0.35	0.64	0.81	1.01	0.74	0.32	1.61	4.41	2.35	2.42	1.92
86	0.30	0.56	0.34	0.63	0.79	0.98	0.72	0.31	1.58	4.34	2.31	2.37	1.85
87	0.30	0.55	0.33	0.62	0.77	0.96	0.71	0.30	1.56	4.28	2.28	2.33	1.79
88	0.29	0.53	0.32	0.62	0.75	0.93	0.69	0.29	1.53	4.22	2.25	2.28	1.74
89	0.29	0.52	0.31	0.61	0.73	0.91	0.68	0.28	1.51	4.16	2.22	2.24	1.70
90	0.28	0.51	0.30	0.60	0.71	0.89	0.67	0.27	1.49	4.10	2.19	2.19	1.65
91	0.27	0.50	0.30	0.60	0.69	0.86	0.65	0.27	1.46	4.04	2.15	2.14	1.62
92	0.27	0.49	0.29	0.59	0.68	0.84	0.64	0.26	1.44	3.98	2.12	2.10	1.58
93	0.26	0.48	0.28	0.59	0.66	0.82	0.62	0.26	1.41	3.92	2.09	2.05	1.54
94	0.25	0.47	0.28	0.58	0.64	0.80	0.61	0.25	1.39	3.86	2.06	2.01	1.51
95	0.25	0.46	0.27	0.57	0.63	0.78	0.60	0.25	1.36	3.81	2.03	1.96	1.48
96	0.24	0.45	0.27	0.57	0.61	0.77	0.58	0.24	1.34	3.75	2.00	1.91	1.44
97	0.23	0.44	0.26	0.56	0.60	0.75	0.57	0.24	1.32	3.69	1.97	1.87	1.41
98	0.23	0.43	0.26	0.55	0.59	0.73	0.55	0.23	1.29	3.63	1.94	1.82	1.38
99	0.22	0.42	0.25	0.55	0.58	0.72	0.54	0.23	1.27	3.57	1.90	1.77	1.35
100	0.21	0.42	0.25	0.54	0.57	0.71	0.52	0.22	1.24	3.52	1.87	1.73	1.32
101	0.21	0.41	0.24	0.53	0.55	0.69	0.51	0.22	1.22	3.46	1.84	1.68	1.28
102	0.20	0.40	0.24	0.53	0.54	0.68	0.50	0.21	1.19	3.40	1.81	1.63	1.25
103	0.19	0.39	0.23	0.52	0.53	0.67	0.49	0.21	1.17	3.34	1.78	1.59	1.22
104	0.19	0.38	0.23	0.51	0.52	0.65	0.48	0.20	1.14	3.28	1.74	1.54	1.19
105	0.18	0.37	0.22	0.51	0.51	0.64	0.47	0.20	1.12	3.22	1.71	1.49	1.15
106	0.17	0.37	0.22	0.50	0.50	0.63	0.46	0.19	1.09	3.16	1.68	1.45	1.12
107	0.16	0.36	0.21	0.49	0.49	0.62	0.45	0.19	1.07	3.10	1.65	1.40	1.09
108	0.16	0.35	0.21	0.49	0.49	0.61	0.44	0.18	1.04	3.04	1.61	1.36	1.06
109	0.15	0.34	0.21	0.48	0.48	0.59	0.44	0.18	1.02	2.98	1.58	1.32	1.03
110	0.14	0.34	0.20	0.48	0.47	0.58	0.43	0.17	0.99	2.92	1.55	1.29	1.00
111	0.14	0.33	0.20	0.47	0.46	0.57	0.42	0.17	0.97	2.86	1.52	1.26	0.97
112	0.13	0.32	0.19	0.46	0.45	0.56	0.41	0.16	0.94	2.80	1.49	1.23	0.93
113	0.13	0.31	0.19	0.46	0.44	0.55	0.41	0.16	0.92	2.74	1.45	1.21	0.90
114	0.12	0.31	0.19	0.45	0.43	0.54	0.40	0.15	0.89	2.69	1.42	1.19	0.87
115	0.11	0.30	0.18	0.44	0.42	0.53	0.39	0.15	0.87	2.63	1.39	1.17	0.84
116	0.11	0.29	0.18	0.44	0.41	0.52	0.39	0.14	0.85	2.57	1.36	1.15	0.81
117	0.10	0.28	0.17	0.43	0.41	0.51	0.38	0.14	0.82	2.51	1.33	1.13	0.78

118	0.09	0.28	0.17	0.42	0.40	0.49	0.37	0.13	0.80	2.45	1.30	1.11	0.75
119	0.09	0.27	0.17	0.42	0.39	0.48	0.37	0.13	0.78	2.39	1.26	1.09	0.72
120	0.08	0.26	0.16	0.41	0.38	0.47	0.36	0.12	0.76	2.33	1.23	1.08	0.69
121	0.08	0.25	0.16	0.40	0.37	0.46	0.35	0.12	0.75	2.27	1.20	1.06	0.66
122	0.07	0.25	0.15	0.40	0.36	0.45	0.35	0.11	0.73	2.21	1.17	1.04	0.63
123	0.06	0.24	0.15	0.39	0.35	0.44	0.34	0.11	0.72	2.16	1.14	1.03	0.59
124	0.06	0.23	0.14	0.38	0.34	0.43	0.33	0.10	0.71	2.10	1.11	1.01	0.56
125	0.05	0.22	0.14	0.38	0.33	0.42	0.33	0.10	0.70	2.04	1.08	0.99	0.53
126	0.05	0.22	0.14	0.37	0.32	0.40	0.32	0.09	0.69	1.99	1.06	0.98	0.50
127	0.05	0.21	0.13	0.36	0.32	0.39	0.31	0.09	0.68	1.94	1.03	0.96	0.47
128	0.04	0.20	0.13	0.36	0.31	0.38	0.31	0.08	0.67	1.90	1.01	0.94	0.44
129	0.04	0.19	0.12	0.35	0.30	0.37	0.30	0.08	0.66	1.87	1.00	0.93	0.41
130	0.04	0.19	0.12	0.34	0.29	0.36	0.29	0.07	0.65	1.84	0.98	0.91	0.38
131	0.04	0.18	0.12	0.34	0.28	0.35	0.29	0.07	0.64	1.81	0.97	0.89	0.35
132	0.03	0.17	0.11	0.33	0.27	0.34	0.28	0.07	0.63	1.78	0.95	0.88	0.32
133	0.03	0.16	0.11	0.32	0.26	0.33	0.27	0.06	0.62	1.76	0.94	0.86	0.29
134	0.03	0.16	0.10	0.32	0.25	0.32	0.27	0.06	0.61	1.73	0.93	0.84	0.26
135	0.03	0.15	0.10	0.31	0.25	0.30	0.26	0.05	0.61	1.71	0.92	0.83	0.23
136	0.03	0.14	0.10	0.30	0.24	0.29	0.25	0.05	0.60	1.69	0.90	0.81	0.20
137	0.03	0.14	0.09	0.30	0.23	0.28	0.25	0.04	0.59	1.66	0.89	0.79	0.17
138	0.03	0.13	0.09	0.29	0.22	0.27	0.24	0.04	0.58	1.64	0.88	0.78	0.15
139	0.02	0.12	0.08	0.29	0.21	0.26	0.24	0.03	0.57	1.62	0.87	0.76	0.12
140	0.02	0.11	0.08	0.28	0.20	0.25	0.23	0.03	0.56	1.60	0.86	0.75	0.10
141	0.02	0.11	0.08	0.28	0.19	0.24	0.22	0.02	0.55	1.58	0.85	0.73	0.08
142	0.02	0.10	0.07	0.27	0.19	0.23	0.22	0.02	0.54	1.56	0.83	0.71	0.07
143	0.02	0.09	0.07	0.27	0.18	0.22	0.21	0.02	0.54	1.54	0.82	0.70	0.06
144	0.02	0.09	0.07	0.26	0.17	0.21	0.20	0.01	0.53	1.52	0.81	0.68	0.05
145	0.02	0.08	0.06	0.26	0.16	0.20	0.20	0.01	0.52	1.49	0.80	0.67	0.04
146	0.02	0.07	0.06	0.26	0.15	0.19	0.19	0.01	0.51	1.47	0.79	0.65	0.04
147	0.02	0.07	0.05	0.25	0.15	0.18	0.19	0.01	0.50	1.45	0.78	0.63	0.03
148	0.02	0.06	0.05	0.25	0.14	0.17	0.18	0.01	0.49	1.43	0.77	0.62	0.03
149	0.02	0.06	0.05	0.25	0.13	0.16	0.18	0.01	0.48	1.41	0.76	0.60	0.03
150	0.01	0.05	0.04	0.25	0.12	0.15	0.17	0.01	0.48	1.39	0.74	0.59	0.03
151	0.01	0.05	0.04	0.24	0.11	0.14	0.16	0.00	0.47	1.37	0.73	0.57	0.03
152	0.01	0.04	0.04	0.24	0.11	0.13	0.16	0.00	0.46	1.35	0.72	0.55	0.02
153	0.01	0.04	0.03	0.24	0.10	0.12	0.15	0.00	0.45	1.33	0.71	0.54	0.02
154	0.01	0.04	0.03	0.23	0.09	0.11	0.15	0.00	0.44	1.31	0.70	0.52	0.02
155	0.01	0.04	0.03	0.23	0.08	0.10	0.14	0.00	0.43	1.29	0.69	0.51	0.02
156	0.01	0.03	0.03	0.23	0.08	0.10	0.13	0.00	0.42	1.27	0.68	0.49	0.02
157	0.01	0.03	0.02	0.23	0.07	0.09	0.13	0.00	0.42	1.25	0.67	0.48	0.02
158	0.01	0.03	0.02	0.22	0.07	0.08	0.12	0.00	0.41	1.23	0.66	0.46	0.02
159	0.01	0.03	0.02	0.22	0.06	0.07	0.12	0.00	0.40	1.21	0.65	0.44	0.02
160	0.01	0.03	0.02	0.22	0.06	0.07	0.11	0.00	0.39	1.19	0.64	0.43	0.02
161	0.01	0.03	0.02	0.21	0.05	0.06	0.11	0.00	0.38	1.17	0.62	0.41	0.01
162	0.01	0.03	0.02	0.21	0.05	0.06	0.10	0.00	0.37	1.15	0.61	0.40	0.01
163	0.01	0.03	0.02	0.21	0.04	0.05	0.09	0.00	0.37	1.13	0.60	0.38	0.01
164	0.01	0.02	0.02	0.21	0.04	0.05	0.09	0.00	0.36	1.11	0.59	0.36	0.01
165	0.01	0.02	0.02	0.20	0.04	0.05	0.08	0.00	0.35	1.09	0.58	0.35	0.01
166	0.01	0.02	0.01	0.20	0.04	0.05	0.08	0.00	0.34	1.07	0.57	0.33	0.01
167	0.01	0.02	0.01	0.20	0.04	0.04	0.07	0.00	0.33	1.05	0.56	0.32	0.01
168	0.01	0.02	0.01	0.20	0.03	0.04	0.07	0.00	0.32	1.03	0.55	0.30	0.01
169	0.00	0.02	0.01	0.19	0.03	0.04	0.06	0.00	0.32	1.01	0.54	0.29	0.01
170	0.00	0.02	0.01	0.19	0.03	0.04	0.06	0.00	0.31	0.99	0.53	0.27	0.01
171	0.00	0.02	0.01	0.19	0.03	0.04	0.05	0.00	0.30	0.97	0.52	0.26	0.01
172	0.00	0.02	0.01	0.19	0.03	0.04	0.05	0.00	0.29	0.95	0.51	0.24	0.01
173	0.00	0.02	0.01	0.18	0.03	0.03	0.04	0.00	0.28	0.93	0.50	0.22	0.01
174	0.00	0.02	0.01	0.18	0.03	0.03	0.04	0.00	0.27	0.91	0.48	0.21	0.01
175	0.00	0.01	0.01	0.18	0.03	0.03	0.04	0.00	0.27	0.89	0.47	0.19	0.01
176	0.00	0.01	0.01	0.17	0.02	0.03	0.03	0.00	0.26	0.87	0.46	0.18	0.01
177	0.00	0.01	0.01	0.17	0.02	0.03	0.03	0.00	0.25	0.85	0.45	0.16	0.01
178	0.00	0.01	0.01	0.17	0.02	0.03	0.03	0.00	0.24	0.83	0.44	0.15	0.00
179	0.00	0.01	0.01	0.17	0.02	0.03	0.03	0.00	0.23	0.81	0.43	0.13	0.00
180	0.00	0.01	0.01	0.17	0.02	0.02	0.03	0.00	0.22	0.79	0.42	0.12	0.00

181	0.00	0.01	0.01	0.16	0.02	0.02	0.03	0.00	0.22	0.77	0.41	0.10	0.00
182	0.00	0.01	0.01	0.16	0.02	0.02	0.02	0.00	0.21	0.75	0.40	0.09	0.00
183	0.00	0.01	0.01	0.16	0.02	0.02	0.02	0.00	0.20	0.73	0.39	0.07	0.00
184	0.00	0.01	0.01	0.16	0.02	0.02	0.02	0.00	0.19	0.71	0.38	0.06	0.00
185	0.00	0.01	0.01	0.15	0.02	0.02	0.02	0.00	0.18	0.69	0.37	0.05	0.00
186	0.00	0.01	0.01	0.15	0.02	0.02	0.02	0.00	0.18	0.67	0.36	0.04	0.00
187	0.00	0.01	0.01	0.15	0.01	0.02	0.02	0.00	0.17	0.65	0.35	0.03	0.00
188	0.00	0.01	0.01	0.15	0.01	0.02	0.02	0.00	0.16	0.63	0.34	0.03	0.00
189	0.00	0.01	0.00	0.14	0.01	0.02	0.02	0.00	0.15	0.61	0.32	0.02	0.00
190	0.00	0.01	0.00	0.14	0.01	0.02	0.02	0.00	0.14	0.59	0.31	0.02	0.00
191	0.00	0.01	0.00	0.14	0.01	0.01	0.02	0.00	0.13	0.57	0.30	0.02	0.00
192	0.00	0.01	0.00	0.14	0.01	0.01	0.02	0.00	0.13	0.55	0.29	0.02	0.00
193	0.00	0.01	0.00	0.13	0.01	0.01	0.02	0.00	0.12	0.53	0.28	0.02	0.00
194	0.00	0.01	0.00	0.13	0.01	0.01	0.01	0.00	0.11	0.51	0.27	0.01	0.00
195	0.00	0.00	0.00	0.13	0.01	0.01	0.01	0.00	0.10	0.50	0.26	0.01	0.00
196	0.00	0.00	0.00	0.13	0.01	0.01	0.01	0.00	0.09	0.48	0.25	0.01	0.00
197	0.00	0.00	0.00	0.13	0.01	0.01	0.01	0.00	0.08	0.46	0.24	0.01	0.00
198	0.00	0.00	0.00	0.12	0.01	0.01	0.01	0.00	0.08	0.44	0.23	0.01	0.00
199	0.00	0.00	0.00	0.12	0.01	0.01	0.01	0.00	0.07	0.42	0.22	0.01	0.00
200	0.00	0.00	0.00	0.12	0.01	0.01	0.01	0.00	0.06	0.40	0.21	0.01	0.00
201	0.00	0.00	0.00	0.12	0.01	0.01	0.01	0.00	0.05	0.38	0.20	0.01	0.00
202	0.00	0.00	0.00	0.11	0.01	0.01	0.01	0.00	0.05	0.36	0.19	0.01	0.00
203	0.00	0.00	0.00	0.11	0.01	0.01	0.01	0.00	0.04	0.34	0.18	0.01	0.00
204	0.00	0.00	0.00	0.11	0.01	0.01	0.01	0.00	0.03	0.32	0.17	0.01	0.00
205	0.00	0.00	0.00	0.11	0.01	0.01	0.01	0.00	0.02	0.30	0.16	0.01	0.00
206	0.00	0.00	0.00	0.10	0.01	0.01	0.01	0.00	0.02	0.28	0.15	0.01	0.00
207	0.00	0.00	0.00	0.10	0.00	0.01	0.01	0.00	0.02	0.26	0.13	0.01	0.00
208	0.00	0.00	0.00	0.10	0.00	0.01	0.01	0.00	0.01	0.24	0.12	0.01	0.00
209	0.00	0.00	0.00	0.10	0.00	0.01	0.01	0.00	0.01	0.22	0.11	0.01	0.00
210	0.00	0.00	0.00	0.10	0.00	0.00	0.01	0.00	0.01	0.20	0.10	0.01	0.00
211	0.00	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.01	0.18	0.09	0.01	0.00
212	0.00	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.01	0.16	0.08	0.01	0.00
213	0.00	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.01	0.14	0.07	0.00	0.00
214	0.00	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.01	0.13	0.06	0.00	0.00
215	0.00	0.00	0.00	0.08	0.00	0.00	0.01	0.00	0.01	0.11	0.05	0.00	0.00
216	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01	0.09	0.04	0.00	0.00
217	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01	0.07	0.03	0.00	0.00
218	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01	0.06	0.03	0.00	0.00
219	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01	0.05	0.02	0.00	0.00
220	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.01	0.04	0.02	0.00	0.00
221	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.00	0.00
222	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00
223	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00
224	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
225	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
226	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
227	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
228	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
229	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
230	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
231	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
232	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
233	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
234	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
235	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
236	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
237	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
238	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
239	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
240	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
241	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
242	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
243	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00

244	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
245	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
246	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
247	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
248	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
249	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
250	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
258	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
260	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
263	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
264	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
265	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
266	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
267	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
268	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
269	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
270	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
271	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
272	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
273	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
274	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
275	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
276	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
277	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
278	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
279	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
280	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
281	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
282	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
283	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
284	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
285	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
286	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
287	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
288	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
289	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
290	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
291	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
292	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
293	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
294	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
295	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
296	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
297	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
298	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
299	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
301	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
302	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
303	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
304	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
306	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

307	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
308	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
309	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
311	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
312	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
313	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
314	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
315	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
316	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
317	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
318	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
319	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
321	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
322	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
323	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
324	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
325	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
326	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
327	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
328	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
329	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
331	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
332	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
334	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
335	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
336	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
337	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
338	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
339	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
340	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
341	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Colorado Urban Hydrograph Procedure

Version 2.0.1 - Release Date: 10/31/2019

Urban Drainage and Flood Control District
Denver, Colorado
email: udfcd@udfcd.org

Purpose:	This program produces hydrographs using the Colorado Unit Hydrograph Procedure (CUHP)
Functions:	
Edit Raingages	Add/Remove Raingages and change names
Edit Subcatchments	Edit subcatchment parameters
Edit Multiple Run Options	Edit the Multiple Run options (Advanced User Features)
Import CUHP 2005 File	Import an older CUHP 2005 workbook into this updated version of CUHP
Check Subcatchments	Check whether subcatchment inputs conform to UDFCD guidelines
Check SWMM Nodes	Check whether all subcatchment target nodes are included in the SWMM .inp file
Run CUHP	Calculate effective precipitation and generate hydrographs for each subcatchment

Settings:

Fill in the blue cells to begin:

Project Title:	Thunder Valley PUD
Project Comment:	100 Year Storm Event
Time Step Between Computations:	1 Minute(s); typically 5 or 1 (peak flow rate will differ slightly).
	☐ Use Relative Path Names
Output Workbook Filename:	P:\17127 Zadel Weld County PUD\Drainage\PHASE 3 Report\CUHP\17127 - CUHP_201 Release 10-31-19_100 yr Output 03.11.2020.xlsx
CUHP/SWMM Interface Filename (Optional):	P:\17127 Zadel Weld County PUD\Drainage\PHASE 3 Report\CUHP\17127 - EPA SWMM 5.0 Hydrograph_100-yr 03.11.2020.txt
EPA SWMM 5 Input Filename (Optional):	P:\17127 Zadel Weld County PUD\Drainage\PHASE 3 Report\CUHP\17127 - Thunder Valley_100-yr Storm.inp
EPA SWMM 5 Application File (Optional):	C:\Program Files (x86)\EPA SWMM 5.1\swmm5.exe
SWMM Hydrograph Start Time (Optional):	3/11/2020 12:00 AM

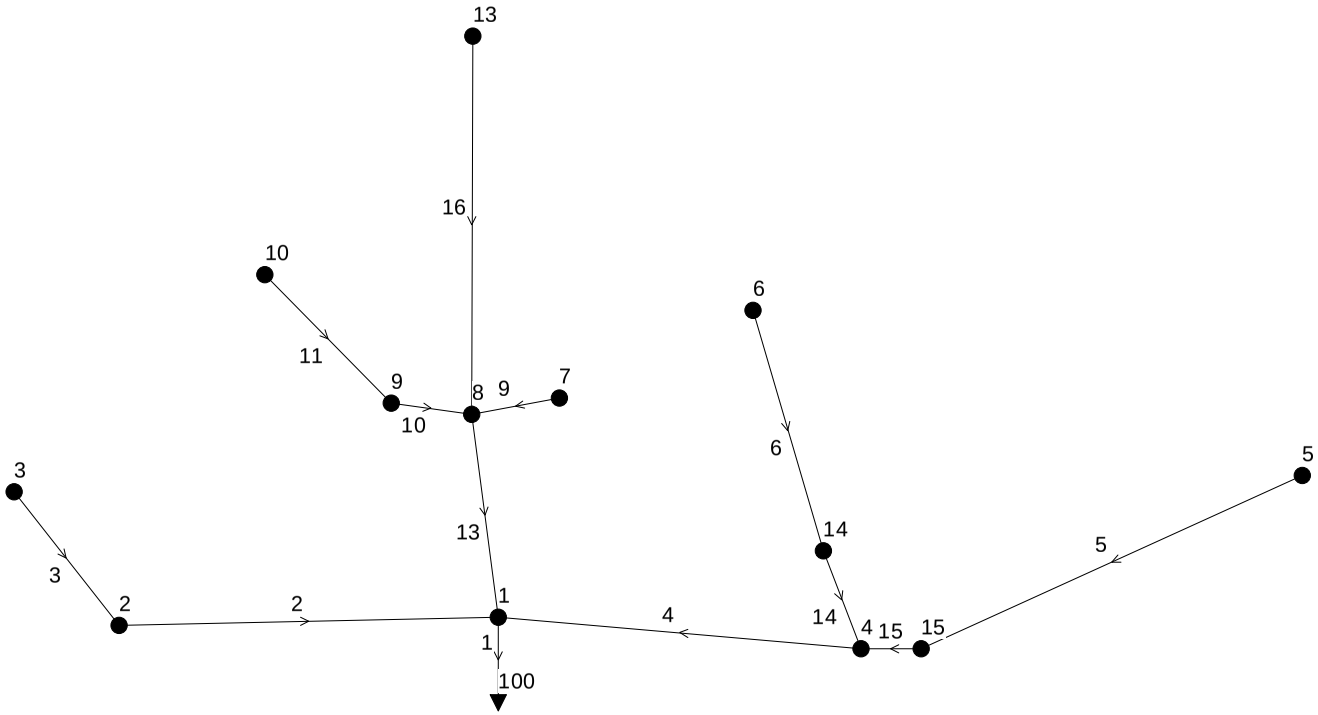
Acknowledgements: Thanks to Ben Urbonas, P.E., D.WRE and James C.Y.Guo, PhD, P.E., for the development of the CUHP project.

CUHP SUBCATCHMENTS

Columns with this color heading are for required user-input
Columns with this color heading are for optional override values
Columns with this color heading are for program-calculated values

								Maximum Depression Storage (Watershed inches)		Horton's Infiltration Parameters			DCIA
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (mi^2)	Length to Centroid (mi)	Length (mi)	Slope (ft/ft)	Percent Imperviousness	Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)	Level 0, 1, or 2
A	2	100 Year	0.0045938	0.041477273	0.0823864	0.03	12	0.4	0.05	4.5	0.0018	0.6	0
B	9	100 Year	0.0076875	0.06155303	0.1460227	0.031	12	0.4	0.05	4.5	0.0018	0.6	0
C	7	100 Year	0.0045	0.053977273	0.088447	0.02	12	0.4	0.05	4.5	0.0018	0.6	0
D	14	100 Year	0.0081719	0.110227273	0.2244318	0.019	12	0.4	0.05	4.5	0.0018	0.6	0
E	1	100 Year	0.0102344	0.102083333	0.119697	0.025	12	0.4	0.05	4.5	0.0018	0.6	0
F	1	100 Year	0.0127656	0.102083333	0.1278409	0.019	12	0.4	0.05	4.5	0.0018	0.6	0
G	15	100 Year	0.0090156	0.096590909	0.1339015	0.023	12	0.4	0.05	4.5	0.0018	0.6	0
OS1	3	100 Year	0.0082188	0.061174242	0.1145833	0.024	2	0.4	0.05	4.5	0.0018	0.6	0
OS2	10	100 Year	0.0336406	0.172348485	0.34375	0.021	2	0.4	0.05	4.5	0.0018	0.6	0
OS3	13	100 Year	0.0911719	0.356628788	0.4668561	0.019	2	0.4	0.05	4.5	0.0018	0.6	0
OS4	13	100 Year	0.0492813	0.241477273	0.3844697	0.019	2	0.4	0.05	4.5	0.0018	0.6	0
OS5	6	100 Year	0.050125	0.211742424	0.3323864	0.023	2	0.4	0.05	4.5	0.0018	0.6	0
OS6	5	100 Year	0.0492969	0.140340909	0.2774621	0.029	2	0.4	0.05	4.5	0.0018	0.6	0

Comment	100 Year Storm		
1Hr Depth	2.71	NOAA Atlas 14 Point Precipitation Frequency Estimates: CO (Note: Use 60-minute recurrence interval depth)	
Return Period	100	Years	
Time	Depth	CurveValue	
0:05	0.027		0.01
0:10	0.081		0.03
0:15	0.125		0.046
0:20	0.217		0.08
0:25	0.379		0.14
0:30	0.678		0.25
0:35	0.379		0.14
0:40	0.217		0.08
0:45	0.168		0.062
0:50	0.136		0.05
0:55	0.108		0.04
1:00	0.108		0.04
1:05	0.108		0.04
1:10	0.054		0.02
1:15	0.054		0.02
1:20	0.033		0.012
1:25	0.033		0.012
1:30	0.033		0.012
1:35	0.033		0.012
1:40	0.033		0.012
1:45	0.033		0.012
1:50	0.033		0.012
1:55	0.033		0.012
2:00	0.033		0.012
2:05	0		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Summary of Unit Hydrograph Parameters Used By Program and Calculated Results (Version 2.0.1)

		Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment Name/ID	User Comment for Catchment	CT	Cp	W50 (min.)	W50 Before Peak	W75 (min.)	W75 Before Peak	Time to Peak (min.)	Peak (cfs)	Volume (c.f)	Excess (inches)	Excess (c.f.)	Time to Peak (min.)	Peak Flow (cfs)	Total Volume (c.f.)	Runoff per Unit Area (cfs/acre)
A		0.124	0.034	26.1	0.98	13.5	0.69	1.6	5	10,672	1.64	17,515	40.0	5	17,505	1.84
B		0.124	0.043	32.6	1.37	17.0	0.97	2.3	7	17,860	1.64	29,310	43.0	8	29,314	1.57
C		0.124	0.034	34.0	1.18	17.7	0.83	2.0	4	10,454	1.64	17,157	45.0	4	17,157	1.52
D		0.124	0.044	58.0	2.26	30.2	1.60	3.8	4	18,985	1.64	31,157	52.0	5	31,157	1.04
E		0.124	0.049	35.0	1.61	18.2	1.14	2.7	9	23,777	1.64	39,021	45.0	10	39,016	1.50
F		0.124	0.054	34.9	1.75	18.2	1.23	2.9	11	29,657	1.64	48,672	45.0	12	48,664	1.50
G		0.124	0.046	38.8	1.67	20.2	1.18	2.8	7	20,945	1.64	34,374	46.0	8	34,369	1.39
OS1		0.157	0.054	30.8	1.58	16.0	1.11	2.6	8	19,094	1.51	28,902	42.0	8	28,898	1.55
OS2		0.157	0.102	46.9	3.97	24.4	2.80	6.6	22	78,154	1.51	118,303	50.0	25	118,299	1.16
OS3		0.157	0.159	50.4	6.47	26.2	4.57	10.8	54	211,811	1.51	320,621	53.0	65	320,619	1.12
OS4		0.157	0.121	50.2	4.96	26.1	3.51	8.3	29	114,490	1.51	173,305	52.0	35	173,303	1.11
OS5		0.157	0.122	41.7	4.20	21.7	2.97	7.0	36	116,450	1.51	176,273	48.0	41	176,266	1.27
OS6		0.157	0.121	29.9	3.07	15.5	2.17	5.1	49	114,527	1.51	173,360	43.0	51	173,347	1.61

Summary of CUHP Input Parameters (Version 2.0.1)

								Depression Storage		Horton's Infiltration Parameters			DCIA Level and Fractions			
Catchment Name/ID	SWMM Node/ID	Raingage Name/ID	Area (sq.mi.)	Dist. to Centroid (miles)	Length (miles)	Slope (ft./ft.)	Percent Imperv.	Pervious (inches)	Imperv. (inches)	Initial Rate (in./hr.)	Final Rate (in.hr.)	Decay Coeff. (1/sec.)	DCIA Level	Dir. Con'ct Imperv. Fraction	Receiv. Perv. Fraction	Percent Eff. Imperv.
A	2	100 YEAR	0.005	0.041	0.082	0.030	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
B	9	100 YEAR	0.008	0.062	0.146	0.031	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
C	7	100 YEAR	0.005	0.054	0.088	0.020	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
D	14	100 YEAR	0.008	0.110	0.224	0.019	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
E	1	100 YEAR	0.010	0.102	0.120	0.025	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
F	1	100 YEAR	0.013	0.102	0.128	0.019	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
G	15	100 YEAR	0.009	0.097	0.134	0.023	12.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.24	0.11	10.82
OS1	3	100 YEAR	0.008	0.061	0.115	0.024	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.00	0.02	1.74
OS2	10	100 YEAR	0.034	0.172	0.344	0.021	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.75
OS3	13	100 YEAR	0.091	0.357	0.467	0.019	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.75
OS4	13	100 YEAR	0.049	0.241	0.384	0.019	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.75
OS5	6	100 YEAR	0.050	0.212	0.332	0.023	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.75
OS6	5	100 YEAR	0.049	0.140	0.277	0.029	2.0	0.40	0.05	4.50	0.60	0.0018	0.00	0.04	0.02	1.75

100 - Year Node Flow

Node Inflow Summary

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Day of Maximum Inflow	Hour of Maximum Inflow	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
1	JUNCTION	22.11	186.29	0	01:18	0.656	8.52	0.000
2	JUNCTION	5.41	12.61	0	00:52	0.131	0.346	0.000
3	JUNCTION	8.18	8.18	0	00:43	0.216	0.216	0.000
4	JUNCTION	0.00	90.04	0	01:12	0	3.26	0.000
5	JUNCTION	50.82	50.82	0	00:44	1.3	1.3	0.000
6	JUNCTION	40.89	40.89	0	00:49	1.32	1.32	0.000
7	JUNCTION	4.39	4.39	0	00:46	0.128	0.128	0.000
8	JUNCTION	0.00	128.55	0	00:59	0	4.94	0.000
9	JUNCTION	7.73	28.49	0	01:12	0.219	1.13	0.000
10	JUNCTION	25.05	25.05	0	00:51	0.885	0.885	0.000
14	JUNCTION	5.42	40.98	0	01:14	0.233	1.61	0.000
15	JUNCTION	8.04	49.30	0	01:10	0.257	1.65	0.000
13	JUNCTION	100.24	100.24	0	00:54	3.69	3.69	0.000
100	OUTFALL	0.00	186.28	0	01:18	0	8.52	0.000

100 - Year Link Flow

Link Flow Summary

Link	Type	Maximum |Flow| CFS	Day of Maximum Flow	Hour of Maximum Flow	Maximum |Velocity| ft/sec	Max / Full Flow	Max / Full Depth
3	CONDUIT	7.80	0	00:55	0.45	0.00	0.00
2	CONDUIT	12.52	0	00:57	3.09	0.10	0.42
1	CONDUIT	186.28	0	01:18	6.26	0.00	0.01
6	CONDUIT	36.18	0	01:15	0.49	0.00	0.00
5	CONDUIT	42.83	0	01:12	0.50	0.00	0.00
4	CONDUIT	41.63	0	00:56	2.65	1.00	1.00
9	CONDUIT	4.39	0	00:46	1.77	0.00	0.00
10	CONDUIT	28.49	0	01:12	2.99	0.00	0.01
11	CONDUIT	22.93	0	01:15	0.41	0.00	0.00
13	CONDUIT	120.98	0	01:21	0.37	0.62	0.79
14	CONDUIT	40.98	0	01:14	2.06	0.00	0.02
15	CONDUIT	49.30	0	01:10	2.16	0.00	0.02
16	CONDUIT	100.15	0	00:55	3.39	0.02	0.13

100 - Year Event
Printouts for Storm Hydrographs

flow in cfs

time in minutes	A	B	C	D	E	F	G	OS1	OS2	OS3	OS4	OS5	OS6
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
10	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
11	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
12	0.01	0.02	0.01	0.01	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
13	0.02	0.02	0.01	0.01	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
14	0.02	0.03	0.02	0.02	0.03	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00
15	0.03	0.03	0.02	0.02	0.04	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.01
16	0.03	0.04	0.02	0.02	0.05	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.01
17	0.04	0.05	0.03	0.03	0.06	0.07	0.05	0.00	0.00	0.01	0.00	0.00	0.01
18	0.04	0.06	0.03	0.03	0.07	0.08	0.05	0.00	0.00	0.01	0.00	0.01	0.01
19	0.05	0.06	0.04	0.04	0.08	0.10	0.06	0.00	0.00	0.01	0.01	0.01	0.01
20	0.06	0.08	0.05	0.04	0.10	0.12	0.08	0.00	0.01	0.01	0.01	0.01	0.02
21	0.12	0.15	0.09	0.07	0.17	0.20	0.13	0.02	0.01	0.02	0.02	0.02	0.05
22	0.20	0.24	0.14	0.11	0.28	0.34	0.22	0.03	0.04	0.05	0.04	0.06	0.12
23	0.27	0.34	0.20	0.17	0.40	0.49	0.32	0.06	0.07	0.09	0.07	0.11	0.22
24	0.35	0.44	0.26	0.23	0.53	0.65	0.42	0.08	0.12	0.16	0.12	0.19	0.34
25	0.48	0.60	0.35	0.31	0.71	0.87	0.56	0.17	0.21	0.30	0.23	0.33	0.62
26	1.02	1.17	0.71	0.52	1.32	1.57	1.03	0.70	0.62	0.81	0.63	0.97	1.99
27	1.66	2.02	1.20	0.91	2.32	2.77	1.80	1.61	1.63	2.05	1.63	2.54	5.22
28	2.31	2.88	1.68	1.40	3.39	4.11	2.66	2.59	3.27	4.23	3.35	5.12	9.99
29	2.94	3.74	2.16	1.92	4.46	5.45	3.51	3.56	5.39	7.44	5.73	8.52	15.69
30	3.58	4.60	2.64	2.44	5.53	6.79	4.36	4.54	7.83	11.61	8.62	12.49	21.73
31	3.95	5.22	2.97	2.89	6.36	7.86	5.03	5.29	10.31	16.44	11.77	16.60	27.30
32	4.26	5.66	3.21	3.24	6.95	8.62	5.51	5.81	12.52	21.56	14.87	20.37	31.92
33	4.55	6.08	3.44	3.52	7.48	9.29	5.94	6.29	14.41	26.72	17.72	23.63	35.69
34	4.82	6.49	3.67	3.79	8.00	9.94	6.36	6.75	16.05	31.72	20.23	26.46	38.90
35	5.09	6.89	3.90	4.06	8.51	10.58	6.77	7.21	17.51	36.41	22.48	28.97	41.85
36	5.21	7.15	4.03	4.28	8.88	11.06	7.08	7.53	18.80	40.66	24.47	31.18	44.45
37	5.28	7.30	4.12	4.45	9.10	11.36	7.28	7.71	19.91	44.41	26.16	33.05	46.44
38	5.33	7.43	4.20	4.59	9.29	11.60	7.45	7.86	20.83	47.65	27.60	34.61	47.88
39	5.37	7.55	4.27	4.71	9.46	11.82	7.60	7.99	21.59	50.43	28.83	35.91	48.94
40	5.41	7.66	4.33	4.83	9.62	12.02	7.75	8.11	22.25	52.82	29.90	37.01	49.78
41	5.40	7.72	4.37	4.94	9.73	12.15	7.86	8.17	22.81	54.92	30.83	37.93	50.40
42	5.37	7.73	4.38	5.02	9.78	12.22	7.92	8.18	23.30	56.75	31.62	38.70	50.74
43	5.35	7.73	4.39	5.10	9.81	12.26	7.97	8.17	23.72	58.33	32.30	39.34	50.82
44	5.33	7.73	4.39	5.17	9.82	12.28	8.01	8.16	24.07	59.68	32.89	39.86	50.75
45	5.31	7.73	4.39	5.23	9.82	12.28	8.04	8.15	24.37	60.86	33.42	40.28	50.63
46	5.26	7.70	4.37	5.29	9.80	12.26	8.04	8.12	24.62	61.89	33.87	40.59	50.45
47	5.20	7.65	4.35	5.33	9.75	12.20	8.02	8.07	24.81	62.78	34.24	40.80	50.19
48	5.15	7.61	4.32	5.36	9.70	12.14	7.98	8.01	24.94	63.52	34.54	40.89	49.86
49	5.09	7.56	4.30	5.39	9.66	12.08	7.95	7.96	25.02	64.12	34.76	40.87	49.48
50	5.04	7.52	4.28	5.41	9.61	12.02	7.92	7.90	25.05	64.59	34.93	40.77	49.07
51	4.96	7.45	4.25	5.42	9.55	11.94	7.88	7.82	25.03	64.94	35.02	40.60	48.62
52	4.87	7.37	4.20	5.42	9.46	11.83	7.83	7.73	24.96	65.15	35.05	40.38	48.08
53	4.79	7.29	4.16	5.42	9.37	11.72	7.76	7.63	24.84	65.23	35.01	40.13	47.48
54	4.72	7.21	4.12	5.40	9.28	11.60	7.70	7.53	24.69	65.19	34.90	39.85	46.83

55	4.65	7.13	4.08	5.39	9.19	11.49	7.64	7.43	24.53	65.02	34.73	39.56	46.15
56	4.58	7.04	4.03	5.37	9.10	11.37	7.58	7.33	24.37	64.74	34.52	39.27	45.46
57	4.51	6.96	3.99	5.35	9.00	11.26	7.53	7.23	24.21	64.37	34.31	38.98	44.77
58	4.45	6.88	3.95	5.33	8.91	11.14	7.47	7.13	24.07	63.96	34.09	38.69	44.12
59	4.39	6.80	3.91	5.31	8.82	11.03	7.41	7.04	23.94	63.55	33.90	38.40	43.52
60	4.33	6.72	3.86	5.29	8.73	10.91	7.35	6.96	23.80	63.15	33.71	38.12	42.95
61	4.28	6.65	3.82	5.27	8.64	10.80	7.29	6.88	23.67	62.77	33.55	37.84	42.41
62	4.22	6.59	3.79	5.26	8.55	10.69	7.23	6.81	23.54	62.43	33.38	37.57	41.92
63	4.17	6.53	3.75	5.24	8.47	10.59	7.17	6.74	23.42	62.11	33.22	37.29	41.44
64	4.11	6.47	3.72	5.23	8.40	10.49	7.11	6.67	23.30	61.79	33.06	37.00	40.99
65	4.06	6.41	3.69	5.22	8.33	10.40	7.05	6.61	23.17	61.48	32.91	36.72	40.55
66	3.96	6.31	3.63	5.19	8.22	10.28	6.96	6.51	23.02	61.15	32.74	36.40	40.03
67	3.85	6.19	3.56	5.15	8.07	10.10	6.84	6.37	22.82	60.77	32.52	35.99	39.36
68	3.73	6.06	3.49	5.10	7.92	9.90	6.72	6.22	22.56	60.32	32.23	35.49	38.55
69	3.62	5.94	3.42	5.04	7.77	9.71	6.60	6.07	22.25	59.77	31.88	34.91	37.65
70	3.51	5.81	3.35	4.98	7.62	9.52	6.48	5.93	21.90	59.12	31.48	34.28	36.72
71	3.40	5.69	3.29	4.93	7.47	9.34	6.37	5.78	21.54	58.41	31.05	33.65	35.79
72	3.29	5.56	3.22	4.87	7.32	9.16	6.26	5.64	21.18	57.63	30.59	33.02	34.86
73	3.18	5.44	3.15	4.81	7.18	8.97	6.15	5.49	20.82	56.81	30.12	32.41	33.93
74	3.08	5.32	3.09	4.75	7.03	8.79	6.04	5.35	20.45	55.95	29.65	31.83	33.01
75	2.97	5.20	3.02	4.70	6.89	8.61	5.94	5.21	20.09	55.07	29.17	31.26	32.09
76	2.86	5.07	2.95	4.64	6.74	8.43	5.83	5.06	19.74	54.18	28.70	30.70	31.17
77	2.76	4.94	2.88	4.58	6.59	8.24	5.71	4.92	19.40	53.29	28.22	30.13	30.24
78	2.66	4.81	2.81	4.51	6.43	8.04	5.60	4.77	19.06	52.39	27.73	29.58	29.30
79	2.57	4.68	2.74	4.45	6.28	7.85	5.49	4.63	18.74	51.47	27.25	29.02	28.36
80	2.48	4.56	2.67	4.39	6.13	7.67	5.37	4.49	18.41	50.57	26.77	28.47	27.44
81	2.40	4.43	2.61	4.32	5.98	7.48	5.26	4.34	18.09	49.68	26.32	27.92	26.52
82	2.33	4.31	2.54	4.26	5.84	7.29	5.16	4.21	17.78	48.82	25.87	27.38	25.62
83	2.25	4.19	2.47	4.20	5.69	7.11	5.05	4.07	17.48	47.98	25.44	26.84	24.73
84	2.18	4.07	2.41	4.13	5.55	6.93	4.94	3.93	17.18	47.17	25.02	26.31	23.85
85	2.12	3.95	2.34	4.07	5.41	6.76	4.84	3.80	16.88	46.38	24.60	25.78	23.02
86	2.05	3.83	2.28	4.01	5.27	6.58	4.73	3.67	16.59	45.61	24.20	25.26	22.24
87	1.99	3.71	2.21	3.95	5.13	6.40	4.63	3.55	16.31	44.85	23.80	24.75	21.50
88	1.93	3.60	2.15	3.90	4.99	6.23	4.53	3.44	16.02	44.10	23.42	24.25	20.82
89	1.87	3.48	2.09	3.84	4.85	6.06	4.43	3.33	15.75	43.38	23.04	23.76	20.18
90	1.82	3.38	2.03	3.79	4.71	5.89	4.33	3.23	15.47	42.67	22.66	23.27	19.58
91	1.77	3.28	1.96	3.74	4.58	5.72	4.23	3.14	15.20	41.97	22.30	22.79	19.00
92	1.71	3.19	1.91	3.69	4.45	5.55	4.13	3.05	14.94	41.28	21.94	22.31	18.45
93	1.66	3.10	1.85	3.64	4.32	5.39	4.03	2.97	14.68	40.61	21.58	21.84	17.93
94	1.61	3.02	1.80	3.59	4.19	5.23	3.93	2.89	14.42	39.94	21.23	21.37	17.44
95	1.56	2.94	1.75	3.55	4.07	5.08	3.83	2.81	14.17	39.29	20.89	20.91	16.96
96	1.52	2.87	1.71	3.50	3.96	4.94	3.74	2.74	13.92	38.65	20.56	20.44	16.51
97	1.47	2.80	1.66	3.46	3.86	4.81	3.64	2.67	13.67	38.02	20.23	19.98	16.06
98	1.42	2.73	1.62	3.41	3.76	4.69	3.55	2.60	13.42	37.40	19.90	19.52	15.63
99	1.38	2.67	1.58	3.37	3.67	4.58	3.45	2.53	13.17	36.79	19.57	19.06	15.21
100	1.33	2.60	1.55	3.32	3.58	4.47	3.36	2.47	12.93	36.18	19.24	18.61	14.81
101	1.29	2.54	1.51	3.28	3.50	4.37	3.27	2.40	12.68	35.58	18.92	18.16	14.41
102	1.25	2.48	1.48	3.24	3.42	4.27	3.18	2.34	12.44	34.98	18.60	17.71	14.01
103	1.21	2.43	1.45	3.20	3.34	4.17	3.10	2.28	12.20	34.39	18.29	17.26	13.63
104	1.16	2.37	1.41	3.15	3.27	4.08	3.03	2.22	11.96	33.80	17.97	16.82	13.26
105	1.12	2.32	1.38	3.11	3.20	3.99	2.96	2.16	11.72	33.21	17.66	16.38	12.89
106	1.08	2.26	1.35	3.07	3.13	3.91	2.89	2.11	11.48	32.63	17.35	15.94	12.53
107	1.04	2.21	1.32	3.03	3.06	3.82	2.83	2.05	11.25	32.05	17.04	15.51	12.17
108	1.00	2.16	1.29	2.99	3.00	3.74	2.77	1.99	11.01	31.47	16.73	15.09	11.83
109	0.96	2.11	1.26	2.95	2.93	3.66	2.71	1.94	10.78	30.90	16.42	14.70	11.48
110	0.92	2.06	1.24	2.91	2.87	3.58	2.66	1.89	10.54	30.33	16.12	14.34	11.15
111	0.88	2.01	1.21	2.87	2.81	3.50	2.61	1.83	10.31	29.77	15.81	13.99	10.81
112	0.85	1.96	1.18	2.83	2.75	3.43	2.56	1.78	10.08	29.20	15.51	13.68	10.48
113	0.81	1.91	1.16	2.79	2.69	3.35	2.51	1.73	9.85	28.64	15.21	13.37	10.16
114	0.77	1.87	1.13	2.75	2.63	3.28	2.46	1.68	9.62	28.08	14.91	13.09	9.84
115	0.74	1.82	1.10	2.71	2.57	3.21	2.41	1.63	9.40	27.53	14.61	12.81	9.52
116	0.70	1.78	1.08	2.67	2.52	3.14	2.36	1.58	9.17	26.97	14.32	12.54	9.21
117	0.67	1.73	1.05	2.63	2.46	3.07	2.32	1.53	8.94	26.43	14.02	12.29	8.90

118	0.63	1.69	1.03	2.60	2.41	3.00	2.27	1.49	8.73	25.88	13.73	12.05	8.60
119	0.60	1.64	1.01	2.56	2.35	2.94	2.23	1.44	8.52	25.34	13.44	11.81	8.30
120	0.56	1.60	0.98	2.52	2.30	2.87	2.19	1.39	8.33	24.79	13.14	11.58	8.00
121	0.52	1.56	0.96	2.48	2.25	2.80	2.14	1.35	8.15	24.25	12.85	11.35	7.71
122	0.49	1.51	0.93	2.44	2.19	2.73	2.10	1.30	7.98	23.71	12.56	11.13	7.42
123	0.45	1.47	0.91	2.40	2.14	2.67	2.06	1.26	7.82	23.17	12.27	10.92	7.14
124	0.42	1.43	0.88	2.36	2.09	2.60	2.02	1.21	7.67	22.64	11.98	10.71	6.86
125	0.38	1.38	0.86	2.32	2.03	2.53	1.97	1.17	7.52	22.10	11.70	10.50	6.58
126	0.35	1.34	0.84	2.28	1.98	2.47	1.93	1.12	7.38	21.59	11.44	10.30	6.30
127	0.33	1.30	0.81	2.24	1.93	2.40	1.89	1.08	7.24	21.10	11.20	10.10	6.02
128	0.30	1.26	0.79	2.20	1.88	2.34	1.85	1.04	7.12	20.65	10.97	9.91	5.74
129	0.28	1.22	0.77	2.17	1.83	2.27	1.81	0.99	6.99	20.23	10.75	9.72	5.46
130	0.26	1.17	0.74	2.13	1.78	2.21	1.77	0.95	6.87	19.83	10.55	9.53	5.18
131	0.24	1.13	0.72	2.09	1.73	2.15	1.73	0.91	6.75	19.46	10.36	9.34	4.90
132	0.22	1.09	0.70	2.05	1.68	2.09	1.70	0.86	6.63	19.09	10.17	9.16	4.62
133	0.21	1.05	0.68	2.01	1.63	2.03	1.66	0.82	6.52	18.75	9.99	8.98	4.35
134	0.19	1.01	0.66	1.97	1.58	1.97	1.62	0.78	6.40	18.42	9.82	8.81	4.07
135	0.18	0.97	0.64	1.93	1.54	1.91	1.58	0.73	6.29	18.10	9.65	8.63	3.79
136	0.17	0.93	0.61	1.89	1.49	1.85	1.55	0.69	6.19	17.79	9.49	8.46	3.52
137	0.16	0.89	0.59	1.86	1.44	1.79	1.51	0.65	6.08	17.50	9.33	8.29	3.24
138	0.15	0.85	0.57	1.82	1.40	1.74	1.48	0.61	5.98	17.20	9.18	8.12	2.97
139	0.14	0.81	0.55	1.78	1.35	1.68	1.44	0.56	5.88	16.92	9.03	7.96	2.71
140	0.13	0.77	0.53	1.75	1.30	1.62	1.41	0.52	5.78	16.65	8.89	7.79	2.47
141	0.12	0.74	0.51	1.72	1.26	1.56	1.37	0.48	5.68	16.38	8.74	7.63	2.26
142	0.11	0.70	0.49	1.69	1.21	1.50	1.34	0.44	5.59	16.11	8.60	7.47	2.07
143	0.10	0.66	0.46	1.66	1.17	1.45	1.31	0.40	5.49	15.85	8.47	7.32	1.90
144	0.09	0.62	0.44	1.63	1.12	1.39	1.27	0.36	5.40	15.60	8.33	7.16	1.74
145	0.09	0.58	0.42	1.60	1.07	1.33	1.24	0.33	5.31	15.35	8.20	7.01	1.60
146	0.08	0.54	0.40	1.58	1.03	1.27	1.21	0.30	5.22	15.11	8.07	6.86	1.47
147	0.07	0.50	0.38	1.56	0.98	1.22	1.17	0.28	5.13	14.87	7.95	6.71	1.35
148	0.07	0.46	0.36	1.53	0.94	1.16	1.14	0.26	5.04	14.64	7.82	6.57	1.25
149	0.06	0.43	0.34	1.51	0.89	1.10	1.11	0.24	4.95	14.41	7.70	6.42	1.15
150	0.06	0.39	0.32	1.49	0.85	1.05	1.08	0.22	4.87	14.18	7.58	6.27	1.06
151	0.05	0.36	0.30	1.47	0.80	0.99	1.04	0.20	4.78	13.96	7.46	6.13	0.97
152	0.05	0.33	0.28	1.45	0.76	0.93	1.01	0.18	4.70	13.73	7.34	5.98	0.89
153	0.04	0.31	0.26	1.43	0.71	0.88	0.98	0.17	4.61	13.52	7.23	5.84	0.82
154	0.04	0.29	0.24	1.41	0.67	0.82	0.95	0.16	4.53	13.30	7.11	5.69	0.75
155	0.03	0.27	0.22	1.39	0.62	0.77	0.91	0.14	4.45	13.09	7.00	5.55	0.68
156	0.03	0.25	0.20	1.37	0.58	0.71	0.88	0.13	4.37	12.88	6.89	5.40	0.62
157	0.03	0.23	0.18	1.35	0.54	0.66	0.85	0.12	4.30	12.67	6.78	5.26	0.56
158	0.03	0.21	0.17	1.33	0.49	0.60	0.82	0.11	4.22	12.47	6.67	5.11	0.51
159	0.02	0.20	0.16	1.31	0.45	0.56	0.78	0.10	4.14	12.27	6.56	4.97	0.46
160	0.02	0.18	0.15	1.30	0.42	0.51	0.75	0.09	4.06	12.07	6.45	4.82	0.42
161	0.02	0.17	0.14	1.28	0.39	0.47	0.72	0.08	3.99	11.87	6.35	4.68	0.38
162	0.02	0.16	0.13	1.26	0.36	0.44	0.69	0.07	3.91	11.68	6.25	4.53	0.34
163	0.02	0.15	0.12	1.25	0.33	0.41	0.65	0.07	3.83	11.49	6.15	4.39	0.30
164	0.02	0.14	0.11	1.23	0.31	0.38	0.62	0.06	3.76	11.30	6.05	4.25	0.27
165	0.01	0.13	0.10	1.21	0.28	0.35	0.59	0.05	3.68	11.12	5.95	4.10	0.24
166	0.01	0.12	0.09	1.20	0.26	0.32	0.56	0.05	3.61	10.94	5.85	3.96	0.21
167	0.01	0.11	0.09	1.18	0.25	0.30	0.52	0.04	3.53	10.75	5.75	3.81	0.18
168	0.01	0.10	0.08	1.17	0.23	0.28	0.49	0.04	3.45	10.57	5.65	3.67	0.15
169	0.01	0.09	0.08	1.15	0.21	0.26	0.46	0.03	3.38	10.39	5.55	3.52	0.13
170	0.01	0.09	0.07	1.14	0.20	0.24	0.43	0.03	3.30	10.20	5.46	3.38	0.11
171	0.01	0.08	0.06	1.12	0.18	0.23	0.40	0.03	3.22	10.02	5.36	3.24	0.09
172	0.01	0.07	0.06	1.11	0.17	0.21	0.37	0.02	3.15	9.84	5.26	3.09	0.08
173	0.01	0.07	0.06	1.09	0.16	0.19	0.34	0.02	3.07	9.66	5.16	2.95	0.06
174	0.01	0.06	0.05	1.08	0.15	0.18	0.31	0.02	3.00	9.48	5.06	2.80	0.05
175	0.01	0.06	0.05	1.06	0.14	0.17	0.29	0.01	2.92	9.30	4.97	2.66	0.04
176	0.01	0.05	0.04	1.05	0.13	0.15	0.26	0.01	2.84	9.12	4.87	2.51	0.03
177	0.01	0.05	0.04	1.03	0.12	0.14	0.25	0.01	2.77	8.93	4.77	2.37	0.03
178	0.01	0.04	0.04	1.02	0.11	0.13	0.23	0.01	2.69	8.75	4.67	2.23	0.02
179	0.01	0.04	0.03	1.01	0.10	0.12	0.21	0.01	2.62	8.57	4.57	2.08	0.02
180	0.01	0.03	0.03	0.99	0.09	0.11	0.20	0.00	2.54	8.39	4.48	1.94	0.02

181	0.01	0.03	0.03	0.98	0.08	0.10	0.18	0.00	2.46	8.21	4.38	1.79	0.02
182	0.01	0.03	0.03	0.97	0.08	0.09	0.17	0.00	2.39	8.03	4.28	1.65	0.02
183	0.01	0.03	0.02	0.95	0.07	0.09	0.16	0.00	2.31	7.85	4.18	1.51	0.01
184	0.01	0.02	0.02	0.94	0.06	0.08	0.15	0.00	2.24	7.67	4.09	1.38	0.01
185	0.01	0.02	0.02	0.93	0.06	0.07	0.14	0.00	2.16	7.49	3.99	1.26	0.01
186	0.00	0.02	0.02	0.91	0.05	0.07	0.13	0.00	2.08	7.30	3.89	1.15	0.01
187	0.00	0.02	0.02	0.90	0.05	0.06	0.12	0.00	2.01	7.12	3.79	1.05	0.01
188	0.00	0.02	0.01	0.89	0.04	0.05	0.11	0.00	1.93	6.94	3.69	0.96	0.01
189	0.00	0.02	0.01	0.87	0.04	0.05	0.10	0.00	1.85	6.76	3.60	0.89	0.01
190	0.00	0.02	0.01	0.86	0.04	0.04	0.09	0.00	1.78	6.58	3.50	0.81	0.01
191	0.00	0.01	0.01	0.85	0.03	0.04	0.09	0.00	1.70	6.40	3.40	0.75	0.01
192	0.00	0.01	0.01	0.83	0.03	0.04	0.08	0.00	1.63	6.22	3.30	0.69	0.01
193	0.00	0.01	0.01	0.82	0.03	0.03	0.07	0.00	1.55	6.04	3.21	0.63	0.01
194	0.00	0.01	0.01	0.81	0.02	0.03	0.07	0.00	1.47	5.86	3.11	0.58	0.01
195	0.00	0.01	0.01	0.79	0.02	0.03	0.06	0.00	1.40	5.68	3.01	0.54	0.01
196	0.00	0.01	0.01	0.78	0.02	0.03	0.06	0.00	1.32	5.50	2.91	0.49	0.01
197	0.00	0.01	0.01	0.77	0.02	0.02	0.05	0.00	1.25	5.31	2.82	0.45	0.01
198	0.00	0.01	0.01	0.76	0.02	0.02	0.05	0.00	1.17	5.13	2.72	0.41	0.01
199	0.00	0.01	0.01	0.74	0.02	0.02	0.04	0.00	1.09	4.95	2.62	0.38	0.01
200	0.00	0.01	0.01	0.73	0.02	0.02	0.04	0.00	1.02	4.77	2.52	0.34	0.01
201	0.00	0.01	0.01	0.72	0.02	0.02	0.04	0.00	0.94	4.59	2.43	0.31	0.01
202	0.00	0.01	0.01	0.70	0.01	0.02	0.03	0.00	0.87	4.41	2.33	0.29	0.00
203	0.00	0.01	0.01	0.69	0.01	0.02	0.03	0.00	0.79	4.23	2.23	0.26	0.00
204	0.00	0.01	0.01	0.68	0.01	0.02	0.03	0.00	0.72	4.05	2.13	0.23	0.00
205	0.00	0.01	0.01	0.66	0.01	0.02	0.03	0.00	0.66	3.87	2.03	0.21	0.00
206	0.00	0.01	0.00	0.65	0.01	0.02	0.02	0.00	0.60	3.69	1.94	0.19	0.00
207	0.00	0.01	0.00	0.64	0.01	0.01	0.02	0.00	0.55	3.51	1.84	0.17	0.00
208	0.00	0.01	0.00	0.62	0.01	0.01	0.02	0.00	0.51	3.33	1.74	0.15	0.00
209	0.00	0.01	0.00	0.61	0.01	0.01	0.02	0.00	0.47	3.15	1.64	0.13	0.00
210	0.00	0.01	0.00	0.60	0.01	0.01	0.02	0.00	0.43	2.97	1.55	0.12	0.00
211	0.00	0.01	0.00	0.59	0.01	0.01	0.01	0.00	0.39	2.78	1.45	0.10	0.00
212	0.00	0.00	0.00	0.57	0.01	0.01	0.01	0.00	0.36	2.60	1.35	0.09	0.00
213	0.00	0.00	0.00	0.56	0.01	0.01	0.01	0.00	0.33	2.42	1.26	0.08	0.00
214	0.00	0.00	0.00	0.55	0.01	0.01	0.01	0.00	0.31	2.24	1.16	0.07	0.00
215	0.00	0.00	0.00	0.53	0.01	0.01	0.01	0.00	0.28	2.07	1.06	0.06	0.00
216	0.00	0.00	0.00	0.52	0.01	0.01	0.01	0.00	0.26	1.89	0.97	0.05	0.00
217	0.00	0.00	0.00	0.51	0.01	0.01	0.01	0.00	0.24	1.72	0.88	0.04	0.00
218	0.00	0.00	0.00	0.49	0.01	0.01	0.01	0.00	0.22	1.57	0.81	0.03	0.00
219	0.00	0.00	0.00	0.48	0.01	0.01	0.01	0.00	0.20	1.43	0.74	0.02	0.00
220	0.00	0.00	0.00	0.47	0.01	0.01	0.01	0.00	0.18	1.31	0.68	0.02	0.00
221	0.00	0.00	0.00	0.45	0.01	0.01	0.01	0.00	0.17	1.21	0.62	0.02	0.00
222	0.00	0.00	0.00	0.44	0.01	0.01	0.01	0.00	0.15	1.11	0.57	0.01	0.00
223	0.00	0.00	0.00	0.43	0.00	0.01	0.01	0.00	0.14	1.02	0.52	0.01	0.00
224	0.00	0.00	0.00	0.42	0.00	0.01	0.01	0.00	0.12	0.93	0.48	0.01	0.00
225	0.00	0.00	0.00	0.40	0.00	0.01	0.01	0.00	0.11	0.86	0.44	0.01	0.00
226	0.00	0.00	0.00	0.39	0.00	0.00	0.01	0.00	0.10	0.79	0.41	0.01	0.00
227	0.00	0.00	0.00	0.38	0.00	0.00	0.01	0.00	0.09	0.73	0.38	0.01	0.00
228	0.00	0.00	0.00	0.36	0.00	0.00	0.01	0.00	0.08	0.67	0.35	0.01	0.00
229	0.00	0.00	0.00	0.35	0.00	0.00	0.01	0.00	0.07	0.62	0.32	0.01	0.00
230	0.00	0.00	0.00	0.34	0.00	0.00	0.01	0.00	0.06	0.56	0.29	0.01	0.00
231	0.00	0.00	0.00	0.33	0.00	0.00	0.01	0.00	0.05	0.52	0.27	0.01	0.00
232	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.05	0.47	0.24	0.01	0.00
233	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.04	0.43	0.22	0.01	0.00
234	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.03	0.39	0.20	0.01	0.00
235	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.03	0.36	0.18	0.00	0.00
236	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.02	0.32	0.17	0.00	0.00
237	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.02	0.29	0.15	0.00	0.00
238	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.02	0.26	0.13	0.00	0.00
239	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.01	0.24	0.12	0.00	0.00
240	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.01	0.21	0.11	0.00	0.00
241	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.01	0.19	0.10	0.00	0.00
242	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.01	0.17	0.08	0.00	0.00
243	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.01	0.15	0.07	0.00	0.00

244	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.01	0.13	0.06	0.00	0.00
245	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.01	0.11	0.06	0.00	0.00
246	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.10	0.05	0.00	0.00
247	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.08	0.04	0.00	0.00
248	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.07	0.03	0.00	0.00
249	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.06	0.03	0.00	0.00
250	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.00
251	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.00
252	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00
253	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
254	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
255	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
256	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
257	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
258	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
259	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
260	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
261	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
262	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
263	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
264	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
265	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
266	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
267	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
268	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
269	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
270	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
271	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
272	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
273	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
274	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
275	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
276	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
277	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
278	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
279	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
280	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
281	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
282	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
283	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
284	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
285	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
286	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
287	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
288	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
289	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
290	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
291	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
292	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
293	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
294	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
295	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
296	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
297	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
298	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
299	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
301	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
302	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
303	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
304	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
306	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

307	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
308	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
309	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
311	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
312	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
313	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
314	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
315	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
316	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
317	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
318	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
319	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
321	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
322	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
323	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
324	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
325	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
326	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
327	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
328	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
329	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
331	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
332	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
334	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
335	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
336	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
337	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
338	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
339	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
340	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

X. Appendix E

A. Culvert and Ditch Calculations

Culvert Report

Thunder Valley PUD; Culvert #1

Invert Elev Dn (ft)	=	5021.99
Pipe Length (ft)	=	52.00
Slope (%)	=	0.98
Invert Elev Up (ft)	=	5022.50
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	1
n-Value	=	0.013
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

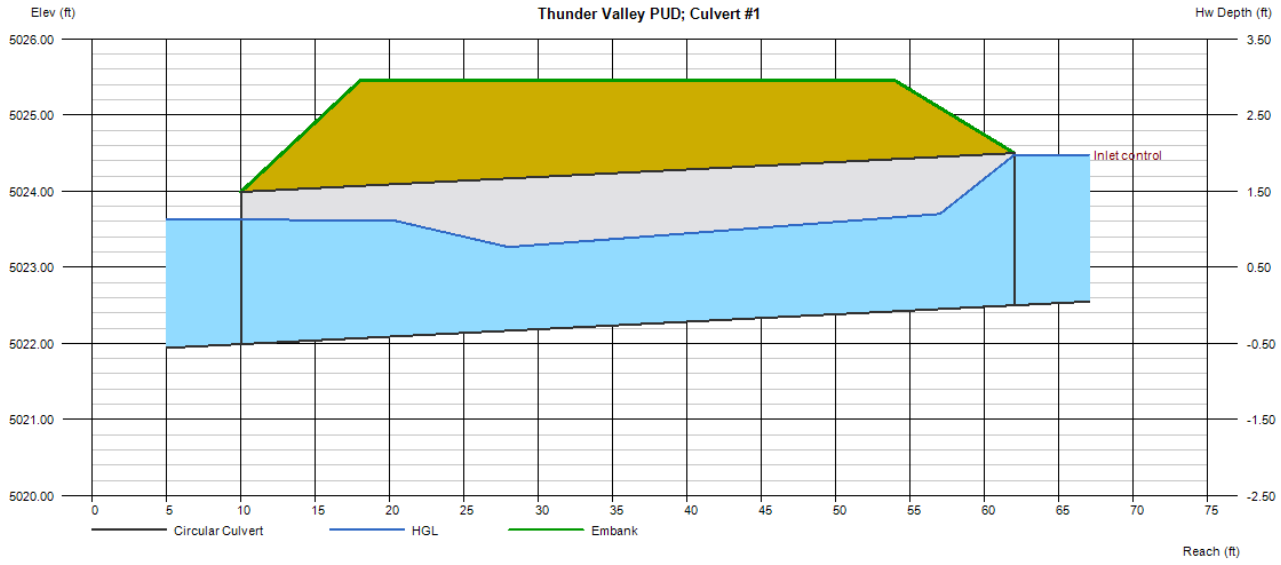
Top Elevation (ft)	=	5025.45
Top Width (ft)	=	36.00
Crest Width (ft)	=	20.00

Calculations

Qmin (cfs)	=	12.61
Qmax (cfs)	=	12.61
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	12.61
Qpipe (cfs)	=	12.61
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	4.58
Veloc Up (ft/s)	=	5.96
HGL Dn (ft)	=	5023.63
HGL Up (ft)	=	5023.78
Hw Elev (ft)	=	5024.48
Hw/D (ft)	=	0.99
Flow Regime	=	Inlet Control



Culvert Report

Thunder Valley PUD; Culvert #2

Invert Elev Dn (ft)	=	5019.00
Pipe Length (ft)	=	37.20
Slope (%)	=	3.92
Invert Elev Up (ft)	=	5020.46
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	2
n-Value	=	0.013
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

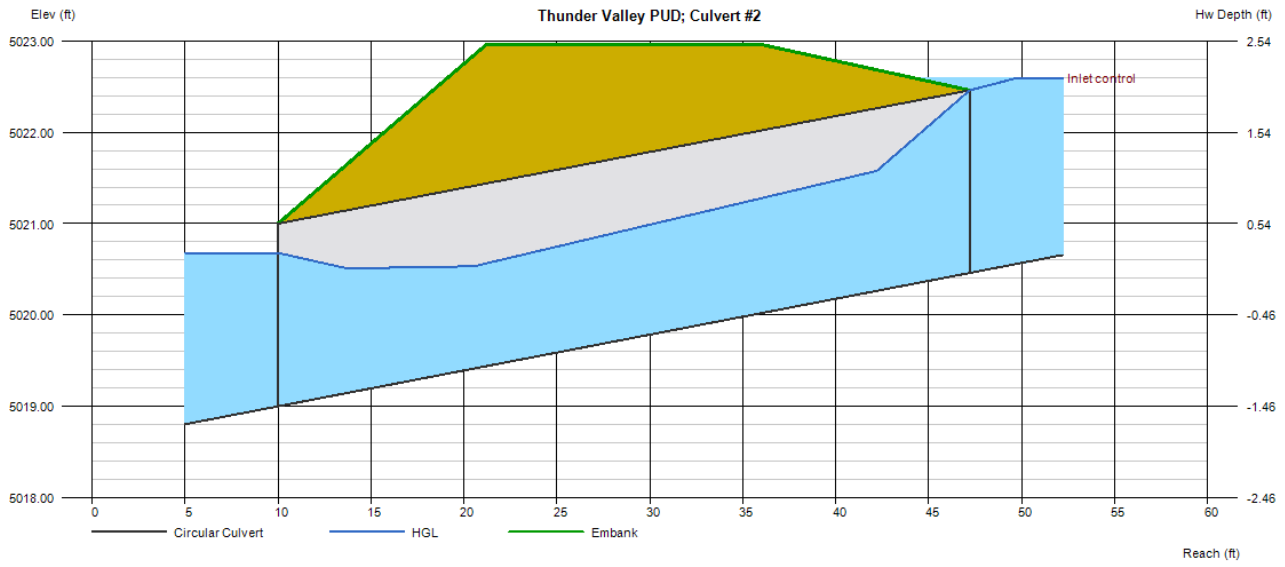
Top Elevation (ft)	=	5022.96
Top Width (ft)	=	14.80
Crest Width (ft)	=	20.00

Calculations

Qmin (cfs)	=	28.49
Qmax (cfs)	=	28.49
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	28.49
Qpipe (cfs)	=	28.49
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	5.06
Veloc Up (ft/s)	=	6.27
HGL Dn (ft)	=	5020.68
HGL Up (ft)	=	5021.82
Hw Elev (ft)	=	5022.59
Hw/D (ft)	=	1.07
Flow Regime	=	Inlet Control



Culvert Report

Thunder Valley PUD; Culvert #3

Invert Elev Dn (ft)	=	5017.51
Pipe Length (ft)	=	56.00
Slope (%)	=	0.50
Invert Elev Up (ft)	=	5017.79
Rise (in)	=	36.0
Shape	=	Circular
Span (in)	=	36.0
No. Barrels	=	2
n-Value	=	0.013
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

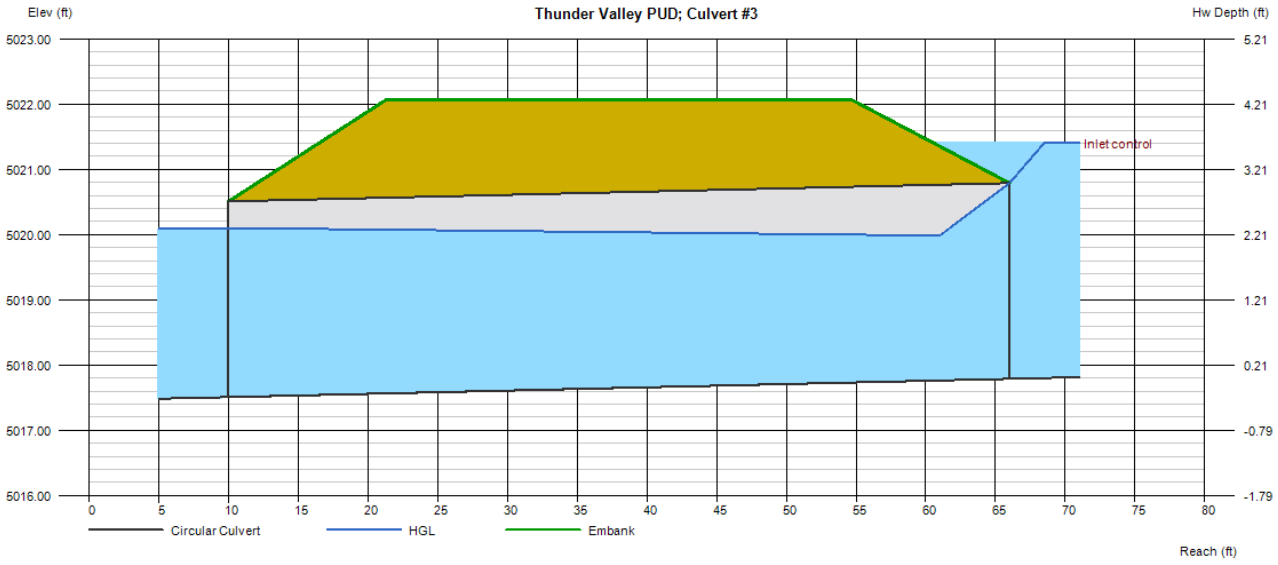
Top Elevation (ft)	=	5022.06
Top Width (ft)	=	33.50
Crest Width (ft)	=	12.50

Calculations

Qmin (cfs)	=	90.04
Qmax (cfs)	=	90.04
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	90.04
Qpipe (cfs)	=	90.04
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	6.93
Veloc Up (ft/s)	=	8.17
HGL Dn (ft)	=	5020.10
HGL Up (ft)	=	5019.97
Hw Elev (ft)	=	5021.41
Hw/D (ft)	=	1.21
Flow Regime	=	Inlet Control



Culvert Report

Thunder Valley PUD; Culvert #4

Invert Elev Dn (ft)	=	5019.12
Pipe Length (ft)	=	40.09
Slope (%)	=	0.92
Invert Elev Up (ft)	=	5019.49
Rise (in)	=	18.0
Shape	=	Circular
Span (in)	=	18.0
No. Barrels	=	1
n-Value	=	0.013
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

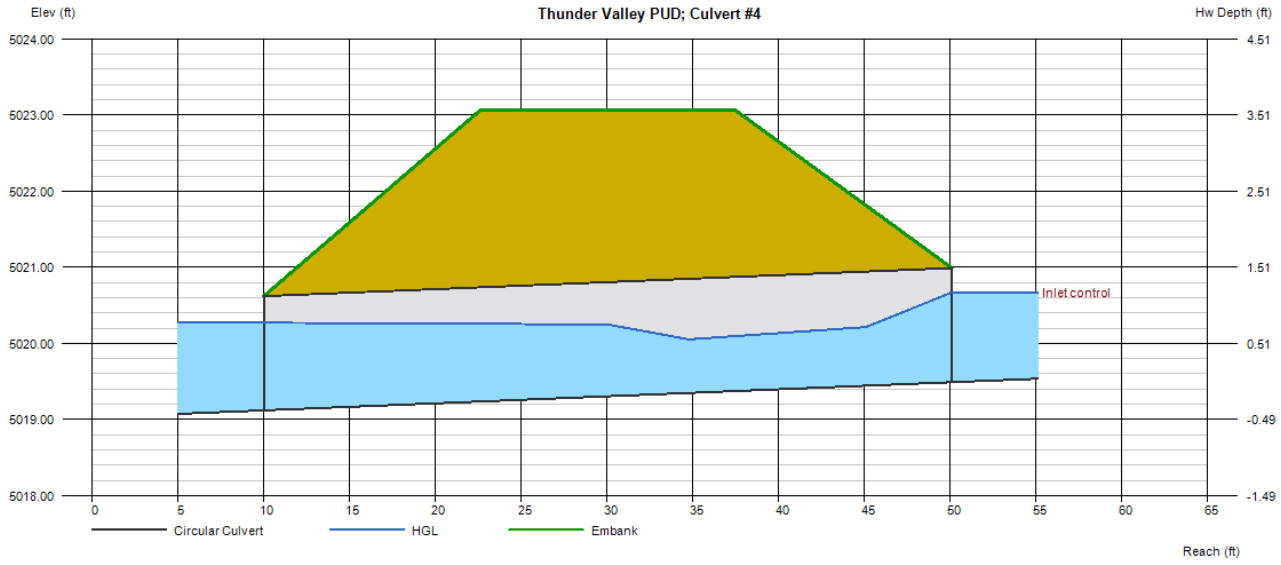
Top Elevation (ft)	=	5023.07
Top Width (ft)	=	14.80
Crest Width (ft)	=	4.00

Calculations

Qmin (cfs)	=	4.39
Qmax (cfs)	=	4.39
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	4.39
Qpipe (cfs)	=	4.39
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	3.02
Veloc Up (ft/s)	=	4.56
HGL Dn (ft)	=	5020.27
HGL Up (ft)	=	5020.29
Hw Elev (ft)	=	5020.67
Hw/D (ft)	=	0.79
Flow Regime	=	Inlet Control



Culvert Report

Thunder Valley PUD; Culvert #5

Invert Elev Dn (ft)	=	5018.02
Pipe Length (ft)	=	68.61
Slope (%)	=	1.52
Invert Elev Up (ft)	=	5019.06
Rise (in)	=	36.0
Shape	=	Circular
Span (in)	=	36.0
No. Barrels	=	3
n-Value	=	0.013
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

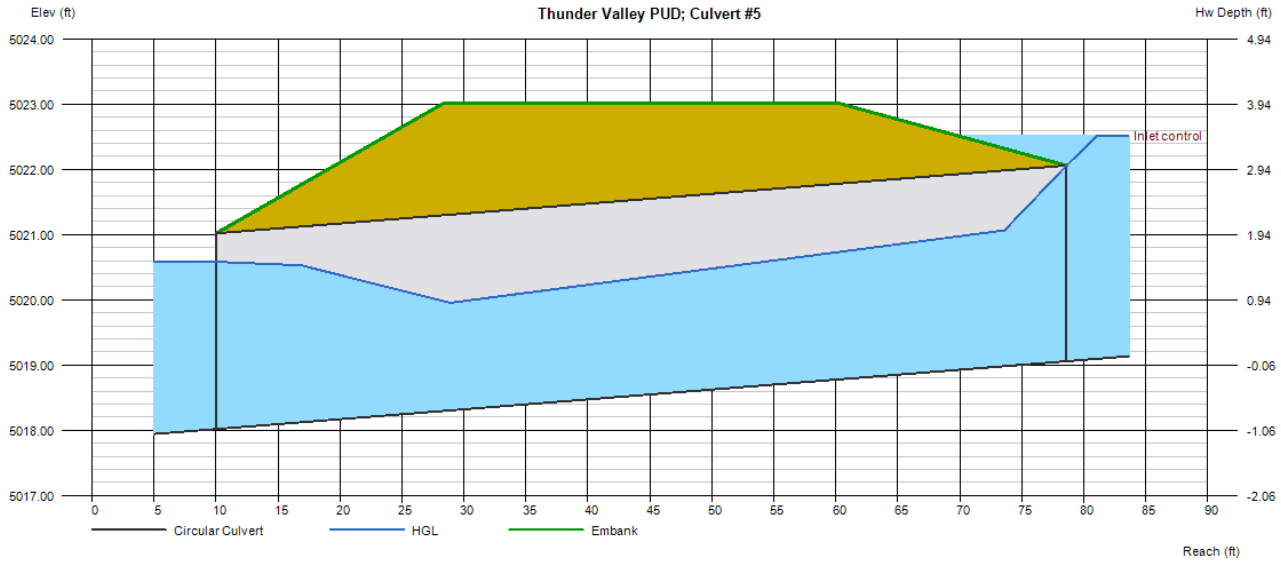
Top Elevation (ft)	=	5023.01
Top Width (ft)	=	32.00
Crest Width (ft)	=	7.00

Calculations

Qmin (cfs)	=	128.55
Qmax (cfs)	=	128.55
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	128.55
Qpipe (cfs)	=	128.55
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	6.66
Veloc Up (ft/s)	=	7.98
HGL Dn (ft)	=	5020.59
HGL Up (ft)	=	5021.19
Hw Elev (ft)	=	5022.52
Hw/D (ft)	=	1.15
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Mar 13 2020

Thunder Valley PUD; Culvert #6

Invert Elev Dn (ft)	=	5006.45
Pipe Length (ft)	=	37.84
Slope (%)	=	5.68
Invert Elev Up (ft)	=	5008.60
Rise (in)	=	36.0
Shape	=	Box
Span (in)	=	60.0
No. Barrels	=	2
n-Value	=	0.012
Culvert Type	=	Flared Wingwalls
Culvert Entrance	=	30D to 75D wingwall flares
Coeff. K,M,c,Y,k	=	0.026, 1, 0.0347, 0.81, 0.4

Embankment

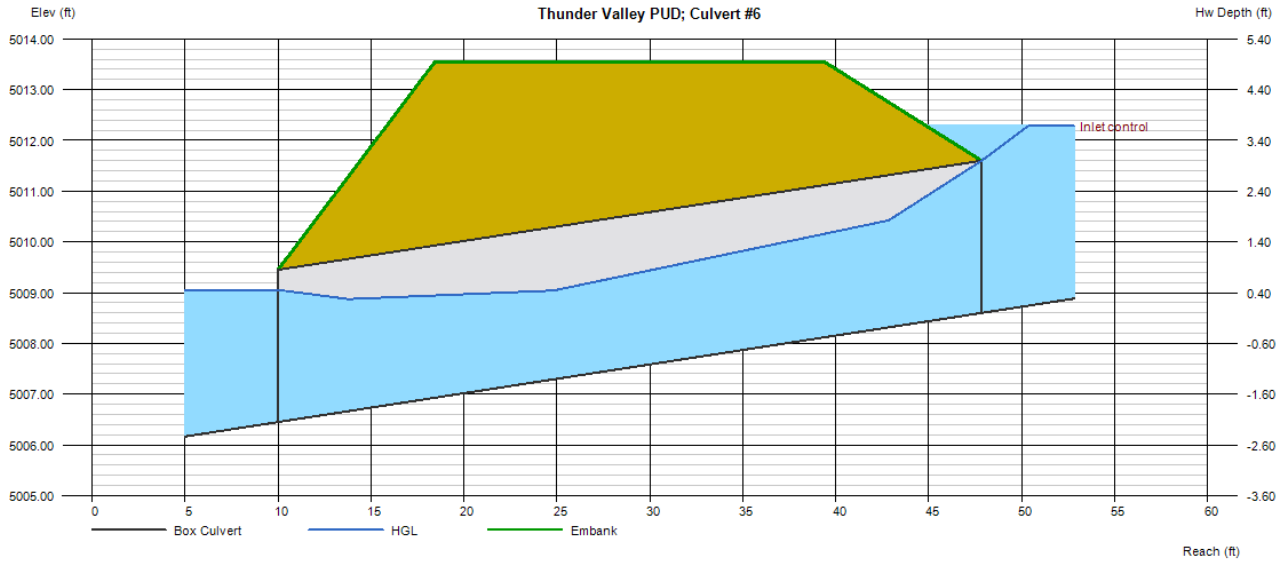
Top Elevation (ft)	=	5013.54
Top Width (ft)	=	21.00
Crest Width (ft)	=	20.00

Calculations

Qmin (cfs)	=	186.28
Qmax (cfs)	=	186.28
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	186.28
Qpipe (cfs)	=	186.28
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	7.15
Veloc Up (ft/s)	=	8.44
HGL Dn (ft)	=	5009.05
HGL Up (ft)	=	5010.81
Hw Elev (ft)	=	5012.28
Hw/D (ft)	=	1.23
Flow Regime	=	Inlet Control



Channel Report

Thunder Valley PUD; Channel #1

Triangular

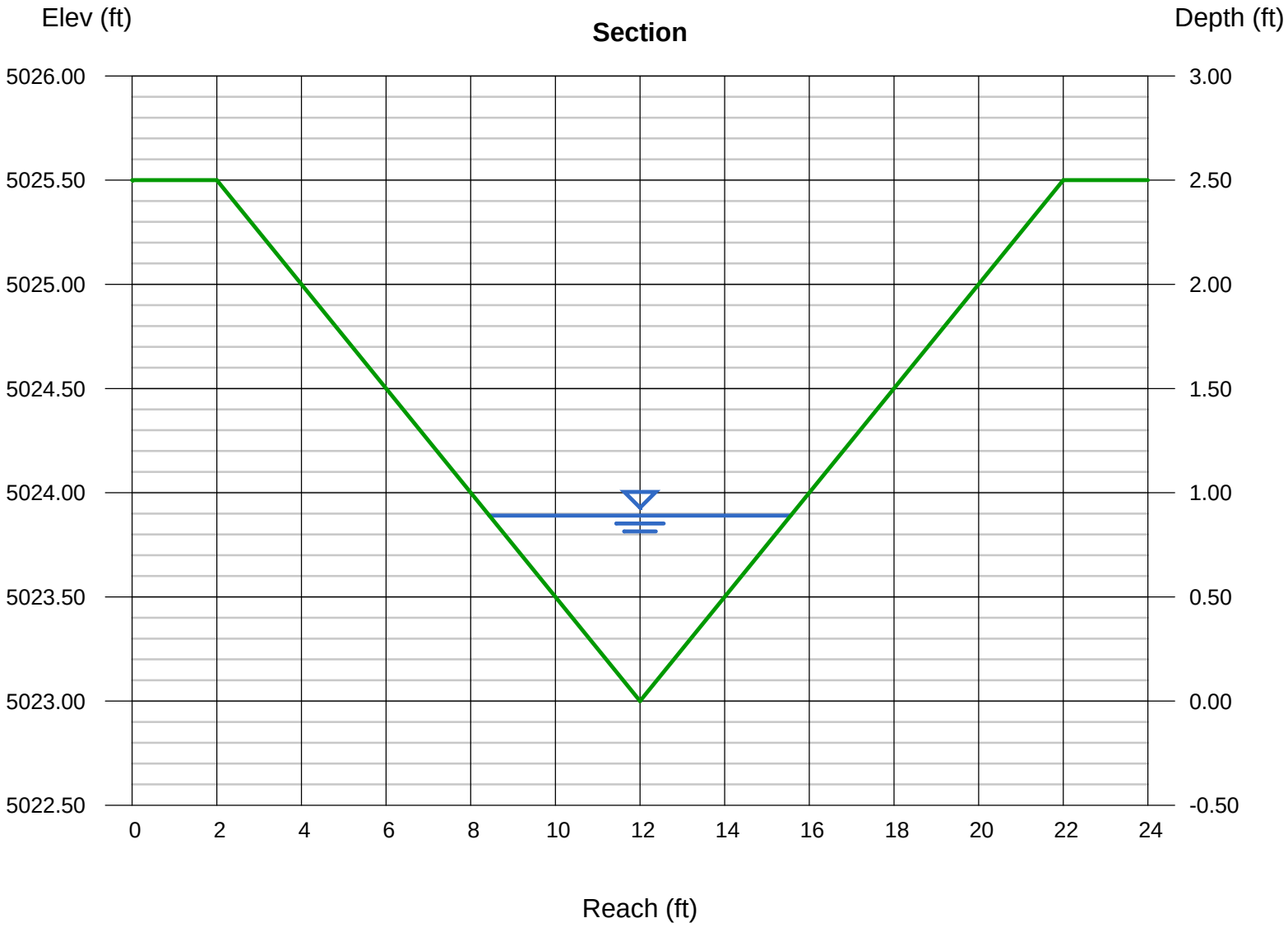
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 5023.00
Slope (%)	= 2.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 12.61

Highlighted

Depth (ft)	= 0.89
Q (cfs)	= 12.61
Area (sqft)	= 3.17
Velocity (ft/s)	= 3.98
Wetted Perim (ft)	= 7.34
Crit Depth, Yc (ft)	= 0.91
Top Width (ft)	= 7.12
EGL (ft)	= 1.14



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #2

Triangular

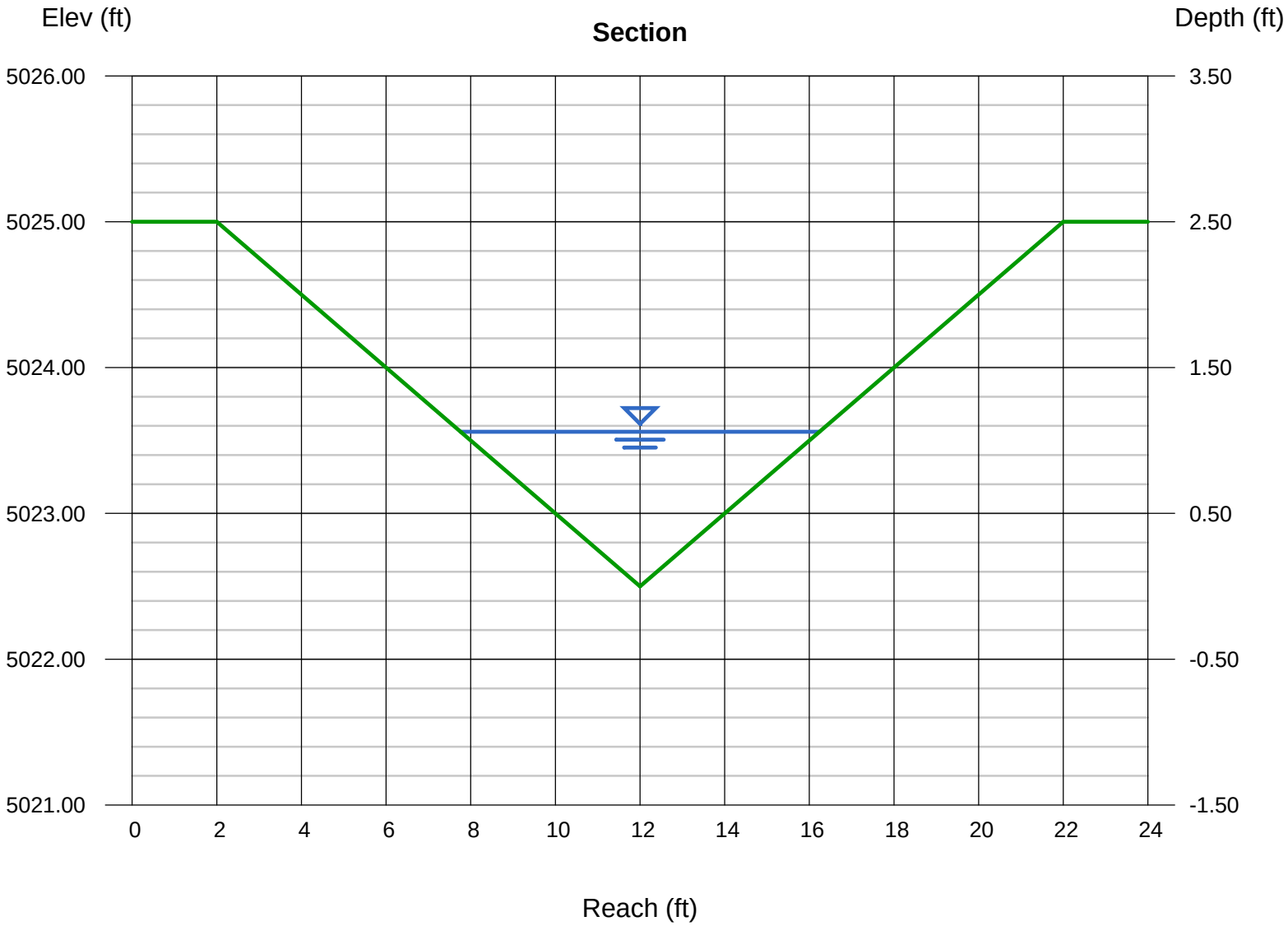
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 5022.50
Slope (%)	= 0.80
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 12.61

Highlighted

Depth (ft)	= 1.06
Q (cfs)	= 12.61
Area (sqft)	= 4.49
Velocity (ft/s)	= 2.81
Wetted Perim (ft)	= 8.74
Crit Depth, Yc (ft)	= 0.91
Top Width (ft)	= 8.48
EGL (ft)	= 1.18



Channel Report

Thunder Valley PUD; Channel #3

Triangular

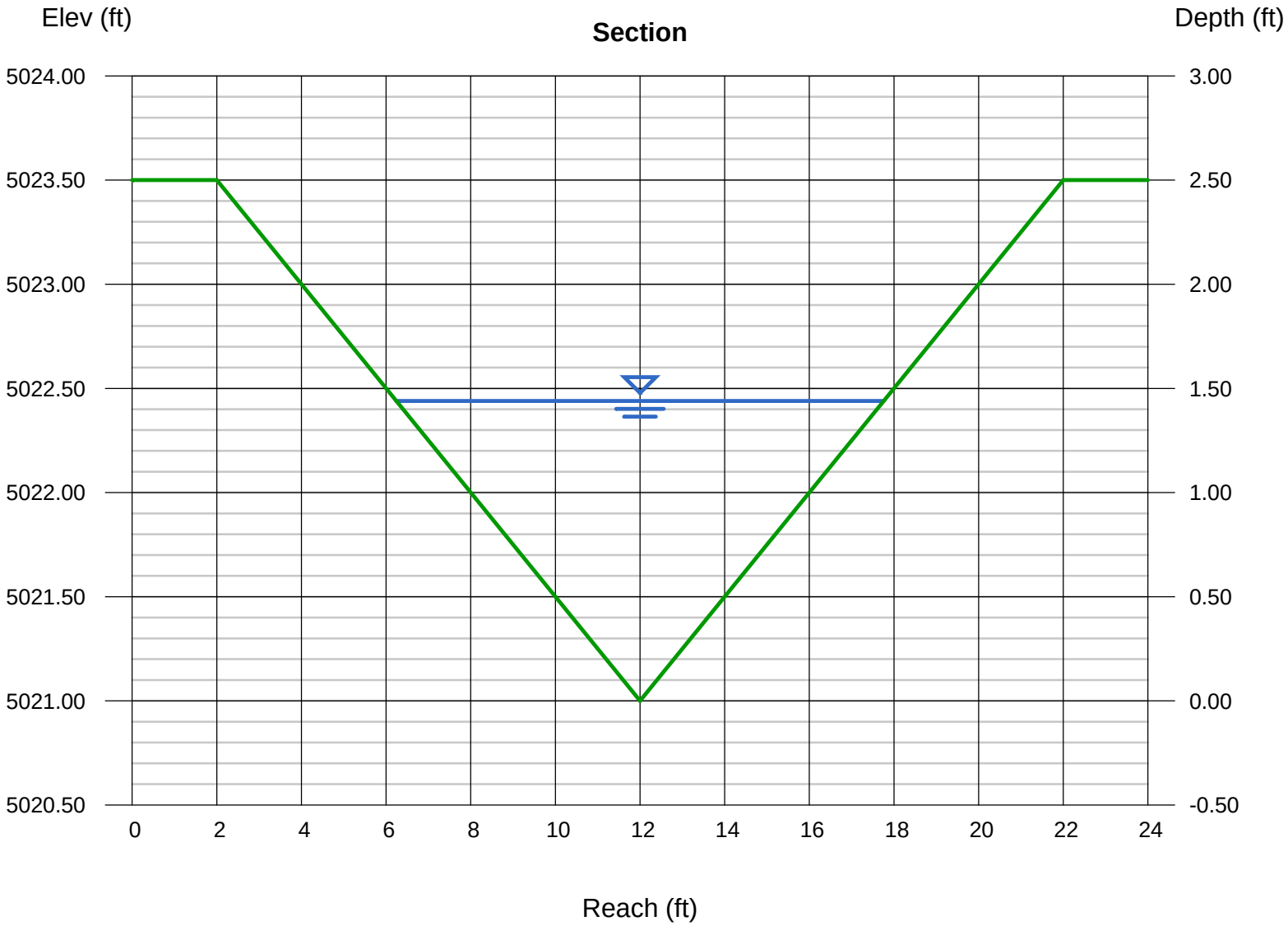
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 5021.00
Slope (%)	= 0.80
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 28.49

Highlighted

Depth (ft)	= 1.44
Q (cfs)	= 28.49
Area (sqft)	= 8.29
Velocity (ft/s)	= 3.43
Wetted Perim (ft)	= 11.87
Crit Depth, Yc (ft)	= 1.26
Top Width (ft)	= 11.52
EGL (ft)	= 1.62



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #4

Trapezoidal

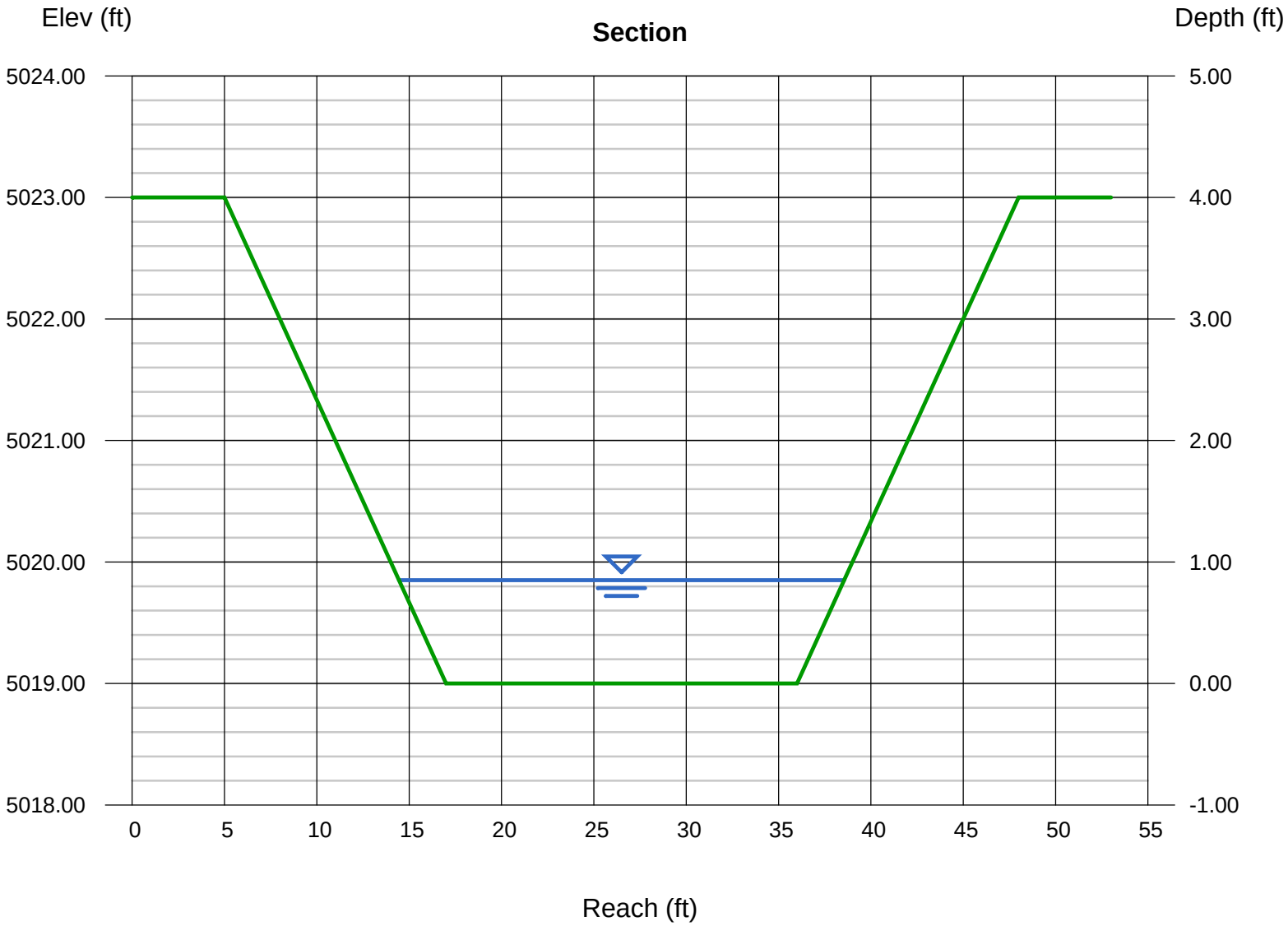
Bottom Width (ft)	= 19.00
Side Slopes (z:1)	= 3.00, 3.00
Total Depth (ft)	= 4.00
Invert Elev (ft)	= 5019.00
Slope (%)	= 1.80
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 100.24

Highlighted

Depth (ft)	= 0.85
Q (cfs)	= 100.24
Area (sqft)	= 18.32
Velocity (ft/s)	= 5.47
Wetted Perim (ft)	= 24.38
Crit Depth, Yc (ft)	= 0.91
Top Width (ft)	= 24.10
EGL (ft)	= 1.32



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #5

Triangular

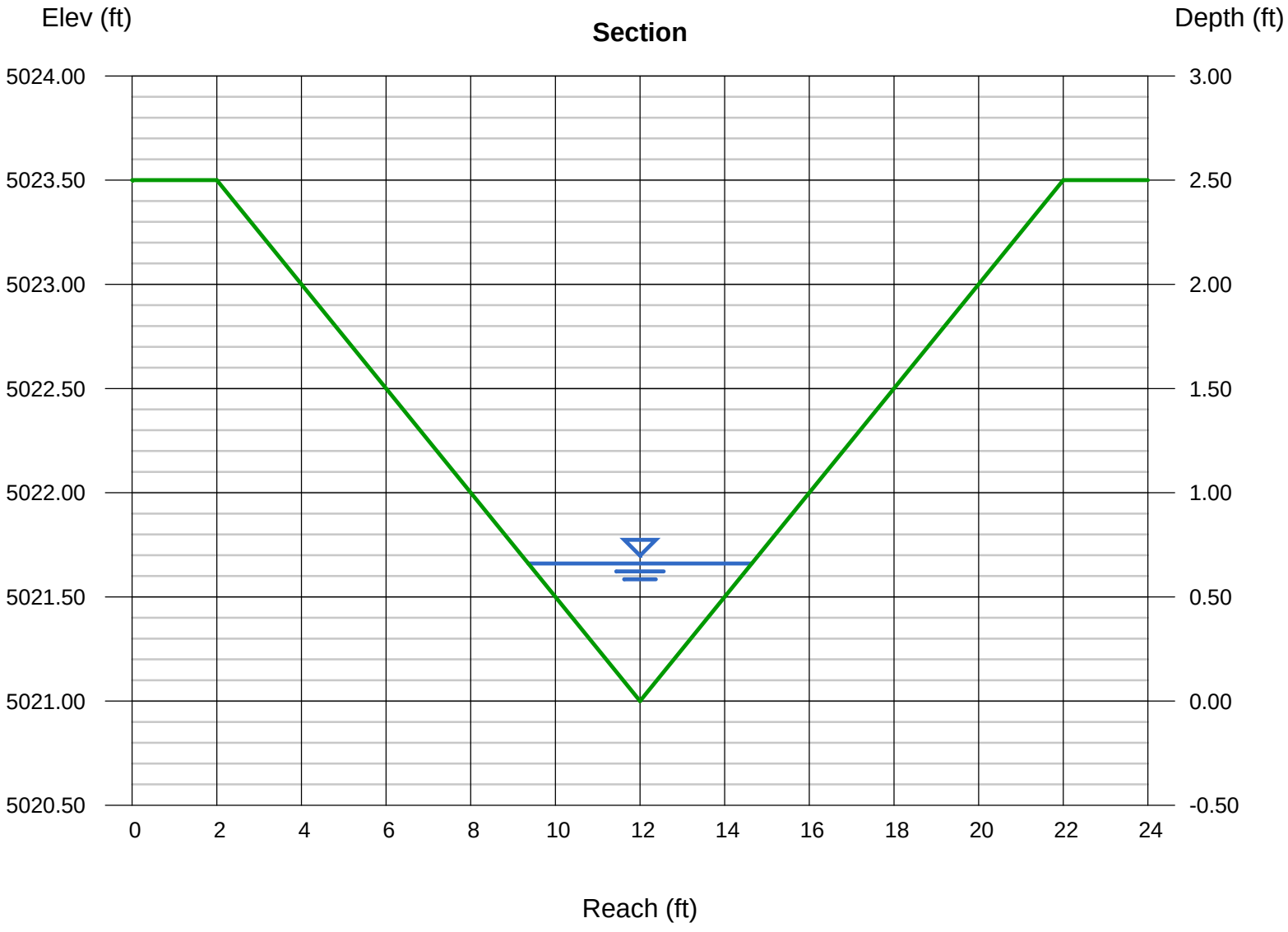
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 5021.00
Slope (%)	= 1.26
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 4.39

Highlighted

Depth (ft)	= 0.66
Q (cfs)	= 4.390
Area (sqft)	= 1.74
Velocity (ft/s)	= 2.52
Wetted Perim (ft)	= 5.44
Crit Depth, Yc (ft)	= 0.60
Top Width (ft)	= 5.28
EGL (ft)	= 0.76



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #6

Triangular

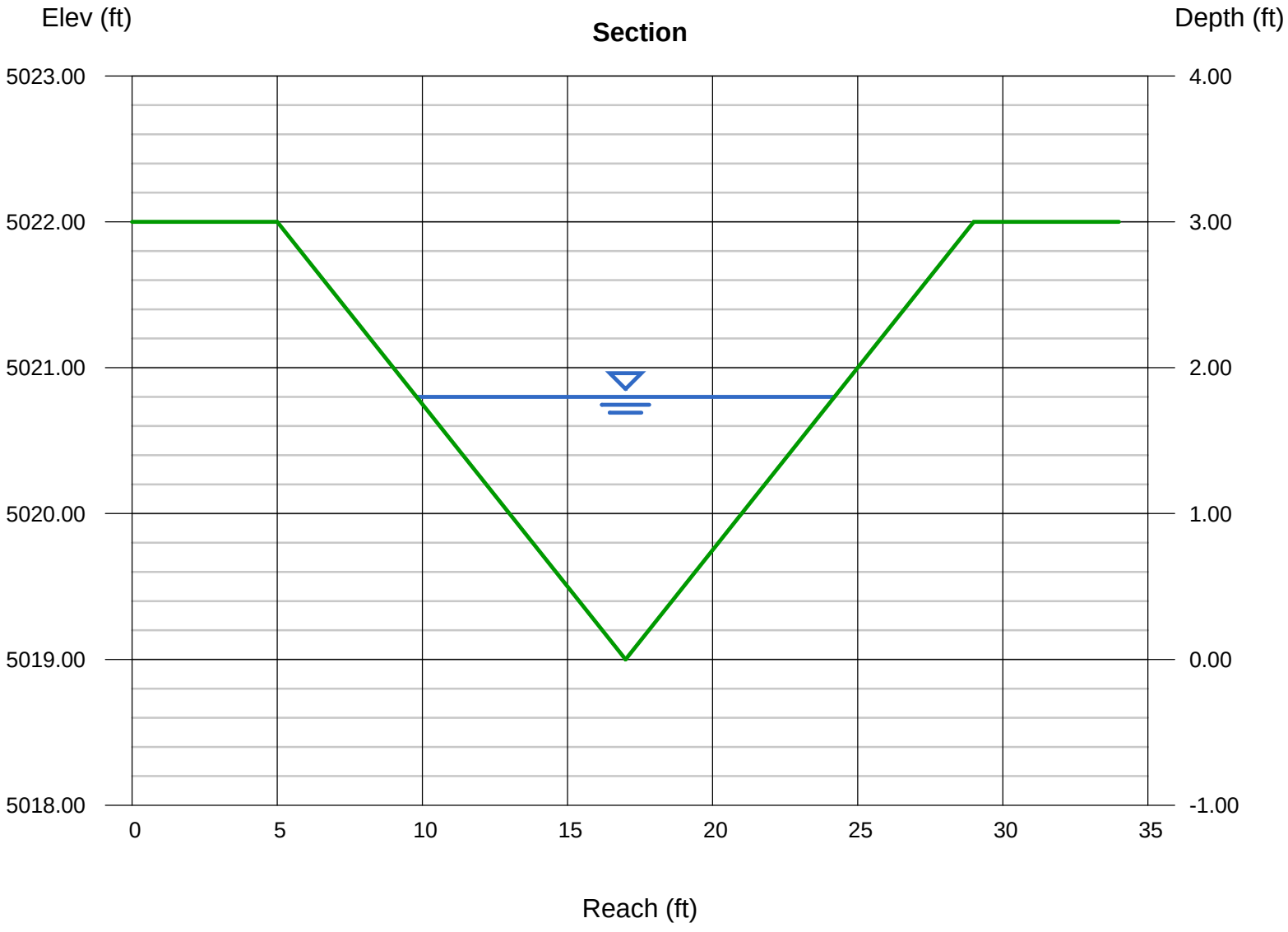
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 5019.00
Slope (%)	= 0.50
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 40.98

Highlighted

Depth (ft)	= 1.80
Q (cfs)	= 40.98
Area (sqft)	= 12.96
Velocity (ft/s)	= 3.16
Wetted Perim (ft)	= 14.84
Crit Depth, Yc (ft)	= 1.46
Top Width (ft)	= 14.40
EGL (ft)	= 1.96



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #7

Triangular

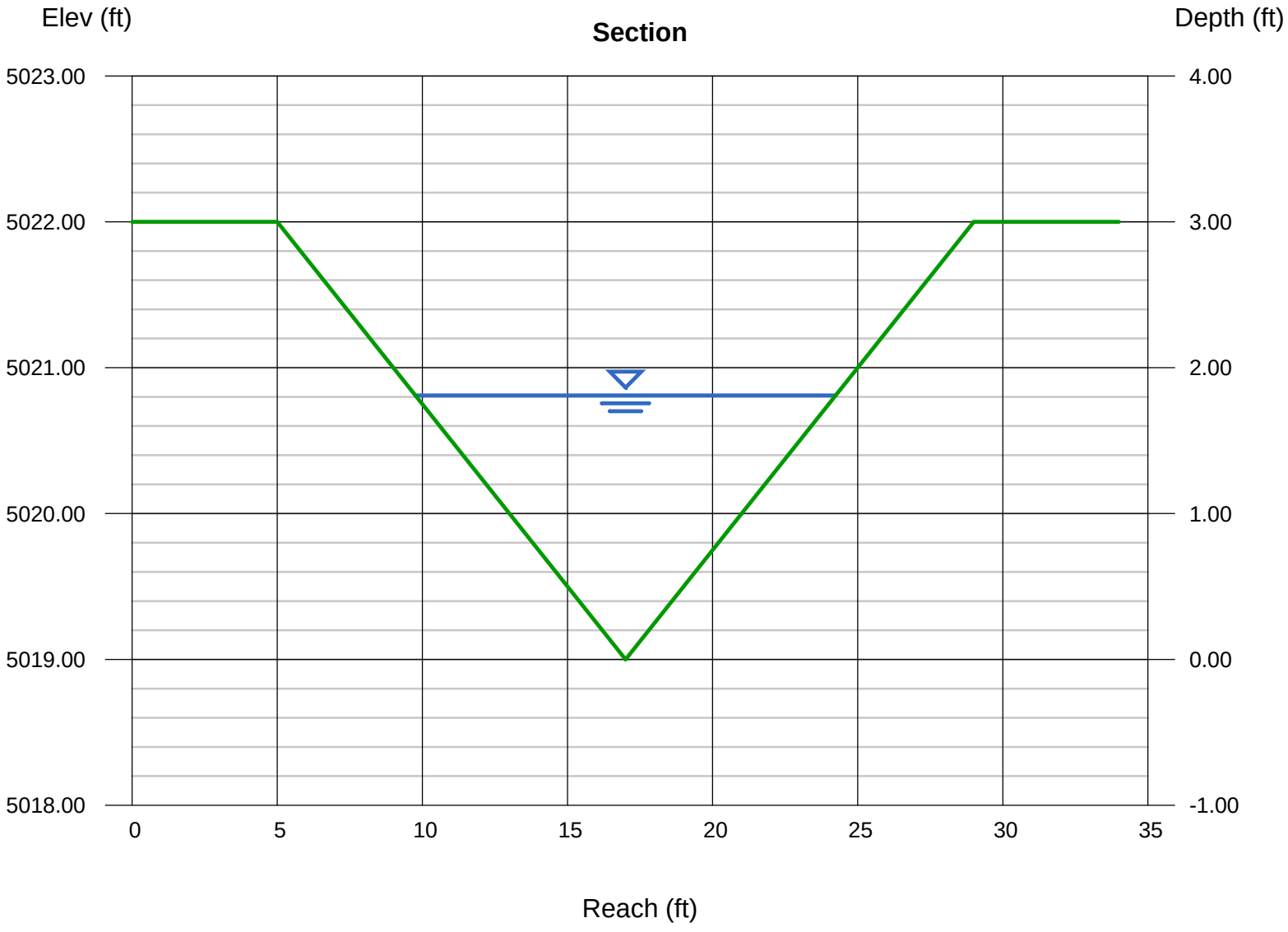
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 5019.00
Slope (%)	= 0.70
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 49.30

Highlighted

Depth (ft)	= 1.81
Q (cfs)	= 49.30
Area (sqft)	= 13.10
Velocity (ft/s)	= 3.76
Wetted Perim (ft)	= 14.93
Crit Depth, Yc (ft)	= 1.57
Top Width (ft)	= 14.48
EGL (ft)	= 2.03



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #8

Triangular

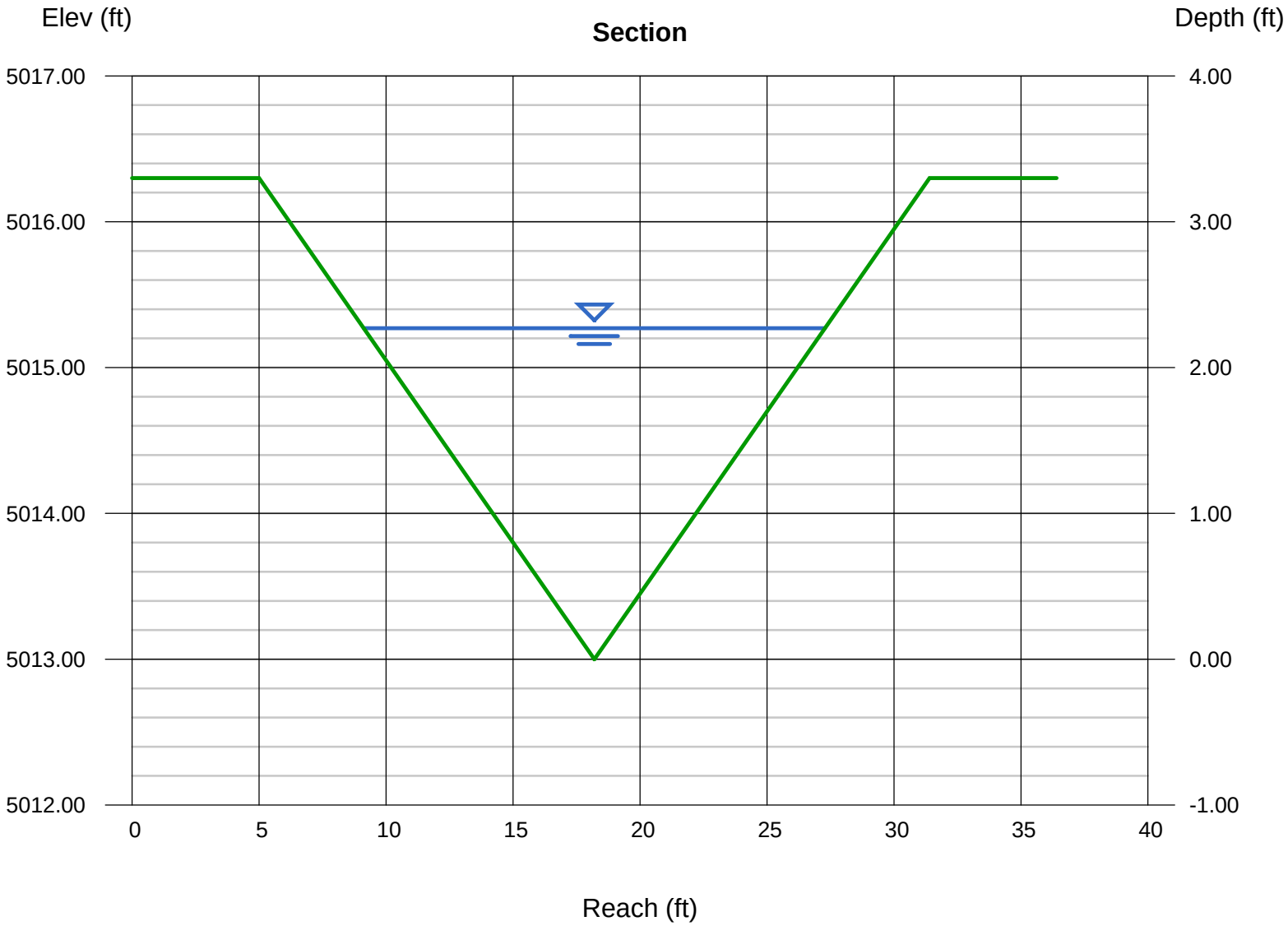
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 3.30
Invert Elev (ft)	= 5013.00
Slope (%)	= 0.70
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 90.40

Highlighted

Depth (ft)	= 2.27
Q (cfs)	= 90.40
Area (sqft)	= 20.61
Velocity (ft/s)	= 4.39
Wetted Perim (ft)	= 18.72
Crit Depth, Yc (ft)	= 2.00
Top Width (ft)	= 18.16
EGL (ft)	= 2.57



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #9

Trapezoidal

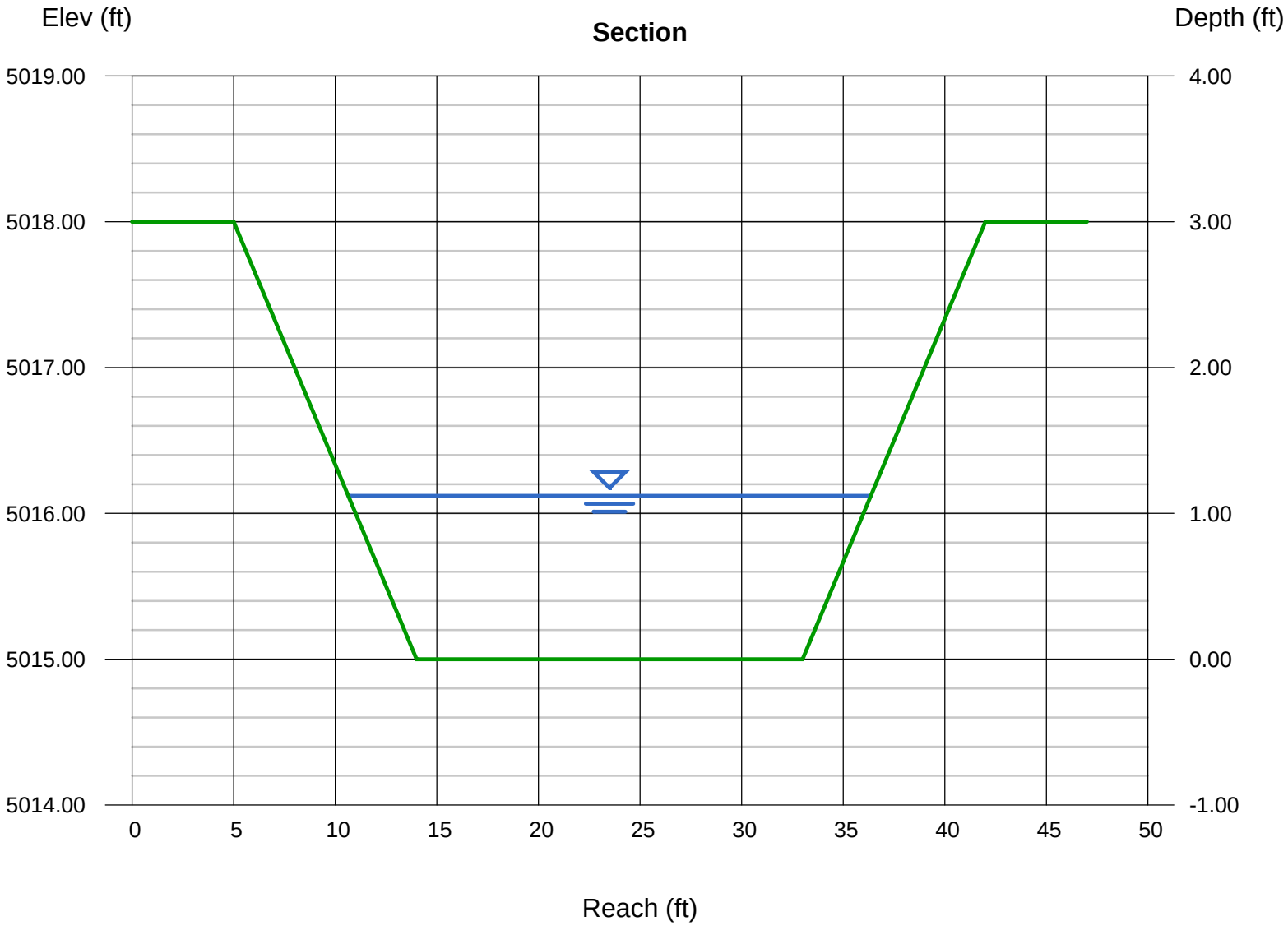
Bottom Width (ft)	= 19.00
Side Slopes (z:1)	= 3.00, 3.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 5015.00
Slope (%)	= 1.15
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 128.55

Highlighted

Depth (ft)	= 1.12
Q (cfs)	= 128.55
Area (sqft)	= 25.04
Velocity (ft/s)	= 5.13
Wetted Perim (ft)	= 26.08
Crit Depth, Yc (ft)	= 1.07
Top Width (ft)	= 25.72
EGL (ft)	= 1.53



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Mar 10 2020

Thunder Valley PUD; Channel #10

Triangular

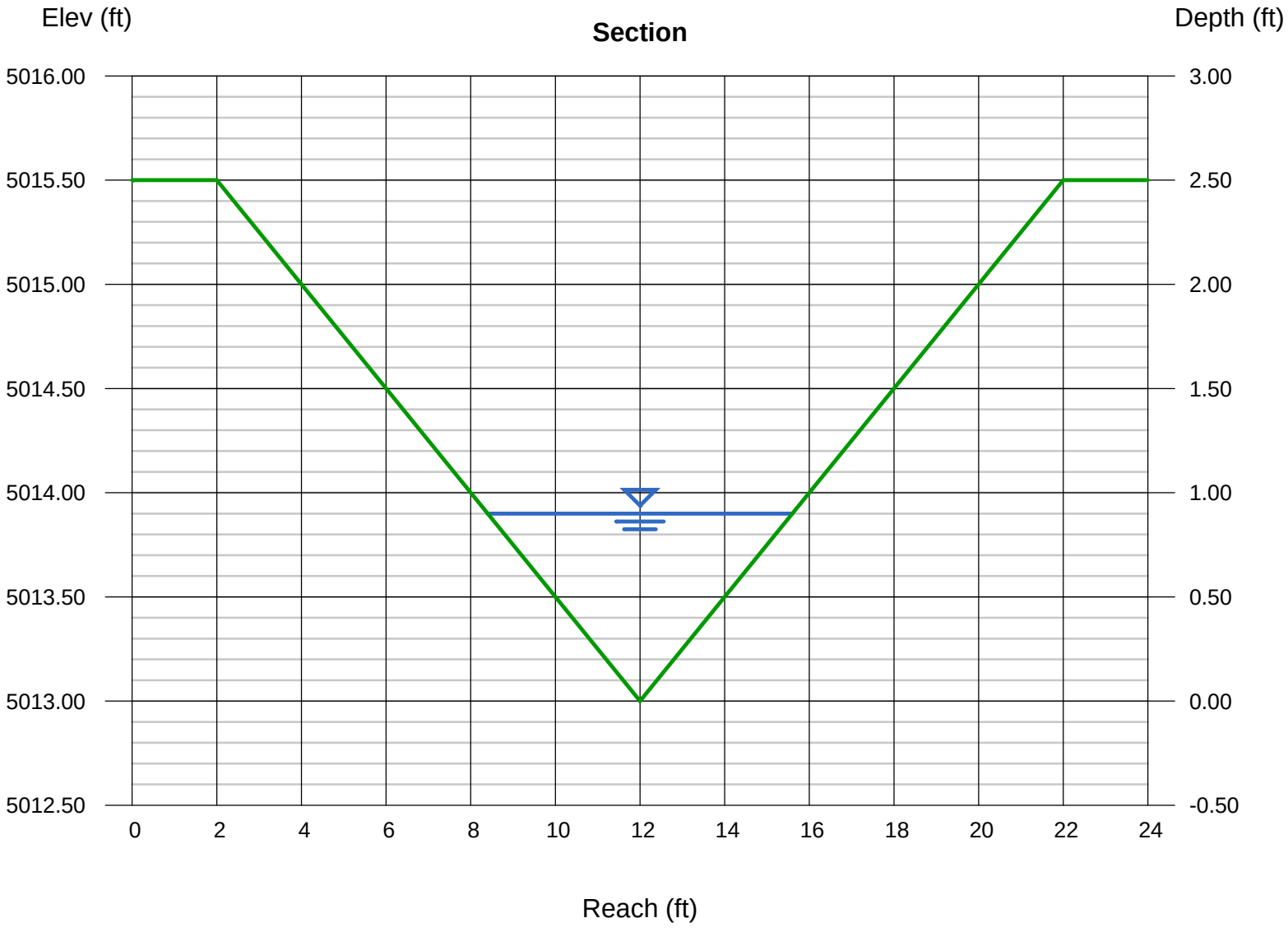
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 5013.00
Slope (%)	= 1.90
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 12.61

Highlighted

Depth (ft)	= 0.90
Q (cfs)	= 12.61
Area (sqft)	= 3.24
Velocity (ft/s)	= 3.89
Wetted Perim (ft)	= 7.42
Crit Depth, Yc (ft)	= 0.91
Top Width (ft)	= 7.20
EGL (ft)	= 1.14



XI. Appendix F

A. Detention Pond Stage Storage Table

THUNDER VALLEY PUD
FORT LUPTON, WELD COUNTY
STAGE-STORAGE TABLE

Contour Elevation (ft)	Contour Area (ac)	Incremental Volume Conic (ac-ft)	Cumulative Volume Conic (ac-ft.)	Depth (ft)	
5,012.10	0.00	0.00	0.000	0.00	
5,012.20	0.02	0.00	0.001	0.10	
5,012.30	0.04	0.00	0.004	0.20	
5,012.40	0.07	0.01	0.010	0.30	
5,012.50	0.11	0.01	0.019	0.40	
5,012.60	0.15	0.01	0.032	0.50	
5,012.70	0.18	0.02	0.048	0.60	
5,012.80	0.18	0.02	0.066	0.70	
5,012.90	0.19	0.02	0.085	0.80	
5,013.00	0.20	0.02	0.104	0.90	
5,013.10	0.22	0.02	0.124	1.00	
5,013.20	0.23	0.02	0.147	1.10	
5,013.30	0.25	0.02	0.171	1.20	
5,013.40	0.27	0.03	0.197	1.30	
5,013.50	0.28	0.03	0.224	1.40	WQCV
5,013.60	0.30	0.03	0.254	1.50	
5,013.70	0.31	0.03	0.284	1.60	
5,013.80	0.33	0.03	0.316	1.70	
5,013.90	0.35	0.03	0.350	1.80	
5,014.00	0.36	0.03	0.381	1.90	
5,014.10	0.39	0.03	0.413	2.00	
5,014.20	0.41	0.04	0.452	2.10	
5,014.30	0.43	0.04	0.494	2.20	5 Year
5,014.40	0.45	0.04	0.538	2.30	
5,014.50	0.47	0.05	0.584	2.40	
5,014.60	0.49	0.05	0.632	2.50	
5,014.70	0.52	0.05	0.683	2.60	
5,014.80	0.54	0.05	0.735	2.70	
5,014.90	0.56	0.06	0.791	2.80	
5,015.00	0.59	0.06	0.849	2.90	
5,015.10	0.62	0.06	0.909	3.00	
5,015.20	0.65	0.06	0.973	3.10	
5,015.30	0.68	0.07	1.040	3.20	
5,015.40	0.71	0.07	1.110	3.30	
5,015.50	0.75	0.07	1.183	3.40	
5,015.60	0.78	0.08	1.259	3.50	
5,015.70	0.81	0.08	1.339	3.60	
5,015.80	0.84	0.08	1.421	3.70	
5,015.90	0.87	0.09	1.507	3.80	
5,016.00	0.90	0.09	1.595	3.90	
5,016.10	0.94	0.09	1.687	4.00	
5,016.20	0.97	0.10	1.783	4.10	
5,016.30	1.00	0.10	1.882	4.20	100 Year/ Spillway
5,016.40	1.04	0.10	1.984	4.30	
5,016.50	1.07	0.11	2.089	4.40	
5,016.60	1.10	0.11	2.198	4.50	
5,016.70	1.14	0.11	2.310	4.60	
5,016.80	1.17	0.12	2.425	4.70	
5,016.90	1.21	0.12	2.544	4.80	Embankment Crest

XII. Appendix G

A. Detention Pond and Outlet Calculations

DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: Thunder Valley PUD

Basin ID: Detention Pond

(For catchments less than 160 acres only. For larger catchments, use hydrograph routing method)
(NOTE: for catchments larger than 90 acres, CUHP hydrograph and routing are recommended)

Determination of MINOR Detention Volume Using Modified FAA Method

Design Information (Input):

Catchment Drainage Imperviousness	I_a =	12.00	percent
Catchment Drainage Area	A =	36.270	acres
Predevelopment NRCS Soil Group	Type =	B	A, B, C, or D
Return Period for Detention Control	T =	5	years (2, 5, 10, 25, 50, or 100)
Time of Concentration of Watershed	Tc =	10	minutes
Allowable Unit Release Rate	q =	0.13	cfs/acre
One-hour Precipitation	P_1 =	1.00	inches
Design Rainfall IDF Formula $i = C_1 * P_1/(C_2+T_c)^{C_3}$			
Coefficient One	C_1 =	28.50	
Coefficient Two	C_2 =	10	
Coefficient Three	C_3 =	0.789	

Determination of Average Outflow from the Basin (Calculated):

Runoff Coefficient	C =	0.15	
Inflow Peak Runoff	Qp-in =	14.59	cfs
Allowable Peak Outflow Rate	Qp-out =	**4.72**	cfs
Mod. FAA Minor Storage Volume =		9,950	**cubic feet**
Mod. FAA Minor Storage Volume =		**0.228**	**acre-ft**

1 <- Enter Rainfall Duration Incremental Increase Value Here (e.g. 5 for 5-Minutes)

Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)
1	4.30	0.032	1.00	4.72	0.006	0.026
2	4.01	0.060	1.00	4.72	0.013	0.047
3	3.77	0.085	1.00	4.72	0.019	0.065
4	3.55	0.106	1.00	4.72	0.026	0.081
5	3.36	0.126	1.00	4.72	0.032	0.094
6	3.20	0.144	1.00	4.72	0.039	0.105
7	3.05	0.160	1.00	4.72	0.045	0.114
8	2.91	0.175	1.00	4.72	0.052	0.123
9	2.79	0.188	1.00	4.72	0.058	0.130
10	2.68	0.201	1.00	4.72	0.065	0.136
11	2.58	0.213	0.95	4.50	0.068	0.144
12	2.49	0.224	0.92	4.32	0.071	0.152
13	2.40	0.234	0.88	4.17	0.075	0.159
14	2.32	0.244	0.86	4.04	0.078	0.166
15	2.25	0.253	0.83	3.93	0.081	0.172
16	2.18	0.261	0.81	3.83	0.084	0.177
17	2.12	0.270	0.79	3.74	0.088	0.182
18	2.06	0.277	0.78	3.67	0.091	0.186
19	2.00	0.285	0.76	3.60	0.094	0.191
20	1.95	0.292	0.75	3.54	0.097	0.194
21	1.90	0.299	0.74	3.48	0.101	0.198
22	1.85	0.305	0.73	3.43	0.104	0.201
23	1.81	0.311	0.72	3.38	0.107	0.204
24	1.76	0.317	0.71	3.34	0.110	0.207
25	1.72	0.323	0.70	3.30	0.114	0.209
26	1.69	0.329	0.69	3.26	0.117	0.212
27	1.65	0.334	0.69	3.23	0.120	0.214
28	1.62	0.339	0.68	3.20	0.123	0.216
29	1.58	0.344	0.67	3.17	0.127	0.217
30	1.55	0.349	0.67	3.14	0.130	0.219
31	1.52	0.354	0.66	3.12	0.133	0.220
32	1.49	0.358	0.66	3.09	0.136	0.222
33	1.47	0.362	0.65	3.07	0.140	0.223
34	1.44	0.367	0.65	3.05	0.143	0.224
35	1.41	0.371	0.64	3.03	0.146	0.225
36	1.39	0.375	0.64	3.01	0.149	0.226
37	1.37	0.379	0.64	2.99	0.153	0.226
38	1.34	0.383	0.63	2.98	0.156	0.227
39	1.32	0.386	0.63	2.96	0.159	0.227
40	1.30	0.390	0.63	2.95	0.162	0.228
41	1.28	0.394	0.62	2.93	0.166	0.228
42	1.26	0.397	0.62	2.92	0.169	0.228
43	1.24	0.400	0.62	2.91	0.172	0.228
44	1.22	0.404	0.61	2.89	0.175	0.228
45	1.21	0.407	0.61	2.88	0.179	0.228
46	1.19	0.410	0.61	2.87	0.182	0.228
47	1.17	0.413	0.61	2.86	0.185	0.228
48	1.16	0.416	0.60	2.85	0.188	0.228
49	1.14	0.419	0.60	2.84	0.192	0.228
50	1.13	0.422	0.60	2.83	0.195	0.227
51	1.11	0.425	0.60	2.82	0.198	0.227
52	1.10	0.428	0.60	2.81	0.201	0.227
53	1.08	0.431	0.59	2.80	0.205	0.226
54	1.07	0.433	0.59	2.79	0.208	0.226
55	1.06	0.436	0.59	2.79	0.211	0.225
56	1.05	0.439	0.59	2.78	0.214	0.224
57	1.03	0.441	0.59	2.77	0.218	0.224
58	1.02	0.444	0.59	2.76	0.221	0.223
59	1.01	0.446	0.58	2.76	0.224	0.222
60	1.00	0.449	0.58	2.75	0.227	0.221
61	0.99	0.451	0.58	2.74	0.231	0.221

Mod. FAA Minor Storage Volume (cubic ft.) = 9,950
Mod. FAA Minor Storage Volume (acre-ft.) = 0.2284

Determination of MAJOR Detention Volume Using Modified FAA Method

Design Information (Input):

Catchment Drainage Imperviousness	I_a =	12.00	percent
Catchment Drainage Area	A =	36.270	acres
Predevelopment NRCS Soil Group	Type =	B	A, B, C, or D
Return Period for Detention Control	T =	100	years (2, 5, 10, 25, 50, or 100)
Time of Concentration of Watershed	Tc =	10	minutes
Allowable Unit Release Rate	q =	0.85	cfs/acre
One-hour Precipitation	P_1 =	2.71	inches
Design Rainfall IDF Formula $i = C_1 * P_1/(C_2+T_c)^{C_3}$			
Coefficient One	C_1 =	28.50	
Coefficient Two	C_2 =	10	
Coefficient Three	C_3 =	0.789	

Determination of Average Outflow from the Basin (Calculated):

Runoff Coefficient	C =	0.41	
Inflow Peak Runoff	Qp-in =	108.05	cfs
Allowable Peak Outflow Rate	Qp-out =	**30.83**	cfs
Mod. FAA Major Storage Volume =		80,747	**cubic feet**
Mod. FAA Major Storage Volume =		**1.854**	**acre-ft**

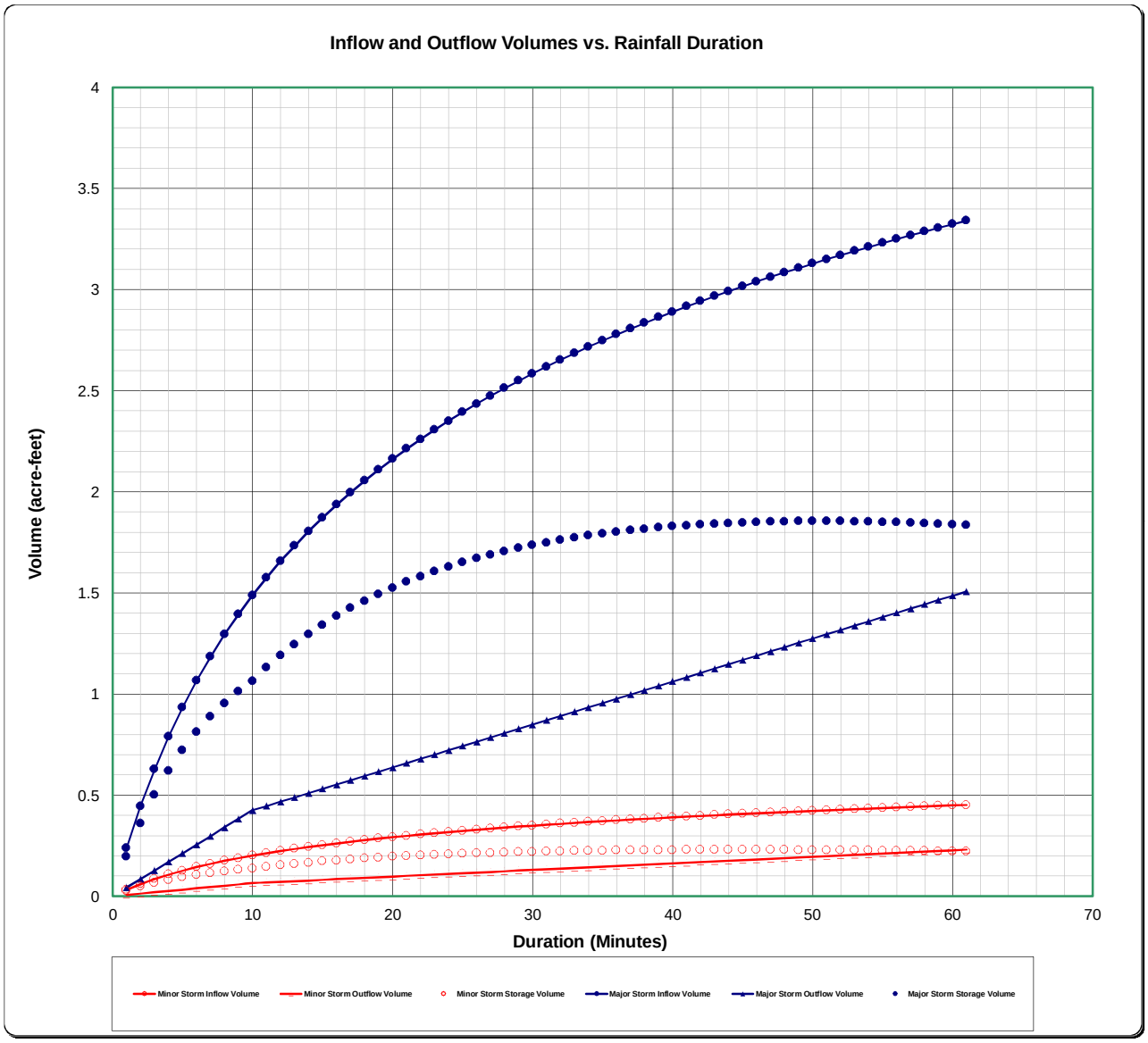
Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)
1	11.65	0.239	1.00	30.83	0.042	0.196
2	10.87	0.445	1.00	30.83	0.085	0.360
3	10.21	0.627	1.00	30.83	0.127	0.500
4	9.63	0.789	1.00	30.83	0.170	0.619
5	9.12	0.934	1.00	30.83	0.212	0.721
6	8.66	1.065	1.00	30.83	0.255	0.810
7	8.26	1.184	1.00	30.83	0.297	0.887
8	7.90	1.294	1.00	30.83	0.340	0.954
9	7.57	1.395	1.00	30.83	0.382	1.013
10	7.27	1.488	1.00	30.83	0.425	1.064
11	6.99	1.575	0.95	29.43	0.446	1.129
12	6.74	1.657	0.92	28.26	0.467	1.189
13	6.51	1.733	0.88	27.27	0.488	1.244
14	6.29	1.804	0.86	26.43	0.510	1.295
15	6.09	1.872	0.83	25.69	0.531	1.341
16	5.91	1.936	0.81	25.05	0.552	1.384
17	5.73	1.997	0.79	24.48	0.573	1.423
18	5.57	2.054	0.78	23.98	0.595	1.460
19	5.42	2.109	0.76	23.53	0.616	1.494
20	5.28	2.162	0.75	23.12	0.637	1.525
21	5.14	2.212	0.74	22.76	0.658	1.554
22	5.01	2.260	0.73	22.42	0.679	1.580
23	4.89	2.306	0.72	22.12	0.701	1.605
24	4.78	2.350	0.71	21.84	0.722	1.628
25	4.67	2.393	0.70	21.58	0.743	1.650
26	4.57	2.434	0.69	21.34	0.764	1.669
27	4.47	2.473	0.69	21.12	0.786	1.688
28	4.38	2.511	0.68	20.92	0.807	1.705
29	4.29	2.548	0.67	20.73	0.828	1.720
30	4.21	2.584	0.67	20.55	0.849	1.735
31	4.12	2.619	0.66	20.39	0.871	1.748
32	4.05	2.652	0.66	20.23	0.892	1.760
33	3.97	2.685	0.65	20.09	0.913	1.772
34	3.90	2.716	0.65	19.95	0.934	1.782
35	3.83	2.747	0.64	19.82	0.955	1.792
36	3.77	2.777	0.64	19.70	0.977	1.800
37	3.70	2.806	0.64	19.58	0.998	1.808
38	3.64	2.835	0.63	19.47	1.019	1.815
39	3.58	2.862	0.63	19.37	1.040	1.822
40	3.53	2.889	0.63	19.27	1.062	1.828
41	3.47	2.916	0.62	19.17	1.083	1.833
42	3.42	2.941	0.62	19.08	1.104	1.837
43	3.37	2.966	0.62	19.00	1.125	1.841
44	3.32	2.991	0.61	18.92	1.147	1.844
45	3.27	3.015	0.61	18.84	1.168	1.847
46	3.22	3.038	0.61	18.77	1.189	1.849
47	3.18	3.061	0.61	18.69	1.210	1.851
48	3.14	3.084	0.60	18.63	1.231	1.852
49	3.09	3.106	0.60	18.56	1.253	1.853
50	3.05	3.128	0.60	18.50	1.274	1.854
51	3.01	3.149	0.60	18.44	1.295	1.854
52	2.98	3.170	0.60	18.38	1.316	1.853
53	2.94	3.190	0.59	18.32	1.338	1.852
54	2.90	3.210	0.59	18.27	1.359	1.851
55	2.87	3.230	0.59	18.22	1.380	1.850
56	2.83	3.249	0.59	18.17	1.401	1.848
57	2.80	3.268	0.59	18.12	1.423	1.846
58	2.77	3.287	0.59	18.07	1.444	1.843
59	2.74	3.305	0.58	18.03	1.465	1.840
60	2.70	3.323	0.58	17.98	1.486	1.837
61	2.67	3.341	0.58	17.94	1.508	1.834

Mod. FAA Major Storage Volume (cubic ft.) = 80,747
Mod. FAA Major Storage Volume (acre-ft.) = 1.8537

DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: Thunder Valley PUD

Basin ID: Detention Pond



STAGE-DISCHARGE SIZING OF THE WATER QUALITY CAPTURE VOLUME (WQCV) OUTLET

Project: Thunder Valley PUD

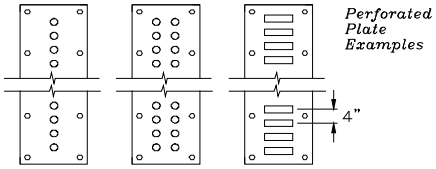
Basin ID: Detention Pond

WQCV Design Volume (Input):

Catchment Imperviousness, I_a =	12.0	percent			
Catchment Area, A =	36.27	acres	Diameter of holes, D =	0.822	inches
Depth at WQCV outlet above lowest perforation, H =	2.2	feet	Number of holes per row, N =	1	
Vertical distance between rows, h =	4.00	inches	**OR**		
Number of rows, NL =	3.00				
Orifice discharge coefficient, C_o =	0.65		Height of slot, H =		inches
Slope of Basin Trickle Channel, S =	0.005	ft / ft	Width of slot, W =		inches
Time to Drain the Pond =	40	hours			

Watershed Design Information (Input):

Percent Soil Type A =	0	%
Percent Soil Type B =	100	%
Percent Soil Type C/D =	0	%



Perforated Plate Examples

Outlet Design Information (Output):

Water Quality Capture Volume, WQCV =	0.063	watershed inches
Water Quality Capture Volume (WQCV) =	0.189	acre-feet
Design Volume (WQCV / 12 * Area * 1.2) Vol =	**0.236**	**acre-feet**
Outlet area per row, Ao =	0.53	square inches
Total opening area at each row based on user-input above, Ao =	0.53	square inches
Total opening area at each row based on user-input above, Ao =	0.004	square feet

3

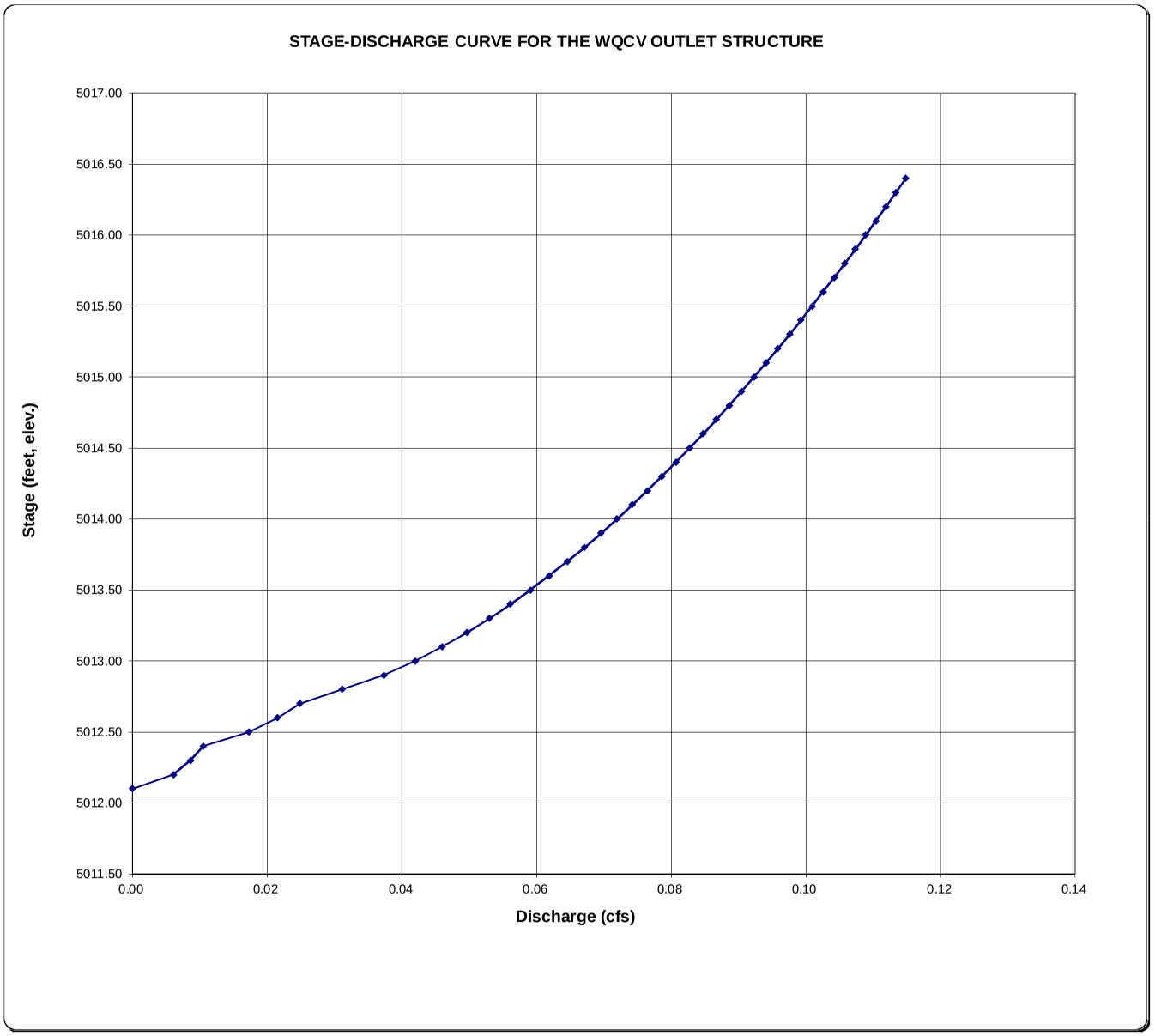
	Central Elevations of Rows of Holes in feet																							Σ
	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	Row 9	Row 10	Row 11	Row 12	Row 13	Row 14	Row 15	Row 16	Row 17	Row 18	Row 19	Row 20	Row 21	Row 22	Row 23	Row 23	Flow
	5012.10	5012.43	5012.77																						
	Collection Capacity for Each Row of Holes in cfs																								
5012.10	0.0000	0.0000	0.0000																						**0.00**
5012.20	0.0061	0.0000	0.0000																						**0.01**
5012.30	0.0086	0.0000	0.0000																						**0.01**
5012.40	0.0105	0.0000	0.0000																						**0.01**
5012.50	0.0122	0.0051	0.0000																						**0.02**
5012.60	0.0136	0.0079	0.0000																						**0.02**
5012.70	0.0149	0.0100	0.0000																						**0.02**
5012.80	0.0161	0.0117	0.0033																						**0.03**
5012.90	0.0172	0.0132	0.0069																						**0.04**
5013.00	0.0182	0.0145	0.0092																						**0.04**
5013.10	0.0192	0.0157	0.0110																						**0.05**
5013.20	0.0202	0.0169	0.0126																						**0.05**
5013.30	0.0211	0.0179	0.0140																						**0.05**
5013.40	0.0219	0.0189	0.0153																						**0.06**
5013.50	0.0228	0.0199	0.0164																						**0.06**
5013.60	0.0236	0.0208	0.0175																						**0.06**
5013.70	0.0243	0.0217	0.0185																						**0.06**
5013.80	0.0251	0.0225	0.0195																						**0.07**
5013.90	0.0258	0.0233	0.0204																						**0.07**
5014.00	0.0265	0.0241	0.0213																						**0.07**
5014.10	0.0272	0.0248	0.0222																						**0.07**
5014.20	0.0279	0.0256	0.0230																						**0.08**
5014.30	0.0285	0.0263	0.0238																						**0.08**
5014.40	0.0292	0.0270	0.0245																						**0.08**
5014.50	0.0298	0.0277	0.0253																						**0.08**
5014.60	0.0304	0.0283	0.0260																						**0.08**
5014.70	0.0310	0.0290	0.0267																						**0.09**
5014.80	0.0316	0.0296	0.0274																						**0.09**
5014.90	0.0322	0.0302	0.0281																						**0.09**
5015.00	0.0327	0.0308	0.0287																						**0.09**
5015.10	0.0333	0.0314	0.0294																						**0.09**
5015.20	0.0339	0.0320	0.0300																						**0.10**
5015.30	0.0344	0.0326	0.0306																						**0.10**
5015.40	0.0349	0.0331	0.0312																						**0.10**
5015.50	0.0355	0.0337	0.0318																						**0.10**
5015.60	0.0360	0.0342	0.0323																						**0.10**
5015.70	0.0365	0.0348	0.0329																						**0.10**
5015.80	0.0370	0.0353	0.0335																						**0.11**
5015.90	0.0375	0.0358	0.0340																						**0.11**
5016.00	0.0380	0.0363	0.0346																						**0.11**
5016.10	0.0385	0.0368	0.0351																						**0.11**
5016.20	0.0389	0.0373	0.0356																						**0.11**
5016.30	0.0394	0.0378	0.0361																						**0.11**
5016.40	0.0399	0.0383	0.0366																						**0.11**
	Override Area Row 1	Override Area Row 2	Override Area Row 3	Override Area Row 4	Override Area Row 5	Override Area Row 6	Override Area Row 7	Override Area Row 8	Override Area Row 9	Override Area Row 10	Override Area Row 11	Override Area Row 12	Override Area Row 13	Override Area Row 14	Override Area Row 15	Override Area Row 16	Override Area Row 17	Override Area Row 18	Override Area Row 19	Override Area Row 20	Override Area Row 21	Override Area Row 22	Override Area Row 23	Override Area Row 24	

STAGE-DISCHARGE SIZING OF THE WATER QUALITY CAPTURE VOLUME (WQCV) OUTLET

Worksheet Protected

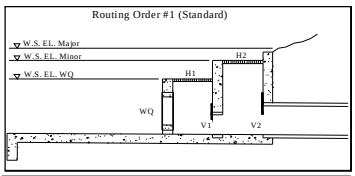
Project: Thunder Valley PUD

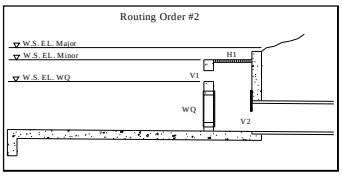
Basin ID: Detention Pond

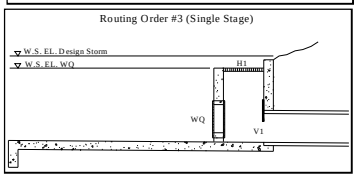


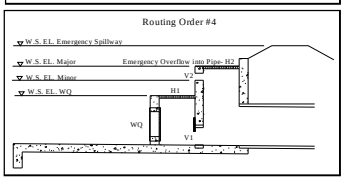
STAGE-DISCHARGE SIZING OF THE WEIRS AND ORIFICES (INLET CONTROL)

Project: Thunder Valley PUD
Basin ID: Detention Pond









Current Routing Order is #2

Design Information (Input):

			#1 Horiz.	#2 Horiz.	#1 Vert.	#2 Vert.	
Circular Opening:	Diameter in Inches	Dia. =			11.69	36.00	inches
OR							
Rectangular Opening:	Width in Feet	W =	4.00				ft.
	Length (Height for Vertical)	L or H =	4.00				ft.
	Percentage of Open Area After Trash Rack Reduction	% open =	35		100	100	%
	Orifice Coefficient	C_o =	0.65		0.65	0.65	
	Weir Coefficient	C_w =	2.60				
	Orifice Elevation (Bottom for Vertical)	E_o =	5014.30		5,014.30	5,012.00	ft.

Calculation of Collection Capacity:

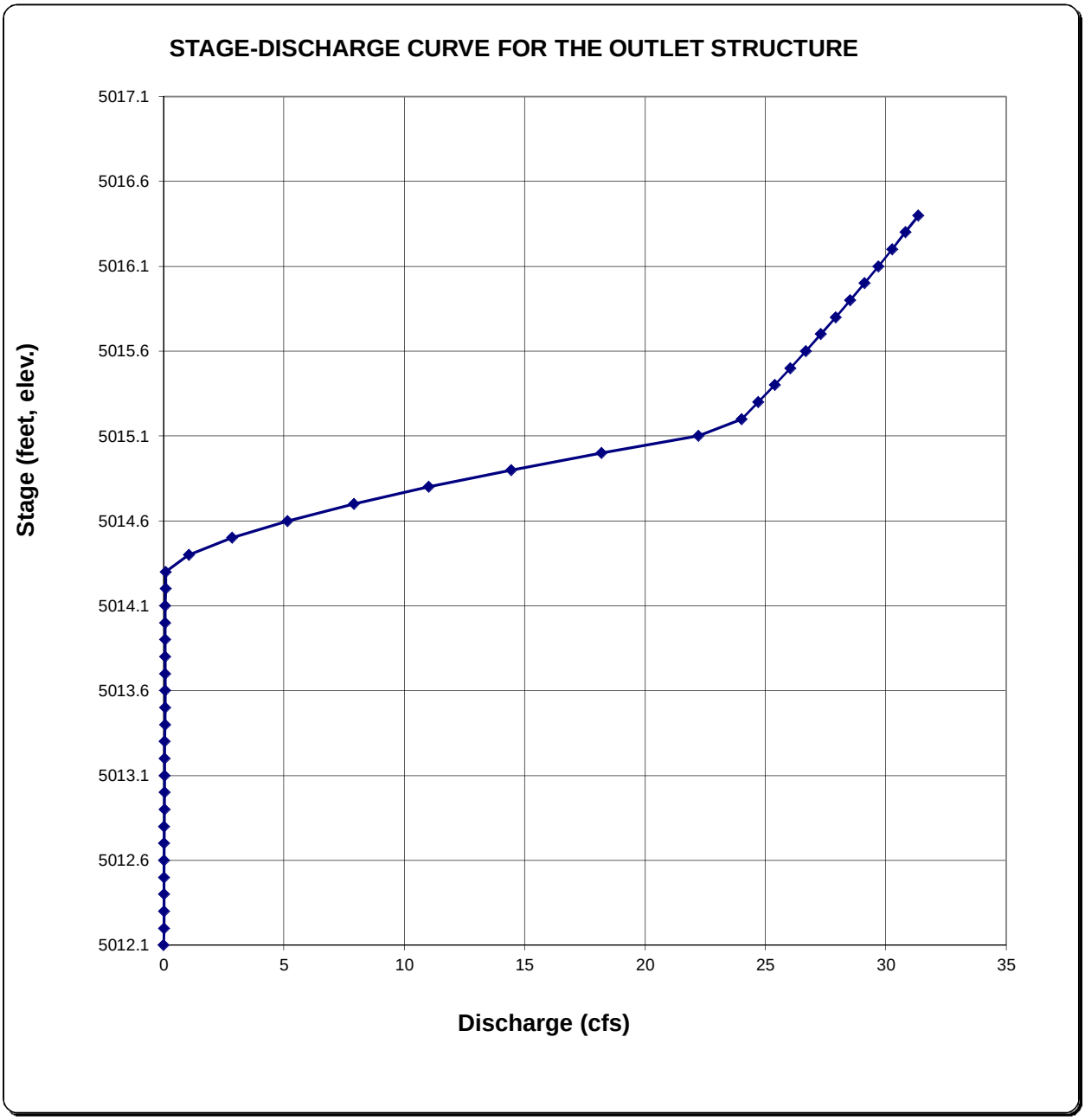
Net Opening Area (after Trash Rack Reduction)	A_o =	5.60		0.75	7.07	sq. ft.
OPTIONAL: User-Overide Net Opening Area	A_o =				3.53	sq. ft.
Perimeter as Weir Length	L_w =	10.80	ft.			
OPTIONAL: User-Overide Weir Length	L_w =			ft.		
Top Elevation of Vertical Orifice Opening, Top =				5015.27	5015.00	ft.
Center Elevation of Vertical Orifice Opening, Cen =				5014.79	5013.50	ft.

Routing 2: Water flows through WQCV plate and #1 vertical opening and #1 horizontal opening into #2 vertical opening (#2 horizontal opening is not used).

			Horizontal Orifices				Vertical Orifices			
Labels for WQCV, Minor, & Major Storage W.S. Elevations (input)	Water Surface Elevation ft (linked)	WQCV Plate/Riser Flow cfs (User-linked)	#1 Horiz. Weir Flow cfs (output)	#1 Horiz. Orifice Flow cfs (output)	#2 Horiz. Weir Flow cfs (output)	#2 Horiz. Orifice Flow cfs (output)	#1 Vert. Collection Capacity cfs (output)	#2 Vert. Collection Capacity cfs (output)	**Total Collection Capacity cfs (output)**	Target Volumes for WQCV, Minor, & Major Storage Volumes (link for goal seek)
	5012.10	0.00	0.00	0.00	0.00	0.00	0.00	0.14	**0.00**	
	5012.20	0.01	0.00	0.00	0.00	0.00	0.00	0.39	**0.01**	
	5012.30	0.01	0.00	0.00	0.00	0.00	0.00	0.71	**0.01**	
	5012.40	0.01	0.00	0.00	0.00	0.00	0.00	1.10	**0.01**	
	5012.50	0.02	0.00	0.00	0.00	0.00	0.00	1.53	**0.02**	
	5012.60	0.02	0.00	0.00	0.00	0.00	0.00	2.02	**0.02**	
	5012.70	0.02	0.00	0.00	0.00	0.00	0.00	2.54	**0.02**	
	5012.80	0.03	0.00	0.00	0.00	0.00	0.00	3.11	**0.03**	
	5012.90	0.04	0.00	0.00	0.00	0.00	0.00	3.71	**0.04**	
	5013.00	0.04	0.00	0.00	0.00	0.00	0.00	4.34	**0.04**	
	5013.10	0.05	0.00	0.00	0.00	0.00	0.00	5.01	**0.05**	
	5013.20	0.05	0.00	0.00	0.00	0.00	0.00	5.71	**0.05**	
	5013.30	0.05	0.00	0.00	0.00	0.00	0.00	6.43	**0.05**	
	5013.40	0.06	0.00	0.00	0.00	0.00	0.00	7.19	**0.06**	
	5013.50	0.06	0.00	0.00	0.00	0.00	0.00	7.97	**0.06**	
	5013.60	0.06	0.00	0.00	0.00	0.00	0.00	8.78	**0.06**	
	5013.70	0.06	0.00	0.00	0.00	0.00	0.00	9.62	**0.06**	
	5013.80	0.07	0.00	0.00	0.00	0.00	0.00	10.48	**0.07**	
	5013.90	0.07	0.00	0.00	0.00	0.00	0.00	11.37	**0.07**	
	5014.00	0.07	0.00	0.00	0.00	0.00	0.00	12.28	**0.07**	
	5014.10	0.07	0.00	0.00	0.00	0.00	0.00	13.21	**0.07**	
	5014.20	0.08	0.00	0.00	0.00	0.00	0.00	14.16	**0.08**	
	5014.30	0.08	0.00	0.00	0.00	0.00	0.00	15.14	**0.08**	
	5014.40	0.08	0.89	9.24	0.00	0.00	0.09	16.14	**1.06**	
	5014.50	0.08	2.51	13.06	0.00	0.00	0.25	17.16	**2.85**	
	5014.60	0.08	4.61	16.00	0.00	0.00	0.46	18.20	**5.16**	
	5014.70	0.09	7.10	18.47	0.00	0.00	0.71	19.25	**7.90**	
	5014.80	0.09	9.93	20.66	0.00	0.00	1.00	20.33	**11.01**	
	5014.90	0.09	13.05	22.63	0.00	0.00	1.31	21.43	**14.45**	
	5015.00	0.09	16.45	24.44	0.00	0.00	1.65	22.55	**18.19**	
	5015.10	0.09	20.09	26.13	0.00	0.00	2.02	23.29	**22.21**	
	5015.20	0.10	23.98	27.71	0.00	0.00	2.41	24.01	**24.01**	
	5015.30	0.10	28.08	29.21	0.00	0.00	2.78	24.70	**24.70**	
	5015.40	0.10	32.40	30.64	0.00	0.00	3.04	25.38	**25.38**	
	5015.50	0.10	36.91	32.00	0.00	0.00	3.28	26.04	**26.04**	
	5015.60	0.10	41.62	33.31	0.00	0.00	3.50	26.68	**26.68**	
	5015.70	0.10	46.51	34.56	0.00	0.00	3.71	27.31	**27.31**	
	5015.80	0.11	51.59	35.78	0.00	0.00	3.91	27.93	**27.93**	
	5015.90	0.11	56.83	36.95	0.00	0.00	4.10	28.53	**28.53**	
	5016.00	0.11	62.24	38.09	0.00	0.00	4.28	29.11	**29.11**	
	5016.10	0.11	67.81	39.19	0.00	0.00	4.45	29.69	**29.69**	
	5016.20	0.11	73.54	40.26	0.00	0.00	4.62	30.26	**30.26**	
	5016.30	0.11	79.42	41.31	0.00	0.00	4.78	30.81	**30.81**	
	5016.40	0.11	85.45	42.33	0.00	0.00	4.94	31.36	**31.36**	

STAGE-DISCHARGE SIZING OF THE WEIRS AND ORIFICES (INLET CONTROL)

Project: Thunder Valley PUD
Basin ID: Detention Pond

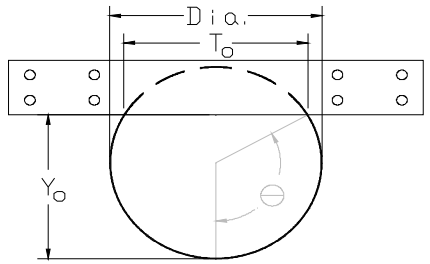


RESTRICTOR PLATE SIZING FOR CIRCULAR VERTICAL ORIFICES

Project: Thunder Valley PUD

Basin ID: Detention Pond

X



		#1 Vertical Orifice	#2 Vertical Orifice	
Sizing the Restrictor Plate for Circular Vertical Orifices or Pipes (Input)				
Water Surface Elevation at Design Depth	Elev: WS =	5,016.30		feet
Pipe/Vertical Orifice Entrance Invert Elevation	Elev: Invert =	5,012.00		feet
Required Peak Flow through Orifice at Design Depth	Q =	30.83		cfs
Pipe/Vertical Orifice Diameter (inches)	Dia =	36.0		inches
Orifice Coefficient	C_o =	0.65		
Full-flow Capacity (Calculated)				
Full-flow area	Af =	7.07		sq ft
Half Central Angle in Radians	Theta =	3.14		rad
Full-flow capacity	Qf =	61.7		cfs
	Percent of Design Flow =	200%		
Calculation of Orifice Flow Condition				
Half Central Angle (0<Theta<3.1416)	Theta =	1.48		rad
Flow area	A_o =	3.11		sq ft
Top width of Orifice (inches)	T_o =	35.84		inches
Height from Invert of Orifice to Bottom of Plate (feet)	Y_o =	1.36		feet
Elevation of Bottom of Plate	Elev Plate Bottom Edge =	5,013.36		feet
Resultant Peak Flow Through Orifice at Design Depth	Q_o =	30.9		cfs
Width of Equivalent Rectangular Vertical Orifice	**Equivalent Width =**	**2.29**		**feet**
Centroid Elevation of Equivalent Rectangular Vertical Orifice	**Equiv. Centroid El. =**	**5,012.68**		**feet**

Weir Report

5-Year Outlet Weir

Rectangular Weir

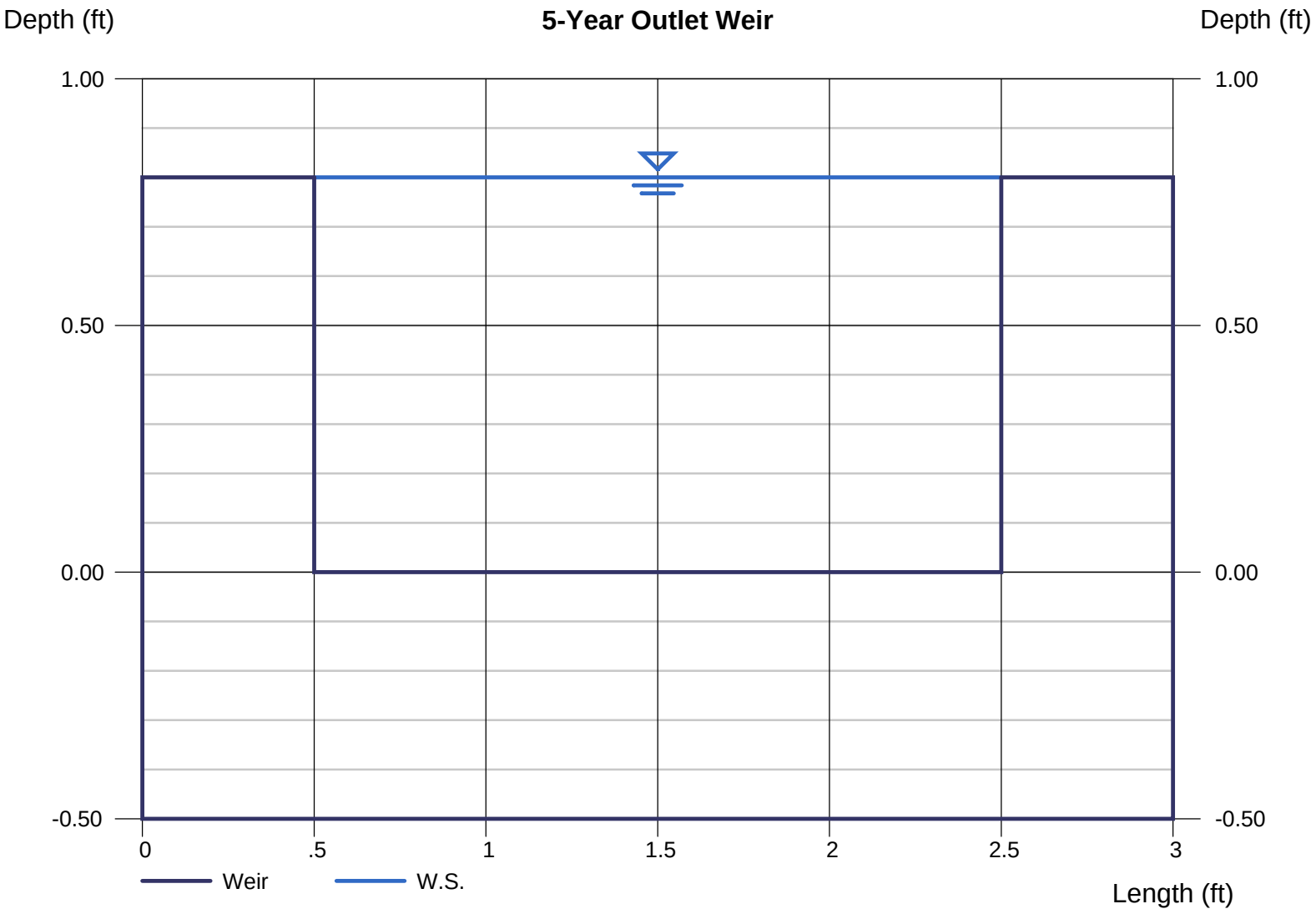
Crest	= Sharp
Bottom Length (ft)	= 2.00
Total Depth (ft)	= 0.80

Calculations

Weir Coeff. Cw	= 3.33
Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

Depth (ft)	= 0.80
Q (cfs)	= 4.766
Area (sqft)	= 1.60
Velocity (ft/s)	= 2.98
Top Width (ft)	= 2.00



Weir Report

Pond Overflow Weir

Trapezoidal Weir

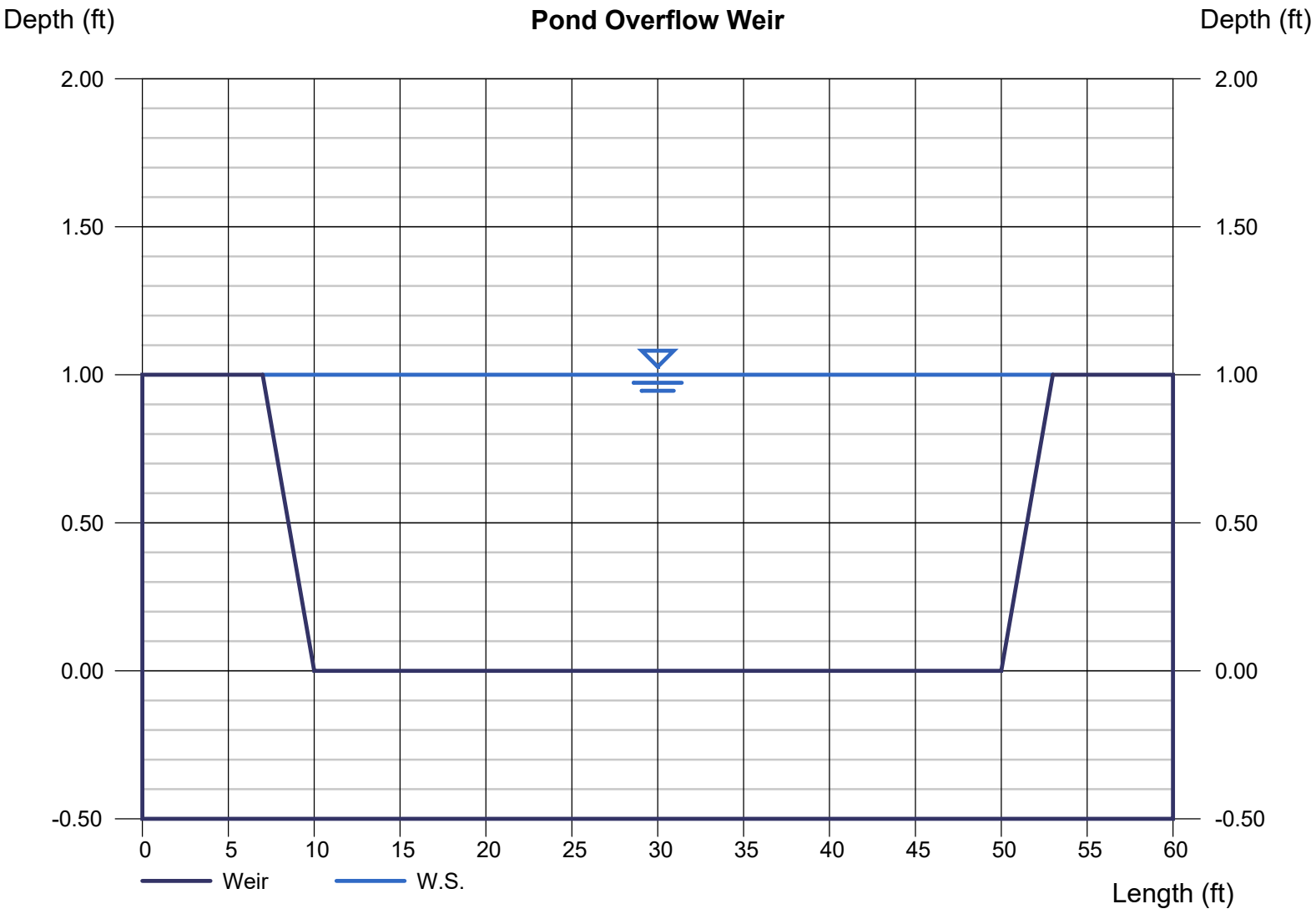
Crest	= Sharp
Bottom Length (ft)	= 40.00
Total Depth (ft)	= 1.00
Side Slope (z:1)	= 3.00

Calculations

Weir Coeff. Cw	= 3.10
Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

Depth (ft)	= 1.00
Q (cfs)	= 131.44
Area (sqft)	= 43.00
Velocity (ft/s)	= 3.06
Top Width (ft)	= 46.00



CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PRELIMINARY GEOTECHNICAL STUDY

Thunder Valley
Weld County, Colorado

Report Prepared for:

Mr. J.C. York, P.E.
J&T Consulting
305 Denver Avenue, Suite D
Fort Lupton, CO 80621

Project No. 18.3040.A
May 4, 2018

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May 4, 2018

Report Prepared by:

Yvonne E. Schimmel, P.E.
Staff Engineer

Darin R. Duran, P.E.
Principal, Geotechnical Engineering Manager

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1. INTRODUCTION

This report presents results of a preliminary geotechnical study for the proposed Thunder Valley development in Weld County, Colorado. The study was made to determine preliminary recommendations for foundation systems, interior floor systems, site preparation, pavement sections, and to present other pertinent geotechnical issues. Factual data gathered during the field and laboratory work is summarized in Tables 1 through 3, Figures 1 through 3, and Appendices A and B. Cesare, Inc.'s (Cesare) opinions and recommendations presented in this report are based on the data generated during this field investigation, laboratory testing, and our experience with similar type projects.

2. PROPOSED CONSTRUCTION

Thunder Valley is located southwest of the intersection of County Road 21 and County Road 10 1/2 in Weld County, Colorado. It is our understanding that the project area will be annexed by the City of Fort Lupton. The planned subdivision is an infill of residences and roads consisting of 13 units and proposed open space along an existing drainage. Cesare understands that neither the specific site nor the proposed structure have been designed. As the proposed construction will be residential, we anticipate the structures will be wood framed, possibly with basements, and floors will be concrete slab-on-grade. Some grading is likely, the extent of which is presently unknown.

3. SITE CONDITIONS

The site is roughly triangular in shape, about 36 acres in size, and is currently occupied by tilled farmland. The site is located southwest of the intersection of County Road 21 and County Road 10 1/2 in Weld County, Colorado. The site is surrounded by agricultural land with scattered agricultural and residential structures. The site is bound to the north by County Road 10 1/2, to the east by County Road 21, and to the south and west by an irrigation canal. The regional topography of the site vicinity is gently sloping down to the east towards the South Platte River. The site is located on a topographic high between Little Dry Creek and Big Dry Creek, both of which flow east-northeast toward confluence with the South Platte River about two miles from the site.

A natural drainage bisects the approximate center of the site, flowing eastward and trending east-west with slopes ranging from about 2 to 5 feet high. Flowing and standing water was observed in this drainage during Cesare's subsurface study. A second, less prominent drainage bisects the south part of the site, flowing eastward with a less pronounced surface expression. Water was not observed in this secondary drainage during Cesare's subsurface study, however, historical aerial imagery shows this area to be intermittently greener, with evidence of ponding or flowing water.

The ditch that forms the western boundary is upslope of the proposed lots and may impact the proposed development. The ditch is lined with concrete and did not contain water during Cesare's subsurface investigation. The ditch has leaked in the past (based on aerial imagery). Based on information from the client, the berm lining the ditch has been repaired and is not leaking at this time.

The northern half of the site slopes gently down to the southeast at a grade of about 1.62%. Elevations on the northern half of the site range from about 5031 to 5015 feet (elevation change of 16 feet). The southern half of the site slopes down to the northeast at a grade of about 3.23%. Elevations on the southern half of the site range from 5034 to 5014 feet (elevation change of 20 feet).

4. GEOLOGIC SETTING

4.1 REGIONAL GEOLOGIC SETTING

The site is located about 20 miles east of the eastern edge of the Rocky Mountains in a broad area predominantly occupied by the South Platte River. The site is included in the northern section of the Denver Basin, a broad synclinal structure roughly centered on the Denver Metropolitan Area. The Denver Basin is asymmetrically shaped, and the western flank is characterized by a zone of steeply dipping bedrock along the Front Range of the Rocky Mountains. The more resistant layers commonly form prominent ridges and hogbacks, while the more easily erodible layers form valleys. The bedding attitude of the bedrock layers flattens rapidly east of the mountain front and is generally considered low angled within the site area.

The project site is located in the Colorado Piedmont section of the Great Plains Physiographic province which is geomorphically characterized by gently sloping pediments, dissected bluffs, benched alluvial terraces with adjacent valleys, and low lying interfluvial hills. The mountain building event that caused the abrupt uplift of the eastern flank of the Rocky Mountains during the Paleogene (66 to 45 million years ago), resulted in the erosion of sedimentary deposits from uplifted regions and deposition into the structurally subsiding Denver Basin. Fluvial systems carried deposits from higher elevations and deposited them in the basin. Bedrock in the regional site vicinity is comprised of sedimentary rocks deposited by these ancient fluvial lacustrine systems, and by the continental seaway that occupied the area during the Cretaceous (about 100 million years ago).

4.2 SITE GEOLOGY

Based on published literature[1], the site is underlain by loess deposits overlying Dawson Formation bedrock. Geologic units are described in the following sections.

4.2.1 Surficial Deposits

Surficial deposits underlying the site consist of loess deposits (windblown silt). The age of these deposits may range from about 191,000 to 130,000 years before present (Illinoian) or range from about 125,000 to 11,000 years before present (Sangamon and Wisconsin). The loess deposits are characterized as sandy to clayey silt with some silty, fine grained sand. The unit locally includes pebbles and small cobbles which are likely colluvial deposits derived from older gravel deposits. The loess was deposited as a blanket of material in more than one depositional episode. Colors range from pale yellow-brown to gray-orange and thickness is commonly 3 to 15 feet but can be more than 25 feet thick in places.

[1] Soister, P.E., 1965, Geologic Map of the Fort Lupton Quadrangle, Weld and Adams County, Colorado: U.S. Geological Survey Geologic Quadrangle Map CQ-37.

4.3.2 Bedrock

Bedrock underlying the site is comprised of Dawson Formation (upper Cretaceous; 100.5 to 65 million years before present), which is predominantly dark gray shale and clay with some yellow-gray siltstone and limonitic arkosic sandstone (in part). Ironstone concretions up to 4 feet in diameter are present in the lower part of this unit. Lenticular coal beds less than 3 feet thick are rare. The sandstone beds are commonly non-calcareous (except in concretions), lenticular in shape, with cut-and-fill structures related to the depositional environment. Thickness of the Dawson Formation is estimated at 550 to 600 feet.

4.3.3 Groundwater

According to Hillier and Schneider (1979)[2], the depth to the water table generally ranges from 5 to 20 feet within colluvium, landslide, and windblown deposits, and within sedimentary rocks close to the surface which are fractured and weathered. The depth of the seasonal water table in this area is typically less than 10 feet. Groundwater was encountered during the subsurface investigation and these conditions are discussed in Section **7. SUBSURFACE CONDITIONS**.

5. INVESTIGATIONS

Subsurface conditions were investigated by drilling 15 borings at the locations indicated in Figure 1. The borings were advanced using a 4 inch diameter, continuous flight, solid stem auger powered by a CME-45 drilling rig. At frequent intervals, samples of the subsoil were taken using a modified California sampler which is driven into the soil by dropping a 140 pound hammer through a free fall of 30 inches. The modified California sampler is a 2.5 inch outside diameter by 2 inch inside diameter device. The procedure to drive the sampler into the soil and to record the number of blows required to drive the sampler into the soil is known as a penetration test. The number of blows required for the sampler to penetrate 12 inches gives an indication of the relative stiffness of cohesive soil or relative density of non-cohesive soil encountered. Results of the penetration tests and locations of sampling are presented on the Logs of Borings, Figures 2 and 3, with Key to Symbols. Bulk samples were collected from each boring.

6. LABORATORY TESTING

Samples were returned to the Cesare laboratory where they were visually classified and appropriate testing assigned to specific samples to evaluate pertinent engineering properties. The laboratory tests included seven swell/consolidation tests to evaluate the effect of wetting and loading on the soil. Three of the samples were remolded to determine the swell potential of fills using onsite material. The samples were loaded to approximate overburden pressure calculated as 100 pounds per square feet (psf) per foot of soil (minimum 400 psf) and then inundated with water. Eleven gradation analysis tests and Atterberg limits tests were conducted to evaluate grain size distribution and plasticity of selected samples. One standard Proctor test was conducted to determine the moisture/density relationship of compacted soil. One R-value was conducted to determine the strength of the subsoil for the design of pavement systems. Two water soluble sulfate tests were conducted to determine the potential reactivity of the soil with cement. Laboratory test results are presented in Table 1 and Appendix A.

[2] Hillier, D.E. and Schneider, P.A., 1979, Depth to the Water Table (1976-1977) in the Boulder-Fort Collins-Greeley Area: United States Geological Survey, Miscellaneous Investigations Series, Map-I-855-I.

7. SUBSURFACE CONDITIONS

Cesare's borings indicate the subsoil, in general, consists of clay and clay, with sand to sandy, overlying sandy claystone to clayey sandstone bedrock to 40 feet, the maximum depth explored. The clay encountered is described as medium stiff to very stiff, slightly moist to moist, and brown in color. The clay, with sand to sandy, was medium stiff to very stiff, slightly moist to moist, and brown, reddish-brown in color. Bedrock consisted of sandy claystone to clayey sandstone which was fine grained, firm to very hard, moist, fractured, laminated in places, with occasional iron oxide staining along fracture planes and laminae, with gypsum, plant fragments, and lignite flecks and thin seams. The bedrock was weathered in the upper section and was gray to brown gray in color. Refer to Figures 2 and 3 for boring logs and key to symbols.

Groundwater was encountered at depths ranging from about 14.5 to 24 feet below ground surface in Borings B-2, B-3, B-5, and B-6 during drilling. Groundwater was not encountered during drilling in Borings B-1, B-4, or Borings B-7 through B-15 drilled for pavement design. Groundwater was measured at depths between 7 and 33.5 feet below ground surface in Borings B-1 through B-6 when checked seven days after drilling. Refer to Table 2 for a summary of groundwater depths. For safety purposes, borings were backfilled at the completion of the study.

TABLE 2. Depth to Groundwater (feet below ground surface)

Boring	During Drilling	Seven Days After Drilling (04/20/18)
B-1	NE	21.5
B-2	14.5	10.0
B-3	24.0	7.0
B-4	NE	33.5
B-5	15.0	18.0
B-6	24.0	9.0

NE: Not encountered

These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations. Groundwater can be expected to fluctuate with various seasonal, irrigation, and weather conditions.

8. GEOTECHNICAL CONSIDERATIONS

8.1 SWELLING SOIL

Cesare's borings for this study indicate the subsoil, in general, consists of clay and clay, with sandy to sandy, overlying sandy claystone to clayey sandstone bedrock. Disregarding disturbed samples, swell/consolidation tests performed on the clay indicate 0.9% to 1.6% swell, which is considered a low swell potential. Swell/consolidation tests performed on the claystone indicate 4.7% to 6.3% swell, which is considered a high to very high swell potential. Sitewide remediation is anticipated.

8.2 GROUNDWATER

Groundwater was encountered at depths between 14.5 and 24 feet below ground surface during drilling, and at depths between 7 and 33.5 feet below ground surface when measured seven days

after drilling. Groundwater will be encountered during overexcavation of this site, which can result in pumping ground conditions. Construction dewatering may be necessary, but it is not anticipated sitewide. Groundwater may also be encountered in excavation for basements.

8.3 EXCAVATIONS

Difficulty may be experienced in the development of this site. The bedrock is weathered to very hard. Earthwork operations that encounter this bedrock may require ripping. Bearing materials loosened by ripping should be recompacted or removed. Conventional earthmoving equipment should be adequate to excavate the onsite overburden soil. In addition, pumping conditions will be encountered when the bottom of overexcavation is within 2 feet of the groundwater table in soil and sandstone bedrock.

Site development will change both existing slopes and groundwater conditions that can create conditions causing unstable slopes. Permanent cut and fill slopes should not exceed 15 feet in height and be no steeper than 3 horizontal to 1 vertical (3H:1V). Steeper and higher slopes should be evaluated on a case-by-case basis. Cesare anticipates temporary slopes may be 1.5H:1V in soil material and 0.5H:1V in bedrock material. Shallower slopes should be anticipated if sands or groundwater are encountered. All excavations should be properly sloped and/or braced, and local and federal safety codes should be observed. Slopes and other stripped areas should be protected against erosion.

Cesare's experience indicates that perched groundwater will likely occur in the soils and sandstone bedrock. Where cuts are planned, dewatering should be anticipated. If seepage is observed in cuts during grading, Cesare should be contacted to evaluate the stability of the cuts on an individual basis. The bottom excavations should not undermine existing infrastructure or adjoining properties.

The bottom excavations for the new structure should not undermine existing foundation systems of structures or infrastructure on adjoining properties. New excavations should not intersect a line drawn on a 45 degree angle down and away from the bottom edge of the existing foundation systems or bottom edge of infrastructure. If this condition cannot be met, shoring or staged excavations may be required.

8.4 OVERLOT GRADING AND FILL

All areas to receive fill should be stripped, grubbed, and scarified a minimum of 6 inches prior to the placement of fill. Where fill soil is necessary, the suitable onsite inorganic soil may be used for fill below structures, roadways, and exterior concrete. Onsite claystone bedrock should be broken down to a soil like consistency with the largest particle size of 3 inches in any direction.

Fill material should be placed in 6 inch maximum, loose lifts within 2% of optimum moisture content (OMC) for sand material (AASHTO classification A-1 to A-2-4 and A-3 to A-5), and within 1% to 4% above OMC for clay material (AASHTO classification A-2-6, A-2-7, A-6, and A-7), and should be compacted to at least 95% of standard Proctor density according to ASTM D698. All topsoil, existing manmade fill, frozen material, and soil containing organic material should be

removed beneath structural and roadway areas prior to placement of fill or concrete. Fill in structural areas should be free of frozen and organic material.

The fill material should be thoroughly mixed to achieve the highest practical level of moisture conditioning during fill placement. Utilization of a heavy construction disc is typically the most effective means of achieving thorough mixing and moisture conditioning of the fill material. Difficulty placing, mixing, and compacting the material may be experienced due to the potentially high moisture of the fill material.

The placement and compaction of overlot fill should be observed and tested on a full-time basis by a representative of our firm. Utility fill should be tested in accordance with jurisdictional requirements. Any material imported for structural fill should be tested and approved for use at this site by the project geotechnical engineer prior to hauling to the site. Swell tests and classification tests should be conducted to determine that the fill meets the required specifications. In general, fill material should have a swell potential under anticipated slab loads of less than 1%. Claystone is not acceptable for import fill.

Material imported for structural fill should be tested and approved for use at this site by the project geotechnical engineer prior to hauling to the site. Swell tests should be conducted to determine if the fill meets required specifications. In general, fill material should be well graded, low permeable materials which meets the following specifications:

Percent finer than No. 200 sieve:	minimum 20%
Liquid limit:	20% to 40%
Plasticity index:	8% to 15%
Swell potential under anticipated slab loads:	less than 1%

8.5 FOUNDATIONS

Swell/consolidation tests performed on the clay indicate 0.9% to 1.6% swell, which is considered a low swell potential. Swell/consolidation tests performed on the claystone indicate 4.4% to 6.2% swell, which is considered a high to very high swell potential. Remolded swells were performed on material from Boring B-4. The material was inundated at 500 psf and testing indicated swells of 3.9%, 3.7%, and 2.7% at 1.1% below OMC, 1.3% above OMC, and 2.2% above OMC. This indicates that overexcavation and recompaction of the onsite material may not reduce swell sufficiently to use shallow foundations or slab-on-grade floors. If sitewide remediation is performed, shallow foundations, such as conventional spread footings or footing pads, will provide adequate support for most structures onsite, provided the remediated subgrade material has a swell potential of less than 1% when tested at a load of 1,000 psf (or 2% when tested at a load of 500 psf), and that there is a minimum of 10 feet of fill beneath the lowest foundation elevation. If final evaluation of lots indicates high swell/consolidation potential, helical piers or cased straight drilled cast-in-place piers should be considered at those locations.

Footings founded below frost depth (36 inches per IBC 2015) on subsoil or compacted fill should anticipate maximum allowable soil bearing pressures of 2,000 to 3,000 psf based on dead load

plus full live load. A minimum dead load pressure may be required in areas of potentially low swelling materials.

Structures founded on piers should anticipate maximum allowable end bearing pressures ranging from 20,000 to 30,000 psf and maximum side shear values of 2,000 to 3,000 psf for that portion of the pier in competent bedrock. Pier lengths will depend on measured swell pressures and depth to bedrock, however, we anticipate lengths ranging from 30 to 40 feet.

Cesare recommends foundation evaluations for design at individual building sites after final grading and the final location of the building sites have been identified.

8.6 FLOOR SLABS

Concrete slabs-on-grade can be used for floors in the residences, provided the subgrade material has a swell potential of less than 1% when tested at a load of 1,000 psf (or 2% when tested at a load of 500 psf). Structural floors are recommended for all structures with expansive material (greater than 1% when tested at a load of 1,000 psf or 2% when tested at a load of 500 psf) within 10 feet of floor slab elevation.

Cesare recommends floor slab recommendations be analyzed at individual building sites after final grading and the locations of the building sites have been determined.

8.7 UNDERGROUND UTILITIES

The corrosion potential of the subsoil around underground pipelines should be evaluated prior to the selection of pipe types. The corrosion potential of the subsoil can be evaluated by conducting laboratory or field resistivity tests, and determination of the sulfate and chloride concentrations and pH value of the subsoil. A qualified corrosion engineer should be consulted to evaluate the corrosion potential.

Utilities are usually constructed beneath the roadways. Compaction of the trench backfill can have a significant effect on the life and serviceability of the pavement. Cesare recommends trench backfill be placed in accordance with local specifications, with specific care taken for fill placed with a wheel compaction attachment on a backhoe. The placement and compaction of fill should be observed and tested by a representative of our firm.

9. DRAINAGE

9.1 SURFACE DRAINAGE

Performance of the development will be significantly influenced by the surface drainage. When developing an overall drainage scheme, considerations should be given to individual building locations and fill. Drainage should be placed in such a manner that surface runoff is directed away from the building's foundation and foundation wall backfill zone and is not allowed to pond adjacent to the buildings, inside overlot fill yards, behind foundation wall backfill zones, or over pavements. Setting foundation levels as high as possible above curb lines will aid in the rapid removal of surface runoff. If surface drainage between preliminary development and construction is neglected, performance of the roadways and building foundations can be poor.

When considering landscaping for common areas or areas around individual residences, Cesare recommends the use of vegetation or landscaping which requires very little initial or long term watering. Use of bubbler or trickler type irrigation systems should be discouraged.

9.2 SUBSURFACE DRAINAGE

Groundwater was encountered at depths ranging from about 14.5 to 24 feet below ground surface in Borings B-2, B-3, B-5, and B-6 during drilling. Groundwater was not encountered during drilling in Borings B-1, B-4, or Borings B-7 through B-15 drilled for pavement design. Groundwater was measured at depths between 7 and 33.5 feet below ground surface in Borings B-1 through B-6 when checked seven days after drilling. Development of a large site often adversely affects groundwater conditions, raising the level of the water table where impervious clay lenses occur. Depressions in the surface of the clay lenses, such as below grade excavations, often permit groundwater or surface water to drain into these areas. The clayey soil, which is relatively impervious, may trap this water creating local perched groundwater problems around the structure. A subsurface drainage system should be provided for any below grade areas, such as basements or crawlspaces. If the below grade areas are within 3 feet of the groundwater table, interior, exterior, and underslab drains may be required.

10. PRELIMINARY PAVEMENT RECOMMENDATIONS

Preliminary pavement recommendations contained in this report are based upon the following:

- *City of Fort Lupton Standards and Specifications for the Design and Construction of Public Improvements*, dated 2018
- An assumed R value of 5 for clay subgrade and 78 for aggregate base course

Table 3 shows preliminary estimated pavement sections to be used for preliminary planning purposes.

TABLE 3. Pavement Section Thickness Alternatives

Option	Hot Mix Asphalt (in.)	Aggregate Base Course (in.)
Full depth	6.0	--
Composite	4.0	8.0

In Cesare's opinion, the roadways in areas with swells greater than 2% will require remediation beneath the pavement section. Subexcavation of 3 feet should be expected. The subgrade treatment should extend to back of curb or to back of sidewalk, if the sidewalk is attached or adjacent to the curb and gutter. The fill in the subexcavated areas shall be compacted to 95% of standard Proctor density according to AASHTO T99 at 0% to 2% above OMC. Placing suitable borrow material may allow for reduced pavement section thicknesses. The replacement materials' swell characteristics should be verified.

The final design thickness of the street pavements could change significantly depending upon overlot grading and site preparation. A subgrade investigation and final pavement design should be performed after overlot grading is completed.

11. WATER SOLUBLE SULFATES

Testing conducted on samples collected from Borings B-3 and B-6 indicated 0.04% and 0.45% water soluble sulfates, respectively. The American Concrete Institute (ACI) considers this range severe water soluble sulfate exposure according to 318-08 R4.3.1. ACI recommends a Type V cement with a maximum water:cementitious ratio of 0.45 and a minimum f'c of 4,500 pounds per square inch (psi) be used for the concrete mixture. The use of pozzolan will further reduce the exposure.

The high levels of water soluble sulfates will preclude the use of lime stabilization of subgrade soil for roadways or other areas. Double application of lime is unlikely to mitigate the high sulfate condition.

12. SEISMIC SITE CLASSIFICATION

The potential for severe ground shaking is low during a reasonable service life for the proposed structures. Earthquake resistant designs commensurate with the regional hazard should be used in the design of the structures. Based on our current understanding of the earthquake hazards in this part of Colorado, we see no reason to increase the seismic zone. The soil types present on the site, based on our experience, will be classified as Type E according to the 2015 International Building Code (ASCE 7, Chapter 20). Additional studies, such as downhole seismic, would be necessary to justify a site classification of D or C.

13. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical evaluation. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical evaluation should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute our best estimate of those measures that are necessary to help the structures and pavement perform in a satisfactory manner based on the information generated during this and previous evaluations, and our experience in working with these conditions.

14. LIMITATIONS

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Cesare reviews the changes and either verifies or modifies the conclusions of this report in writing.

The borings drilled for this study were located to obtain a reasonably accurate picture of underground conditions for preliminary design purposes. Variations frequently occur from these

conditions which are not indicated by the borings. These variations are sometimes sufficient to necessitate modifications in the design. If unexpected conditions are observed during construction, Cesare should be notified and retained to review our recommendations.

Cesare's scope of services for this report does not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. The geotechnical engineer in charge of this project is not a mold prevention consultant. None of the services performed in connection with this study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not, of itself, be sufficient to prevent mold from growing in or on the structures involved.

CESARE, INC.
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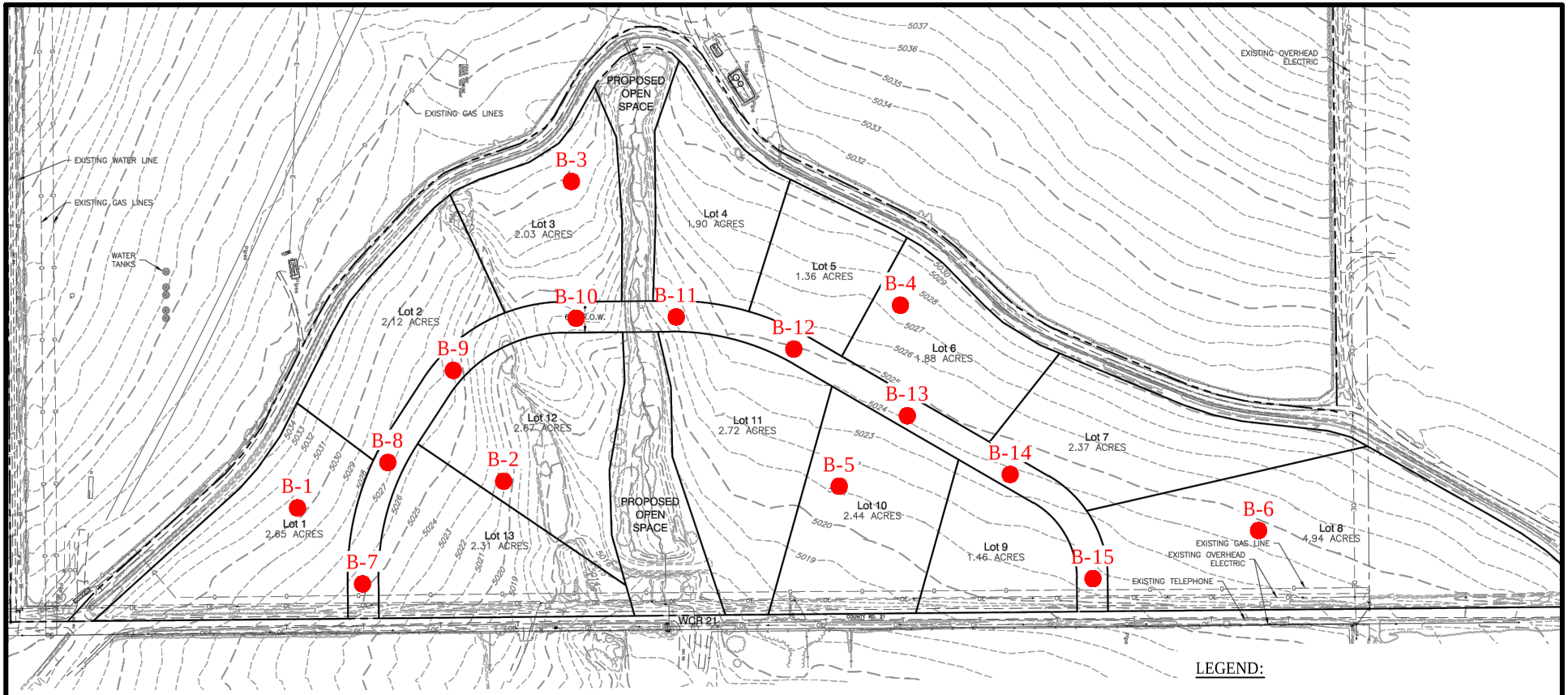
TABLE 1
Summary of Laboratory Test Results
Thunder Valley
Project No. 18.3040

Sample Location					Standard Proctor (ASTM D698)		Gradation			Atterberg Limits		Swell/Consolidation			
Boring	Depth (feet)	Natural Dry Density (pcf)	Natural Moisture Content (%)	Water Soluble Sulfates (%)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)	Material Type
B-1	14	100.9	23.4									1,400	6.3	11,500	CLAYSTONE, sandy, mottled, gray brown
B-2	1		14.7				0	17	83	42	27				(CL) CLAY, with sand, brown, A-7-6(22)
B-3	0 to 5			0.04											CLAY, with sand, brown
B-4	15 to 25		5.9		104.9	19.7	0	8	92	52	37				(CL), CLAY, grayish brown, A-7-6(36)
B-4	15 to 25	104.3(1)	18.6(1)									500	3.9	2,250	(CL), CLAY, grayish brown, A-7-6(36), remolded at 99.4% of ASTM D698 and -1.1% of optimum
B-4	15 to 25	103.9(1)	21.0(1)									500	3.7	3,075	(CL), CLAY, grayish brown, A-7-6(36), remolded at 99.0% of ASTM D698 and +1.3% of optimum
B-4	15 to 25	104.9(1)	21.9(1)									500	2.7	2,750	(CL), CLAY, grayish brown, A-7-6(36), remolded at 100.0% of ASTM D698 and +2.2% of optimum
B-5	4	108.4	13.7									400	0.9	1,725	CLAY, sandy, brown
B-5	14		20.4				3	36	61	31	20				(CL), CLAY, sandy, brown, A-6(9)
B-6	0 to 5			0.45											CLAY, with sand, brown
B-6	19	114.8	14.5									1,900	4.7	12,600	CLAYSTONE, gray
B-7	0 to 5		7.6				5	17	78	40	22				(CL), CLAY, with sand, brown, A-6(16)
B-8	4	124.2	11.8									200	5.5	NA	CLAYSTONE, mottled, gray
B-8	0 to 5		6.6				3	17	80	39	22				(CL), CLAY, with sand, brown, A-6(17)
B-9	0 to 5		8.1				0	20	80	36	20				(CL), CLAY, with sand, brown, A-6(14)
B-10	0 to 5		9.1				0	23	77	39	24				(CL), CLAY, with sand, brown, A-6(17)
B-11	0 to 5		8.5				0	28	72	40	29				(CL), CLAY, with sand, brown, A-6(18)
B-12	0 to 5		7.9				0	15	85	39	22				(CL), CLAY, with sand, brown, A-6(18)
B-13	0 to 5		7.2				0	15	85	37	20				(CL), CLAY, with sand, brown, A-6(16)
B-14	0 to 5		6.8				2	13	85	37	21				(CL), CLAY, brown, A-6(17)
B-14	1	86.1	7.8									200	1.6	NA	CLAY, sandy, brown
B-15	0 to 5		8.6				0	86	14	40	24				(CL), CLAY, brown, A-6(20)

NA = not applicable
TBD = to be determined
(1) remolded dry density and moisture dcontent

W:\2018\Frederick\18.3040 Thunder Valley Preliminary Geotechnical Study\Draft Docs\Figure 1.dwg 4/6/2018 9:22 AM



LAND USE TABLE		
LAND USE	ACRES	% OF AREA
ROW	2.84	7.80
SINGLE FAMILY RESIDENCE	30.85	85.00
OPEN SPACE	2.59	7.20
TOTALS	36.28	100.00

SINGLE FAMILY RESIDENCE SUMMARY
NUMBER OF UNITS = 13
GROSS DENSITY = 0.26 UNITS/ACRE
FLOOR AREA PER UNIT = 3,000 SF MINIMUM

SITE PLAN PROVIDED BY CLIENT

APPROXIMATE SCALE: 1 INCH = 300 FEET

PROJECT NO:	18.3040		
PROJECT NAME:	Thunder Valley		
DRAWN BY:	lJBE	CHECKED BY:	JMF
DWG DATE:	04.04.18	REV. DATE:	--

FIGURE 1
Boring Location Plan

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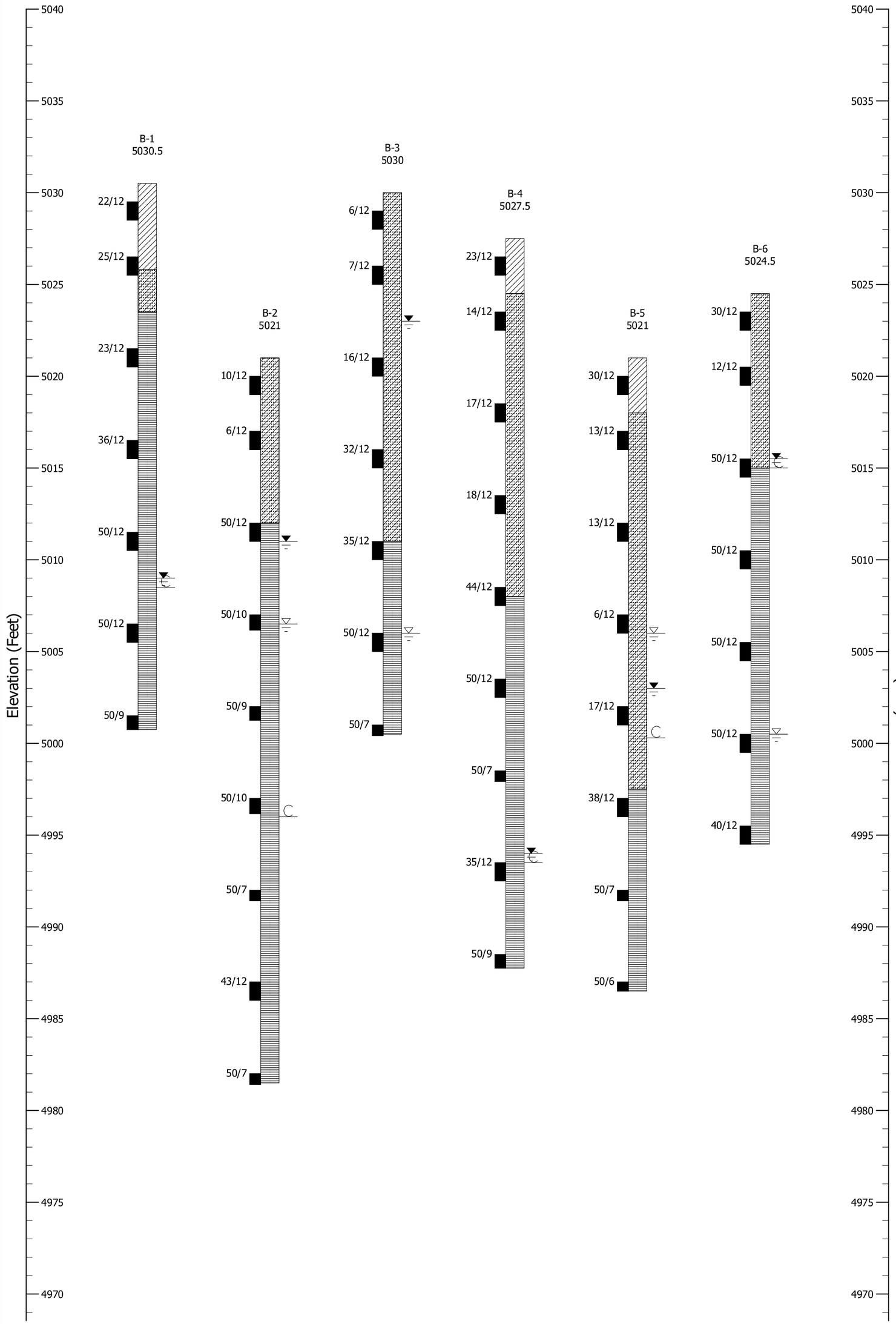

PROJECT NO:	18.3040
PROJECT NAME:	Thunder Valley
DWG DATE:	4/23/2018

FIGURE 2

Logs of Borings

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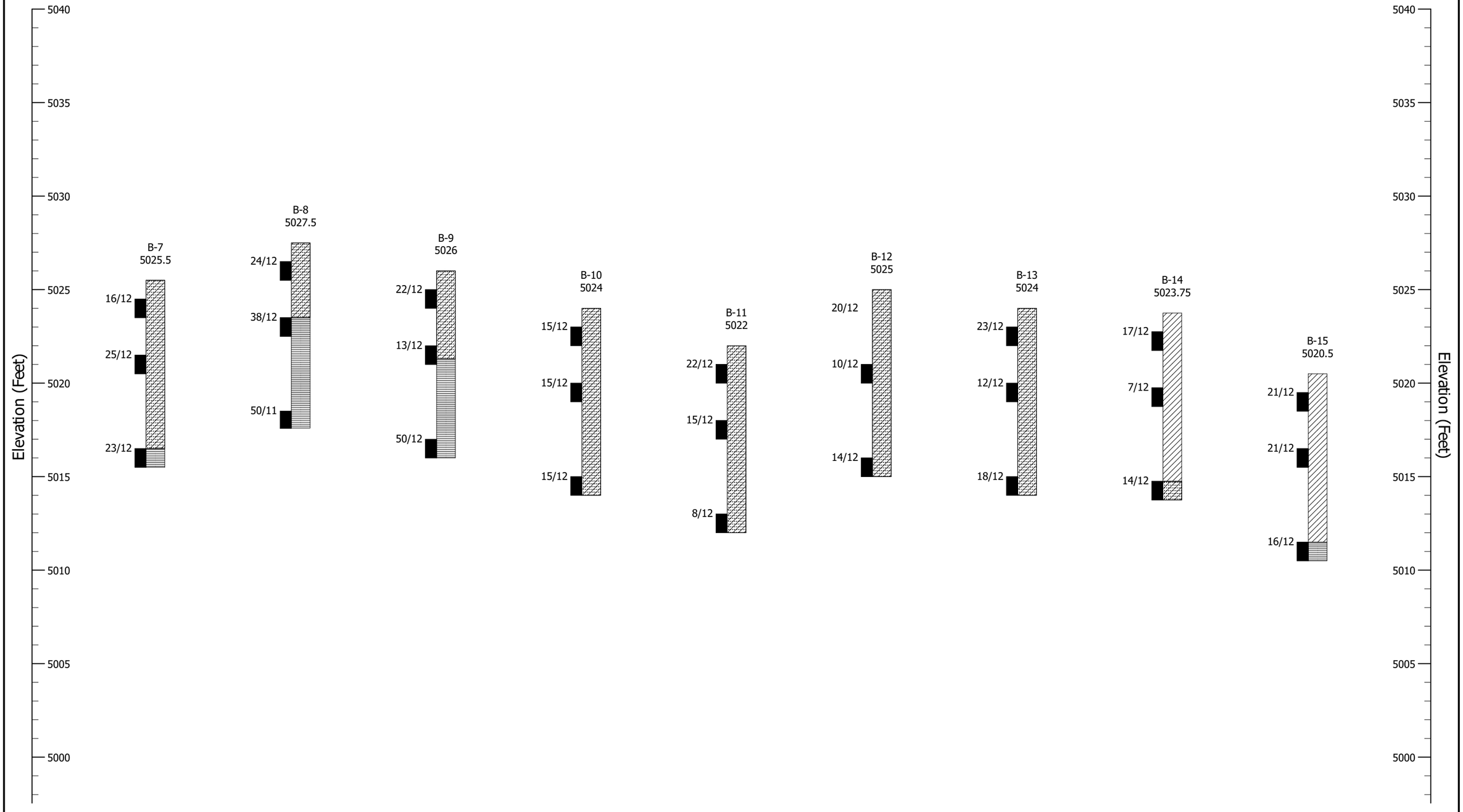

PROJECT NO:	18.3040
PROJECT NAME:	Thunder Valley
DWG DATE:	4/23/2018

FIGURE 3

Logs of Borings

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KEY TO SYMBOLS

Symbol Description

Strata symbols

CLAY, medium stiff to very stiff, slightly moist to moist, brown, (CL), A-7-6.

CLAY, with sand to sandy, medium stiff to very stiff, slightly moist to moist, brown, reddish brown (CL), A-7-6, A-6.

CLAYSTONE, sandy to SANDSTONE, clayey, fine-grained, firm to very hard, moist, fractured, occasionally laminated, occasional iron oxide staining along fracture planes, gypsum deposits, carbonized plant fragments,and lignite flecks and thin seams, weathered in the upper section, gray to brown gray, (CL) to (CH), A-6, A-7-6.

Misc. Symbols

Water level during drilling

Water level 7 days after drilling

Depth to caving 7 days after drilling

Notes:

1. 22/12 indicates 22 blows with a 140-pound hammer falling 30 inches were required to drive a modified California barrel sampler 12 inches.

2. Exploratory borings B-1 through B-15 were drilled on April 12 and 13, 2018 using a CME-55 drill rig with a 4-inch diameter continuous flight solid stem auger.

4. Elevations of borings B-1 through B-15 were approximated using plans provided by J&T Consulting and then verified by Cesare, Inc. using a hand level.

5. Groundwater was encountered at depths ranging from 14.5 to 24 feet below ground surface during drilling (B-2, B-3, B-5, and B-6). Groundwater was encountered at depths ranging from 7 to 33.5 feet below ground surface when measured 8 days after drilling (B-1 through B-6). For safety purposes, borings were backfilled at the completion of the study.

6. Contacts between soil units are approximate and may be gradational.

7. These logs are subject to the limitations, conclusions, and recommendations in this report.
Project No. 18.3040.

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APPENDIX A

Laboratory Test Results

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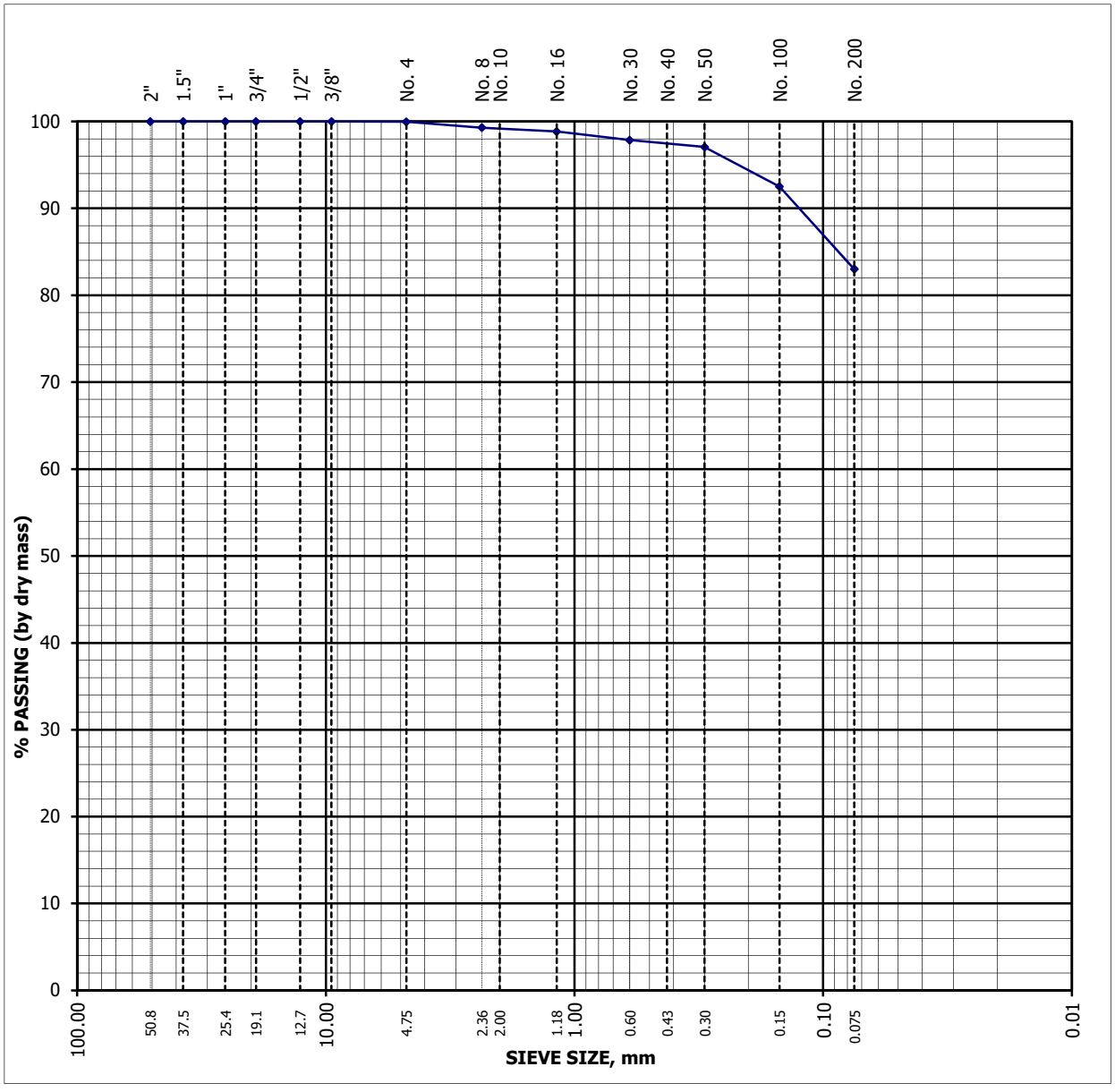
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	17-Mar-18
Project Name:	Thunder Valley	Technician:	J. Weinerth
Lab ID Number:	182937	Reviewer:	Y. Schimmel
Sample Location:	B-2 at 1'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **22**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	100
#4	100
#8	99
#10	
#16	99
#30	98
#40	
#50	97
#100	93
#200	83.0

Moisture (M) & Density (D)	
M, %:	14.7
D, pcf:	

LL	42
PL	15
PI	27

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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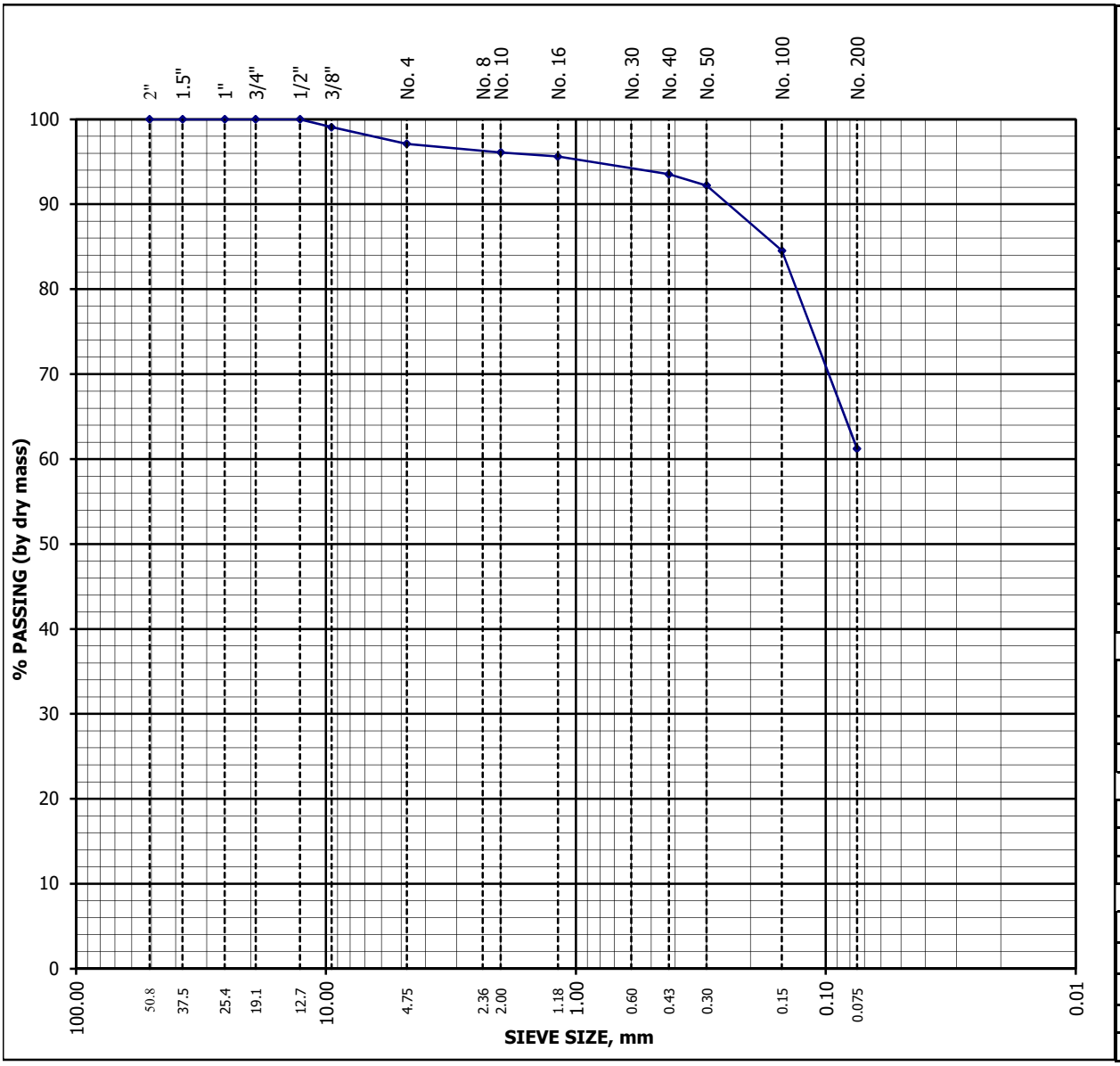
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	17-Mar-18
Project Name:	Thunder Valley	Technician:	J. Weinerth
Lab ID Number:	182941	Reviewer:	Y. Schimmel
Sample Location:	B-5 at 14'		
Visual Description:	CLAY, sandy, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **9**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Sandy lean clay**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	100
3/8"	99
#4	97
#8	
#10	96
#16	96
#30	
#40	94
#50	92
#100	85
#200	61.2

Moisture (M) & Density (D)	
M, %:	20.4
D, pcf:	

LL	31
PL	11
PI	20

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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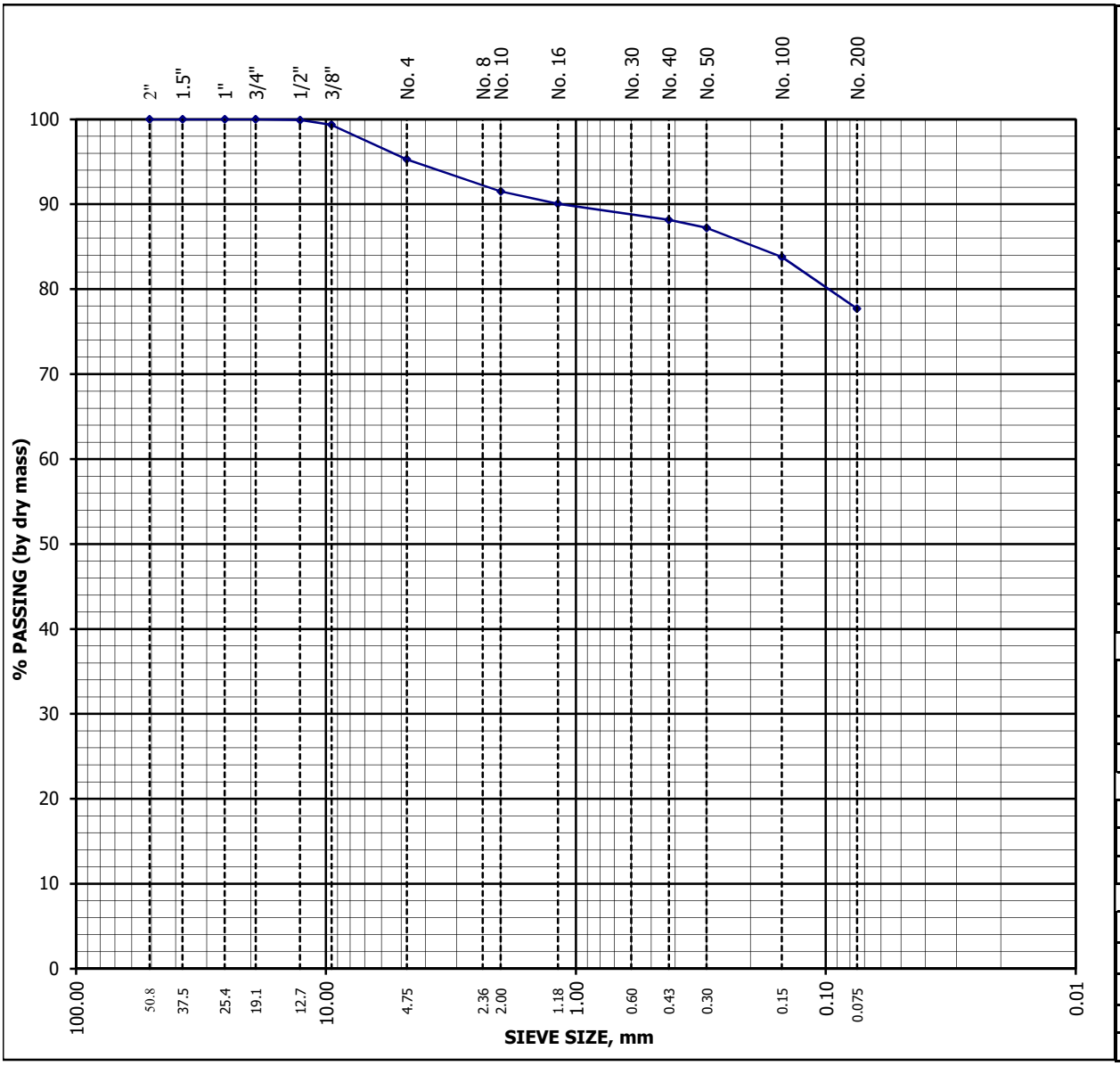
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182049	Reviewer:	Y. Schimmel
Sample Location:	B-7 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **16**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	100
1/2"	100
3/8"	99
#4	95
#8	
#10	92
#16	90
#30	
#40	88
#50	87
#100	84
#200	77.7

Moisture (M) & Density (D)	
M, %:	7.6
D, pcf:	

LL	40
PL	18
PI	22

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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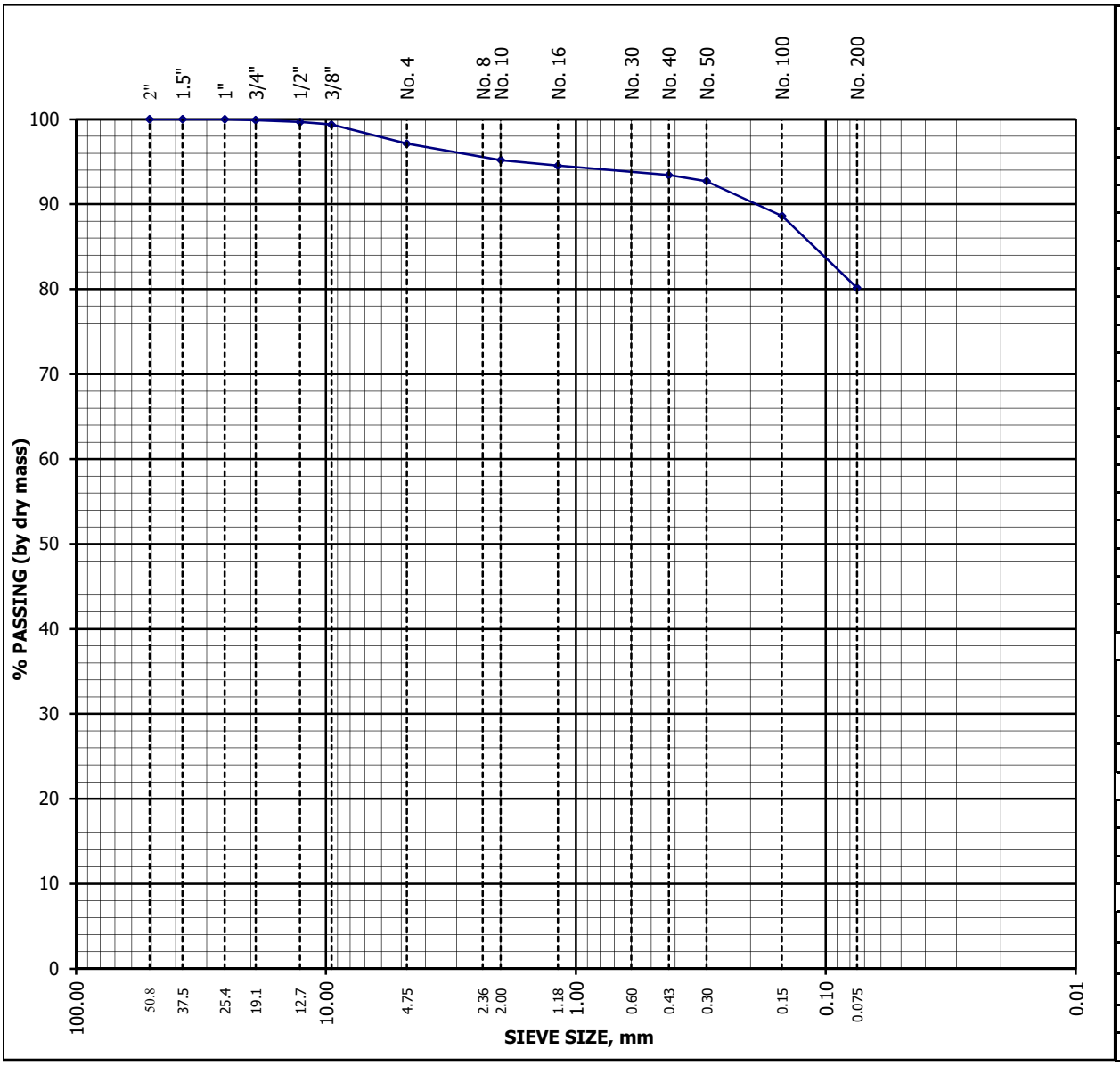
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182050	Reviewer:	Y. Schimmel
Sample Location:	B-8 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **17**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	100
3/4"	100
1/2"	100
3/8"	99
#4	97
#8	
#10	95
#16	95
#30	
#40	93
#50	93
#100	89
#200	80.1

Moisture (M) & Density (D)	
M, %:	6.6
D, pcf:	

LL	39
PL	17
PI	22

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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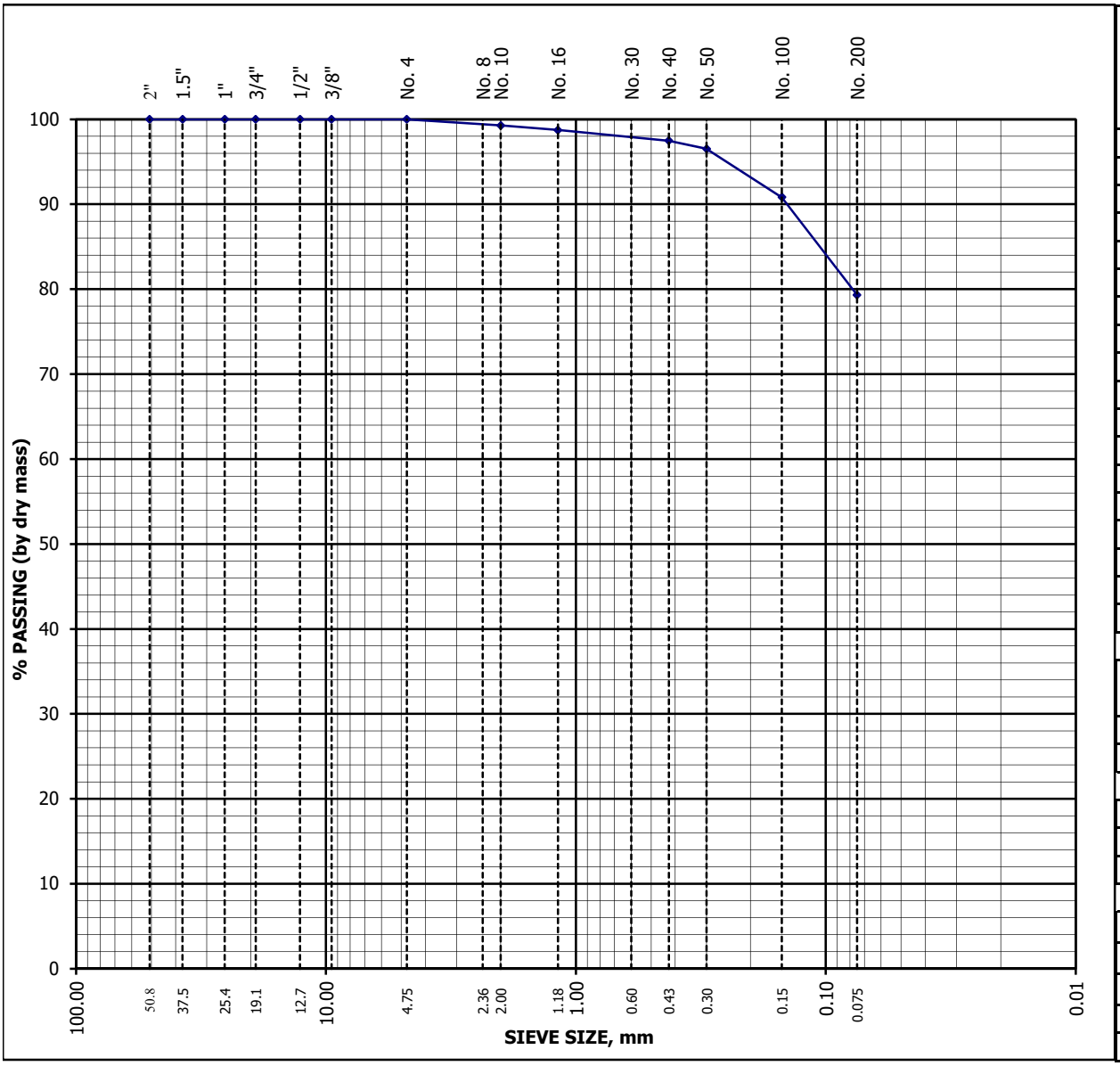
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182051	Reviewer:	Y. Schimmel
Sample Location:	B-9 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **14**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	99
#16	99
#30	
#40	97
#50	97
#100	91
#200	79.3

Moisture (M) & Density (D)	
M, %:	8.1
D, pcf:	

LL	36
PL	16
PI	20

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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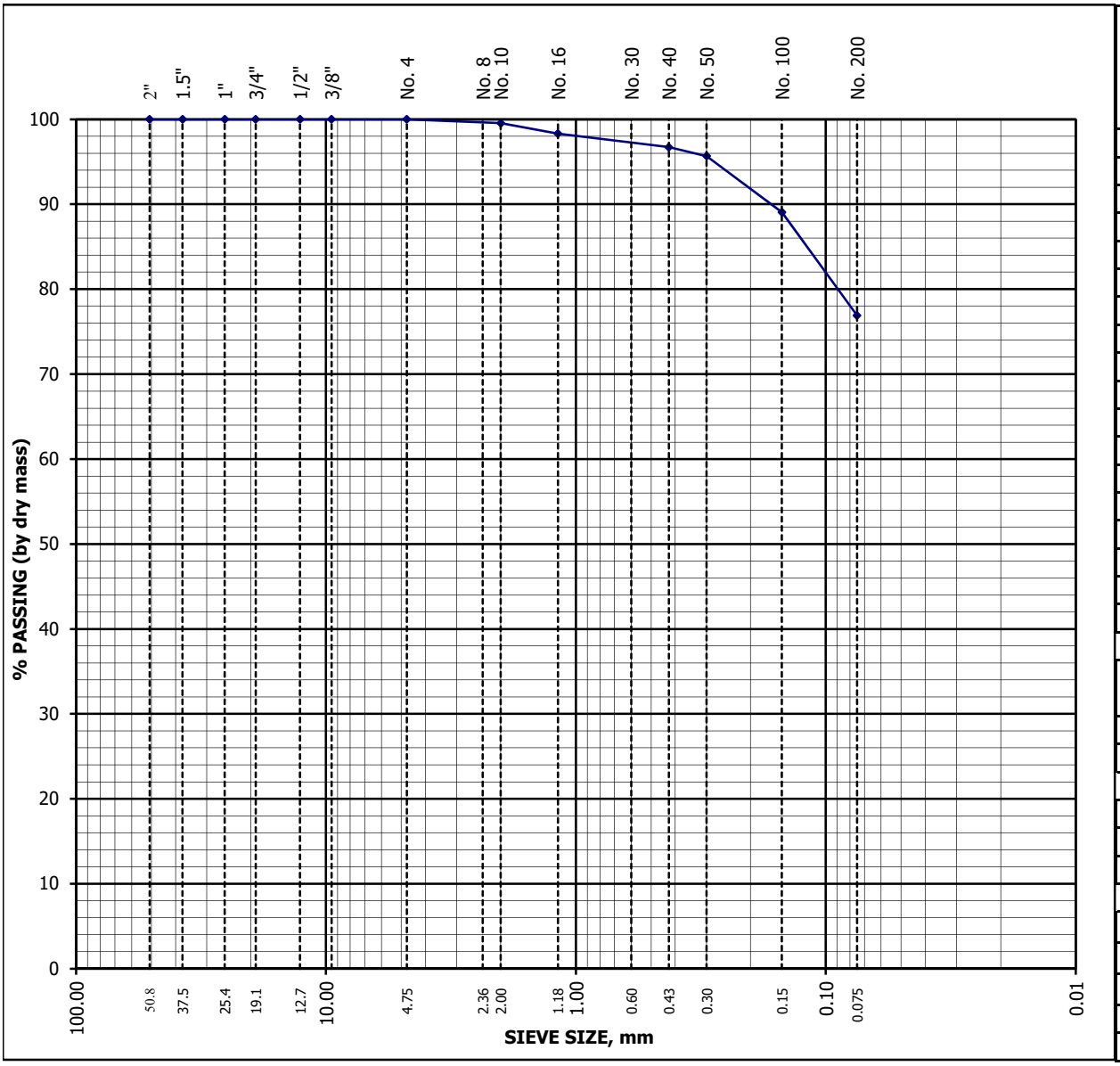
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182052	Reviewer:	Y. Schimmel
Sample Location:	B-10 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **17**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	98
#30	
#40	97
#50	96
#100	89
#200	76.9

Moisture (M) & Density (D)	
M, %:	9.1
D, pcf:	

LL	39
PL	15
PI	24

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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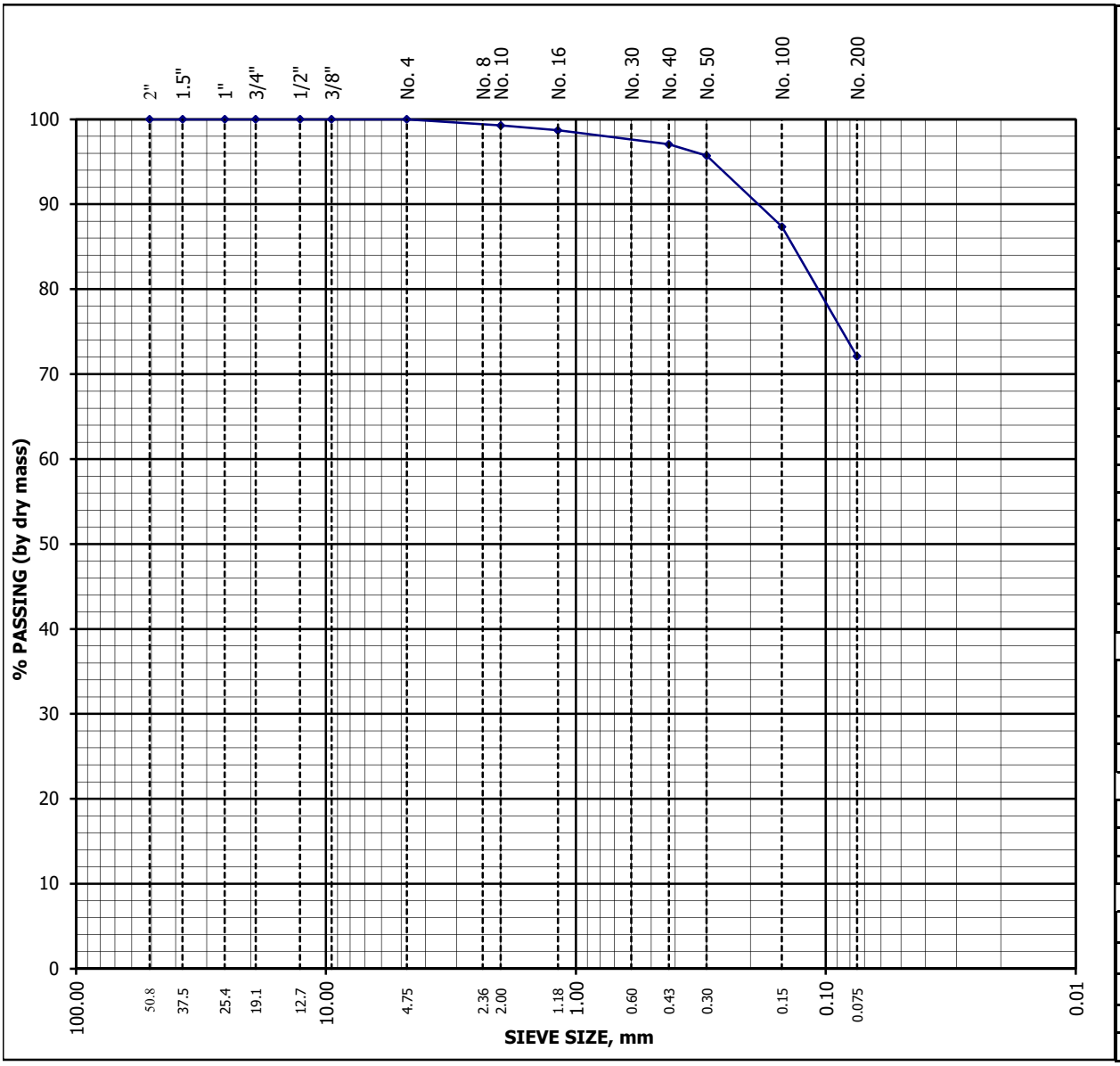
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182053	Reviewer:	Y. Schimmel
Sample Location:	B-11 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **18**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	99
#16	99
#30	
#40	97
#50	96
#100	87
#200	72.1

Moisture (M) & Density (D)	
M, %:	8.5
D, pcf:	

LL	40
PL	11
PI	29

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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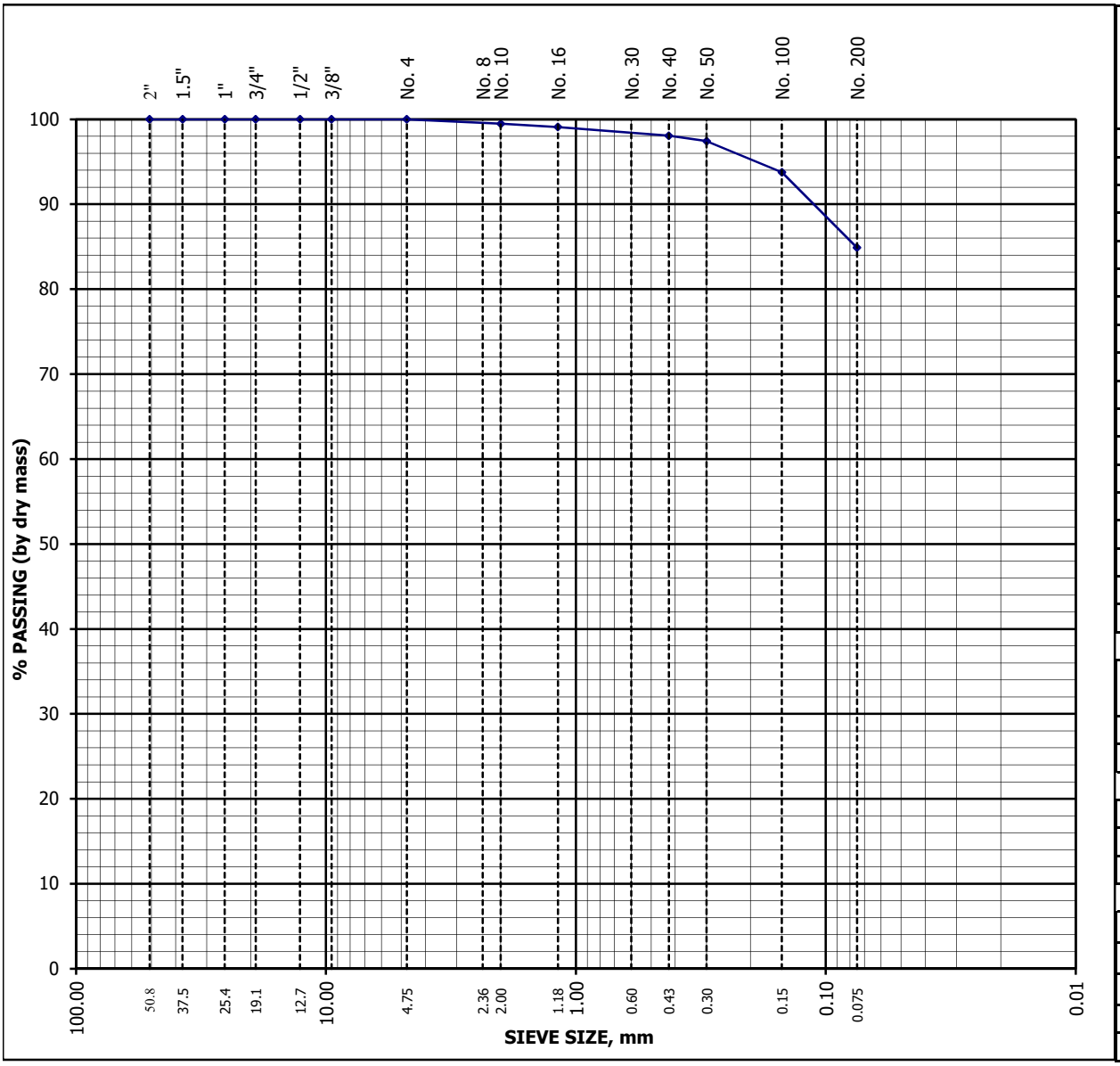
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182054	Reviewer:	Y. Schimmel
Sample Location:	B-12 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **18**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	99
#16	99
#30	
#40	98
#50	97
#100	94
#200	84.9

Moisture (M) & Density (D)	
M, %:	7.9
D, pcf:	

LL	39
PL	17
PI	22

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

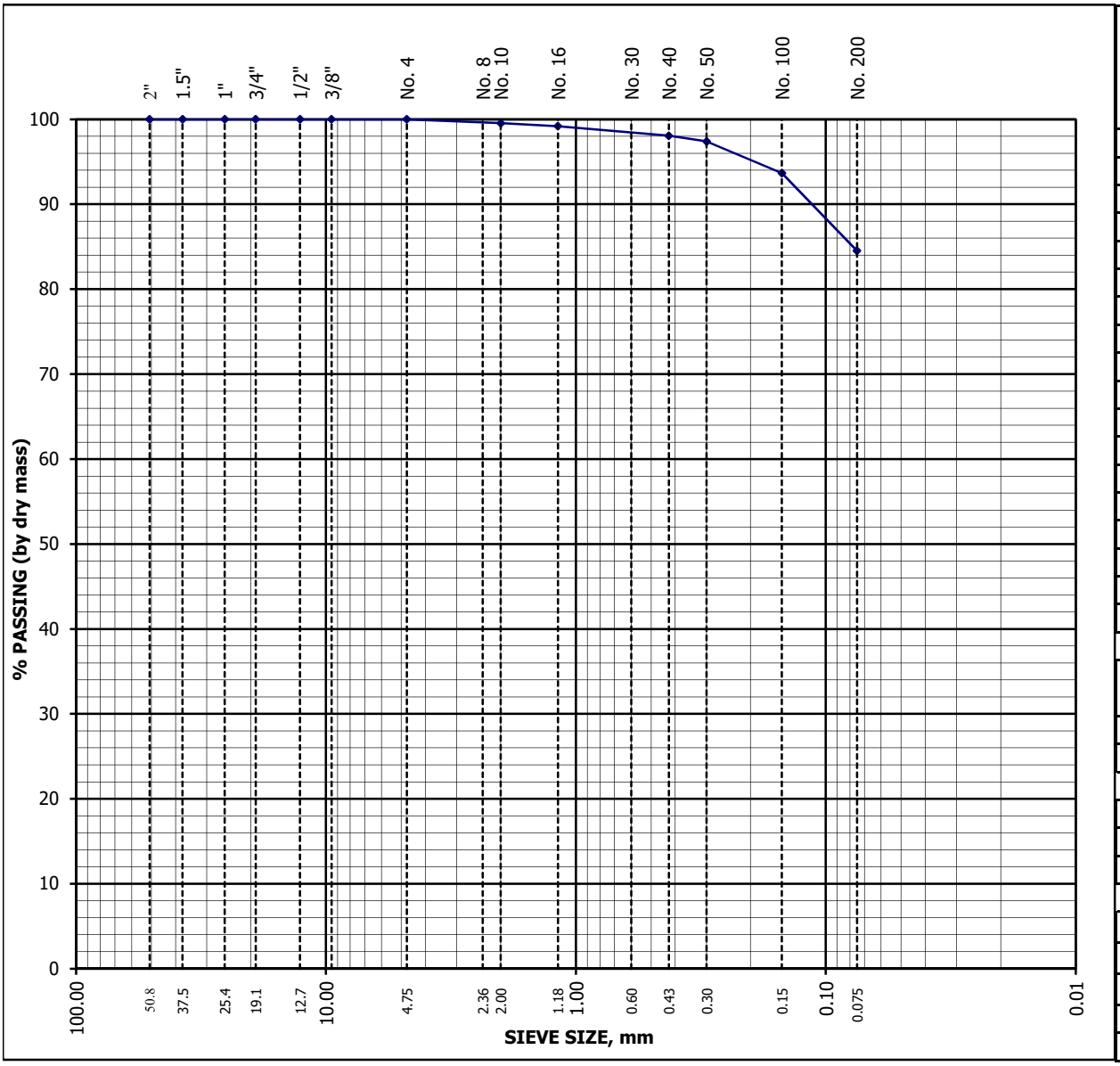
CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182055	Reviewer:	Y. Schimmel
Sample Location:	B-13 at 0' to 5'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **16**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	99
#30	
#40	98
#50	97
#100	94
#200	84.5

Moisture (M) & Density (D)	
M, %:	7.2
D, pcf:	

LL	37
PL	17
PI	20

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

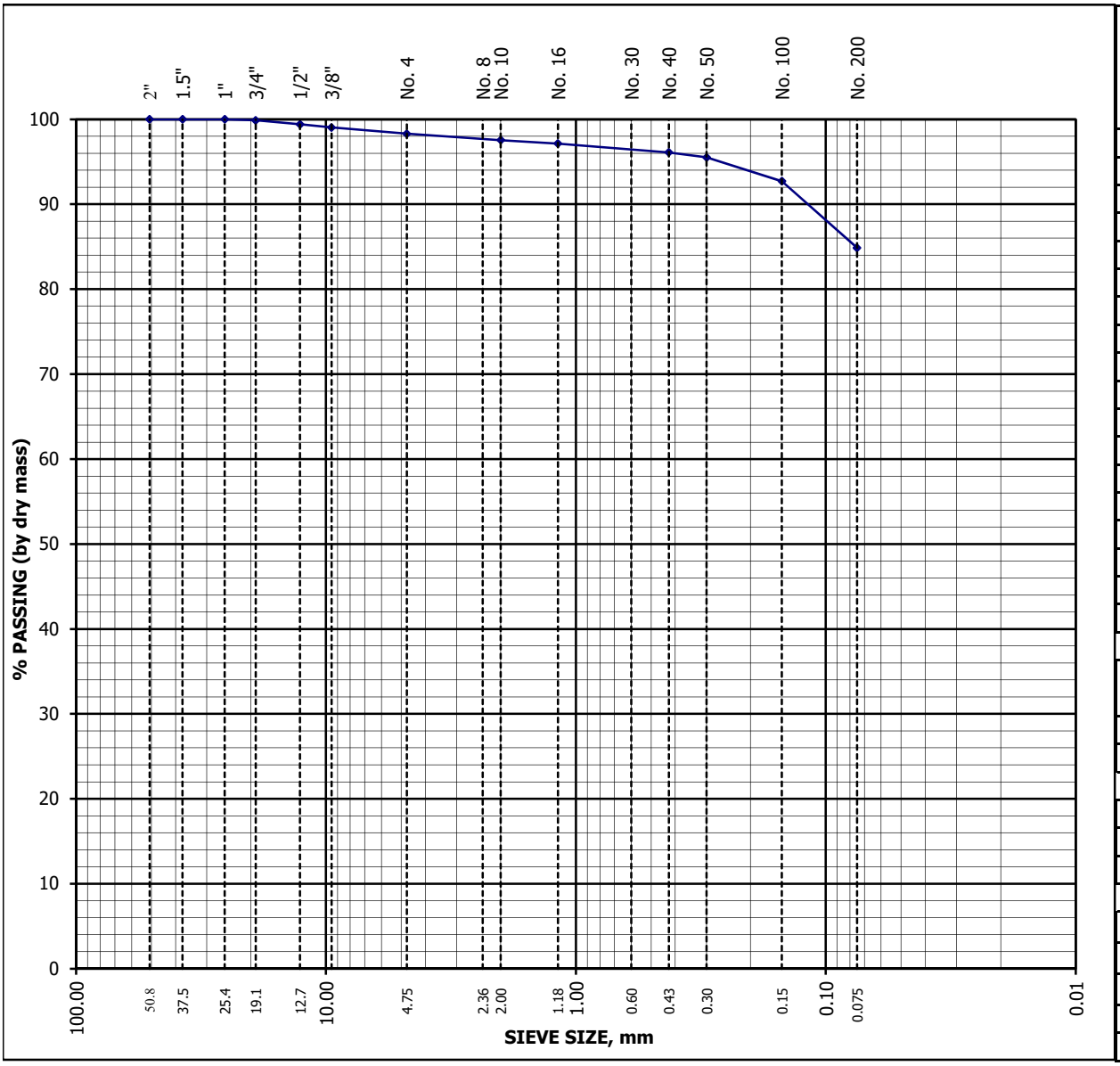
CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182056	Reviewer:	Y. Schimmel
Sample Location:	B-14 at 0' to 5'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **17**

Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
2"	
1.5"	
1"	100
3/4"	100
1/2"	99
3/8"	99
#4	98
#8	
#10	98
#16	97
#30	
#40	96
#50	96
#100	93
#200	84.9

Moisture (M) & Density (D)	
M, %:	6.8
D, pcf:	

LL	37
PL	16
PI	21

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

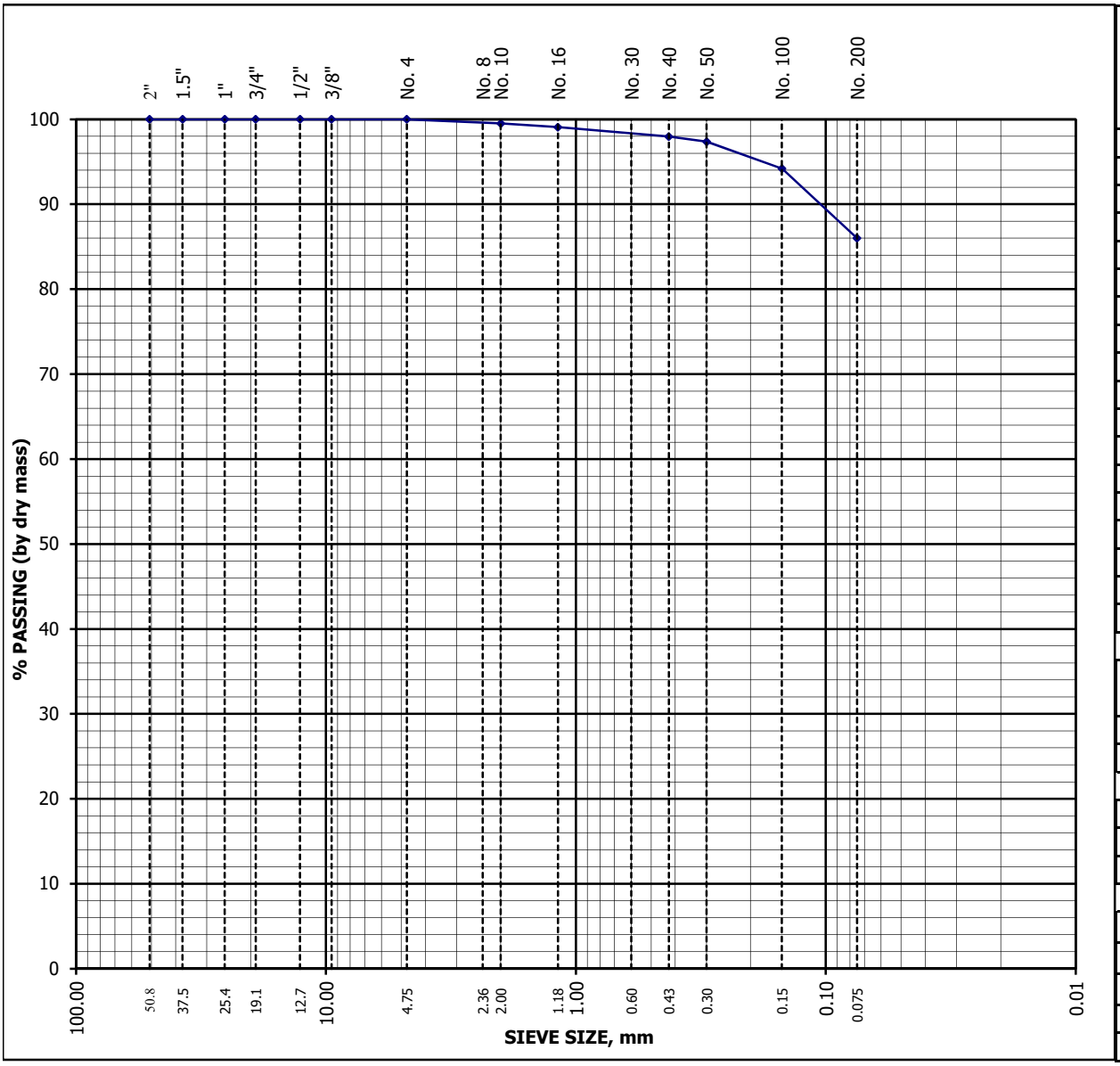
CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	16-Apr-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182057	Reviewer:	Y. Schimmel
Sample Location:	B-15 at 0' to 5'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **20**

Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	99
#30	
#40	98
#50	97
#100	94
#200	86.0

Moisture (M) & Density (D)	
M, %:	8.6
D, pcf:	

LL	40
PL	16
PI	24

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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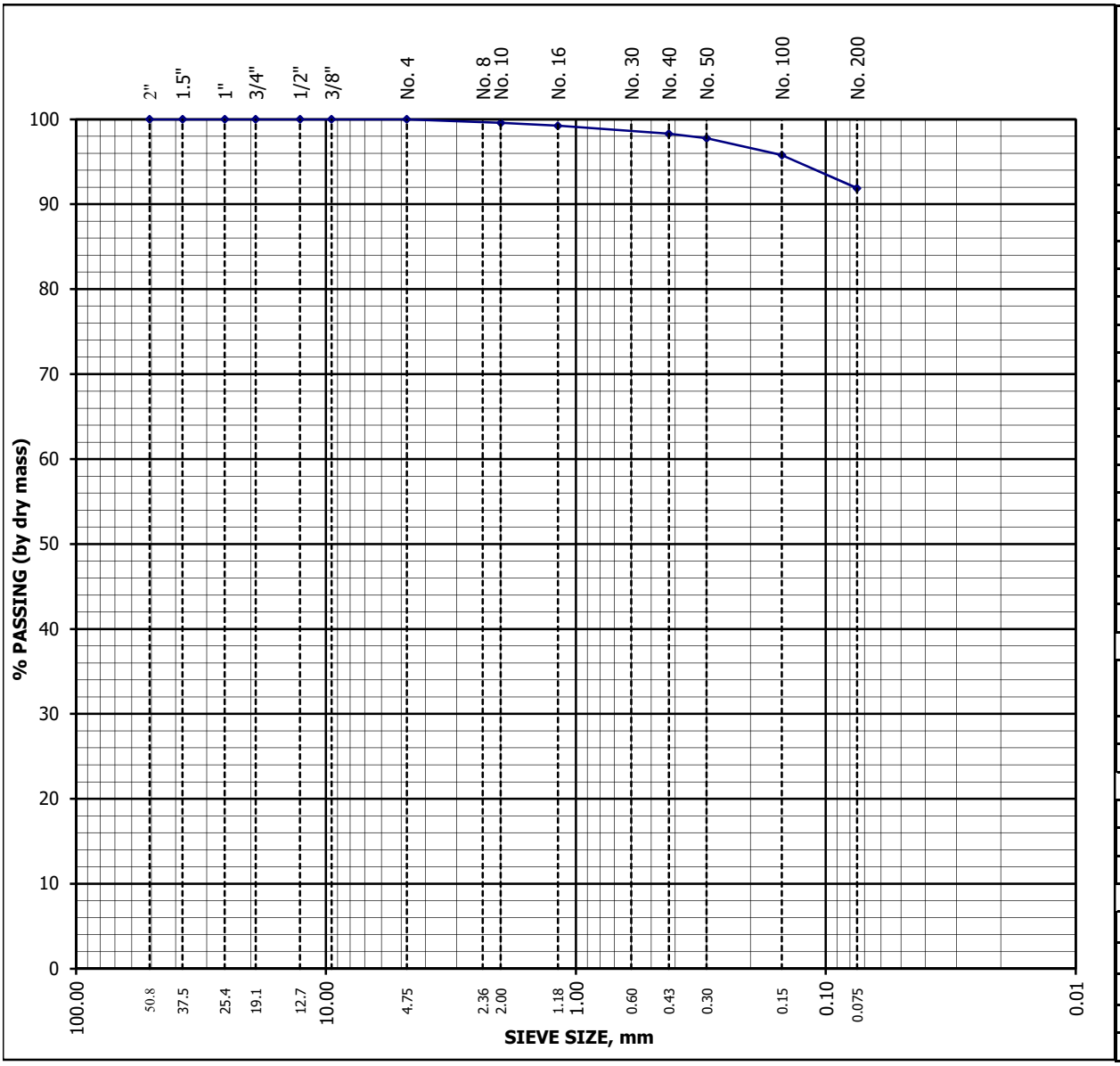
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	18.3040, J&T Consulting	Date:	14-Mar-18
Project Name:	Thunder Valley	Technician:	N. Dillon
Lab ID Number:	F182058	Reviewer:	Y. Schimmel
Sample Location:	B-4 at 15' to 25'		
Visual Description:	CLAY, grayish brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **36**

Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	99
#30	
#40	98
#50	98
#100	96
#200	91.9

Moisture (M) & Density (D)	
M, %:	5.9
D, pcf:	

LL	52
PL	15
PI	37

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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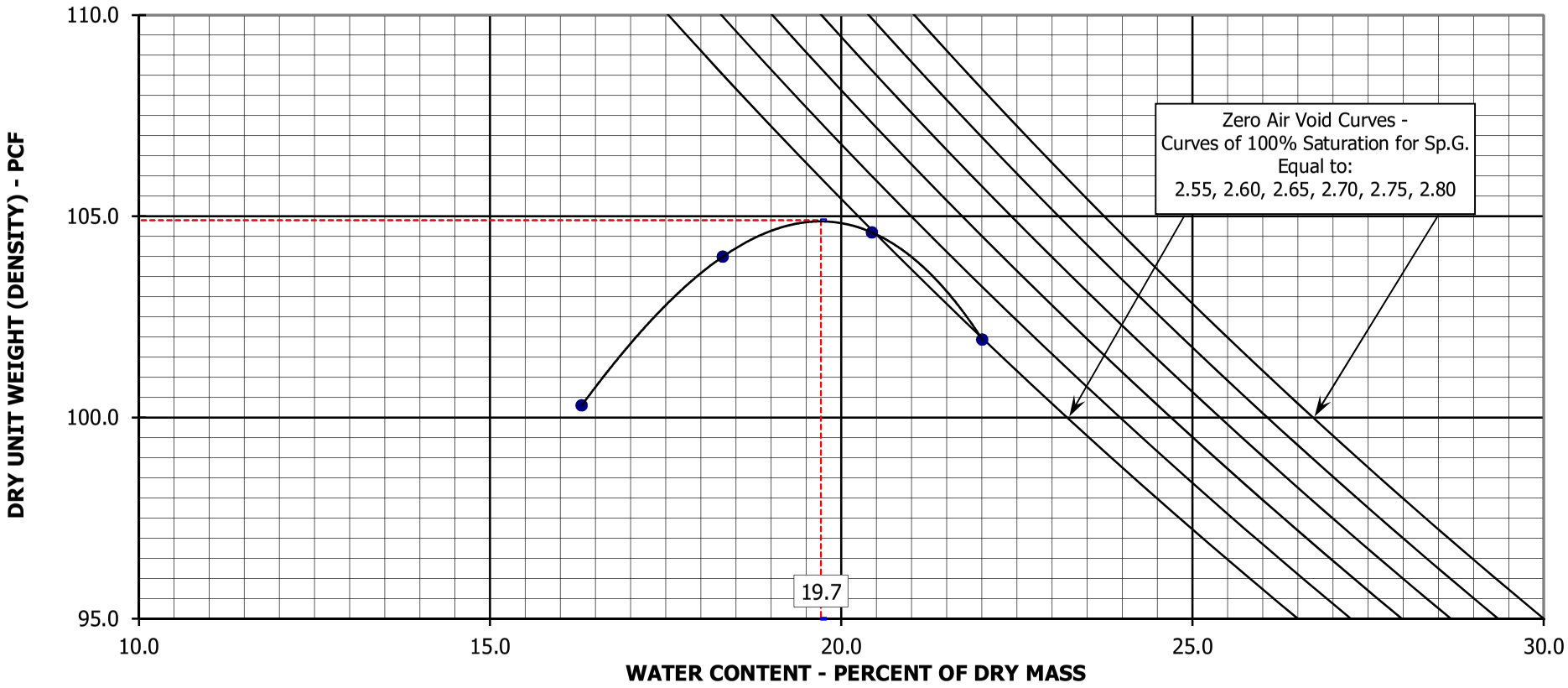
ASTM/AASHTO Compaction
Test Procedure Designation: ASTM D 698 (Standard)
Method: A

Laboratory Maximum Dry Unit Weight (Density): 104.9 pcf
Laboratory Optimum Moisture Content (OMC): 19.7 %



Sample Location	Elev. or Depth, ft	LL	PL	PI	-#200, %	Soil Description & Classification
B-4	15' to 25'	52	15	37	92	Visual: CLAY, grayish brown AASHTO: A-7-6(36) USCS: (CL) Lean clay

Moisture/Density Relationship (Proctor) Test

Project Number:	18.3040, J&T Consulting		
Project Name:	Thunder Valley		
Drawn By:	A. Wright	Tested by:	N. Dillon
Checked By:	Y. Schimmel	Date:	14-Apr-18
Date:	16-Apr-18	Lab ID Number:	F182058

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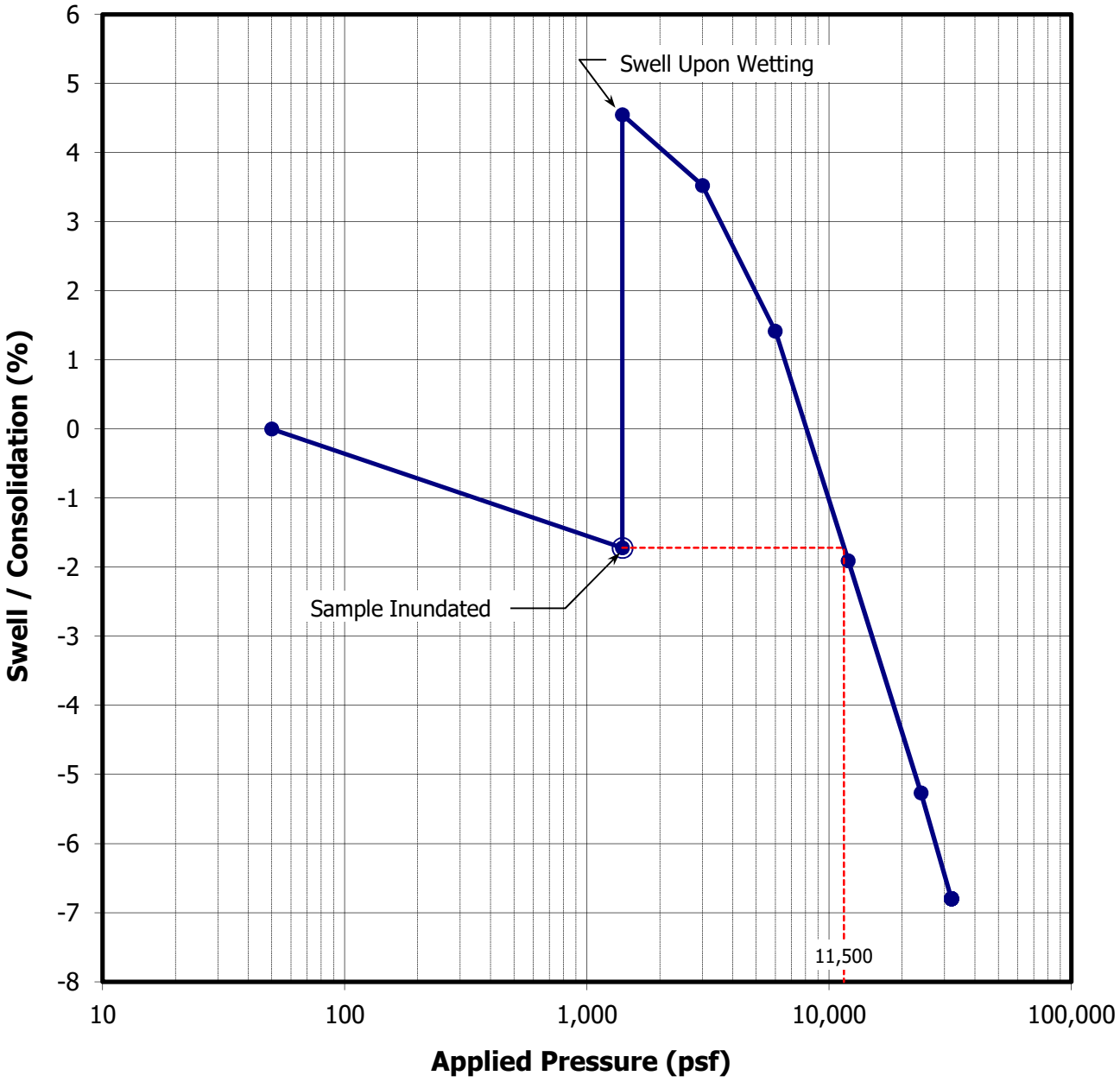
SWELL/CONSOLIDATION PLOT

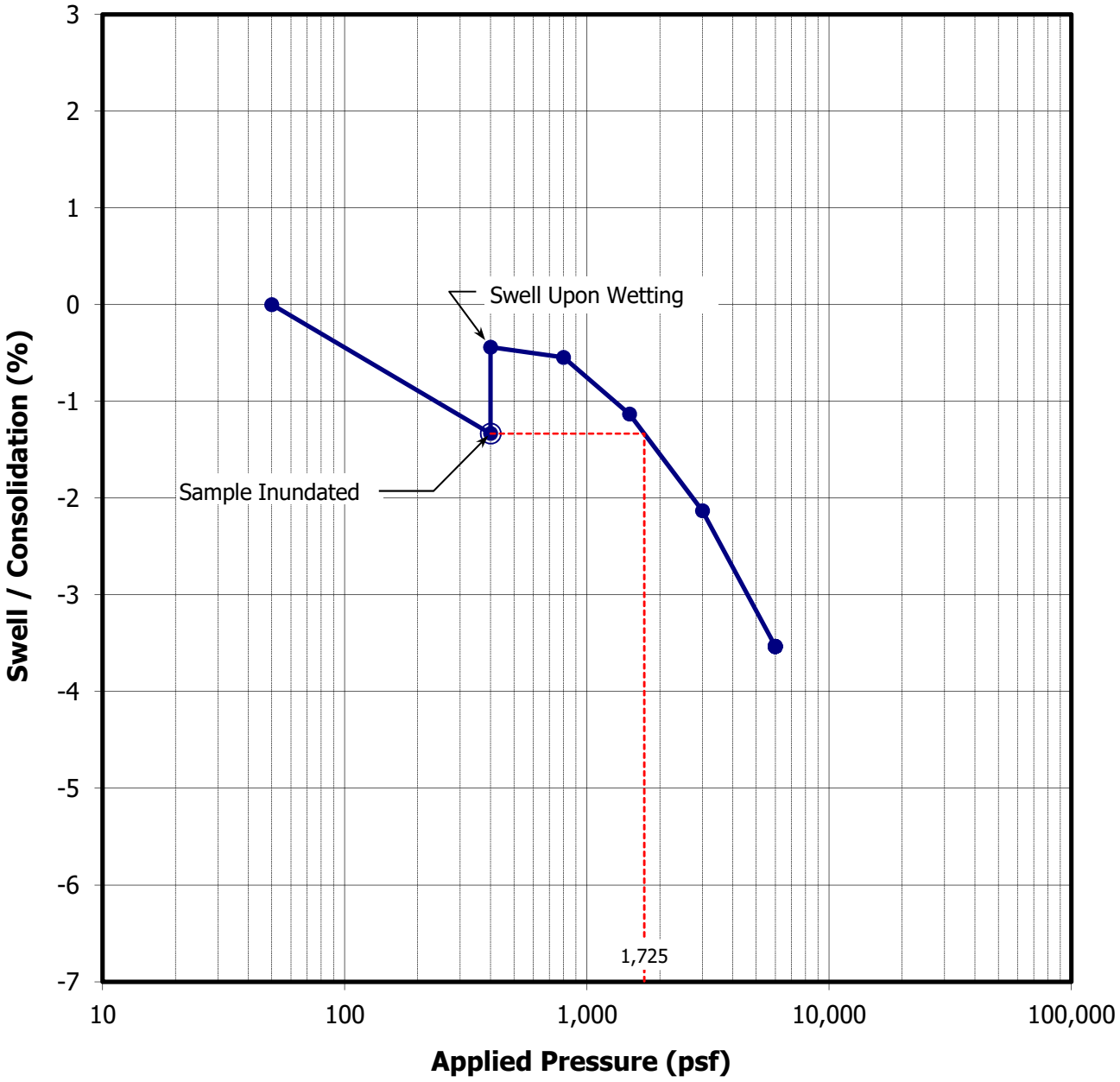


Sample Location	Sample Depth (feet)	Lab ID Number: 182936 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-1	14	CLAYSTONE, sandy, mottled, gray brown	100.9	23.4	1,400	6.3	11,500

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182936**

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (feet)	Lab ID Number: 182940 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-5	4	CLAY, sandy, brown	108.4	13.7	400	0.9	1,725

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182940**

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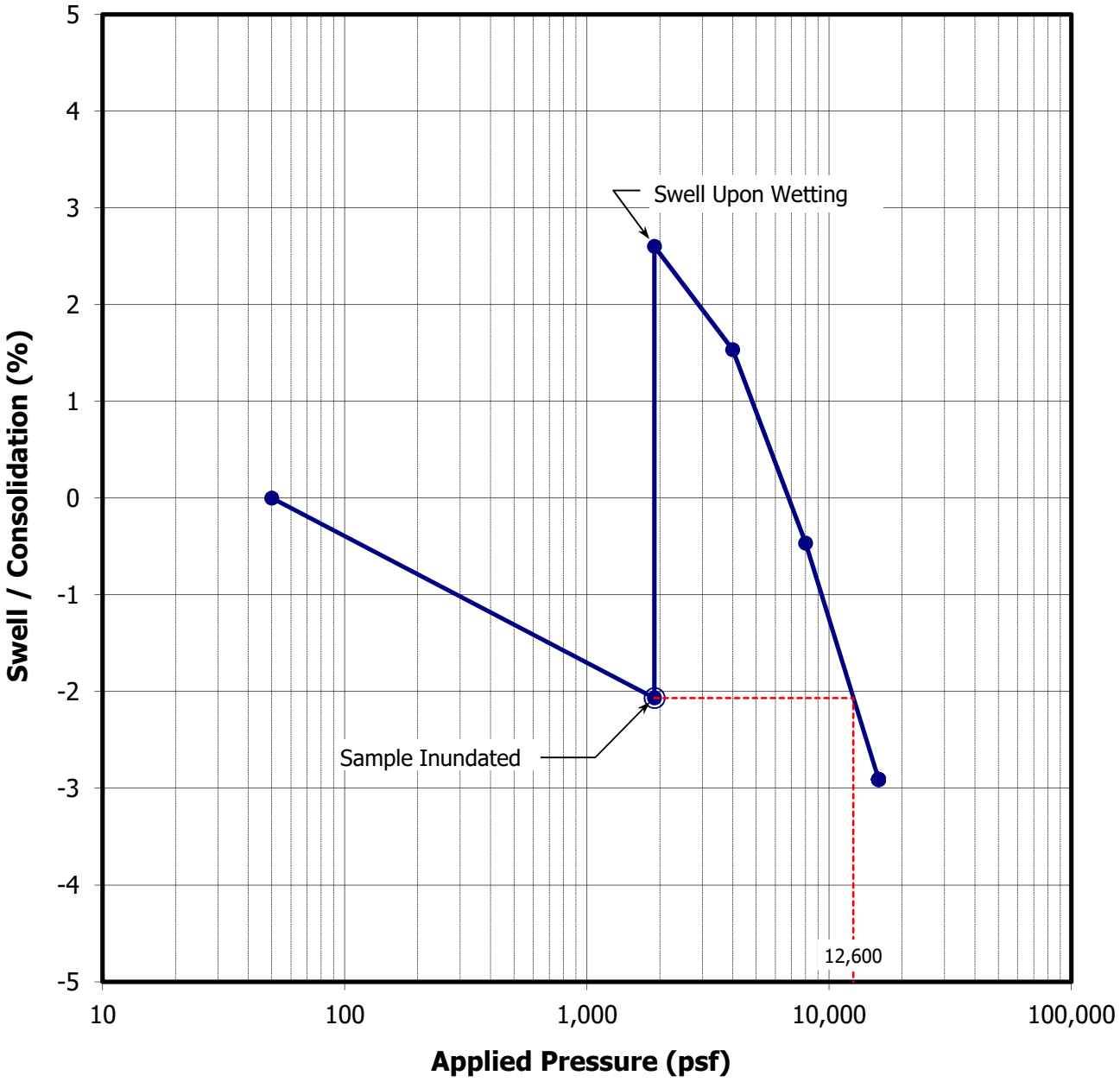
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (feet)	Lab ID Number: 182943-1 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-6	19	CLAYSTONE, gray	114.8	14.5	1,900	4.7	12,600

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182943-1**

CESARE, INC.
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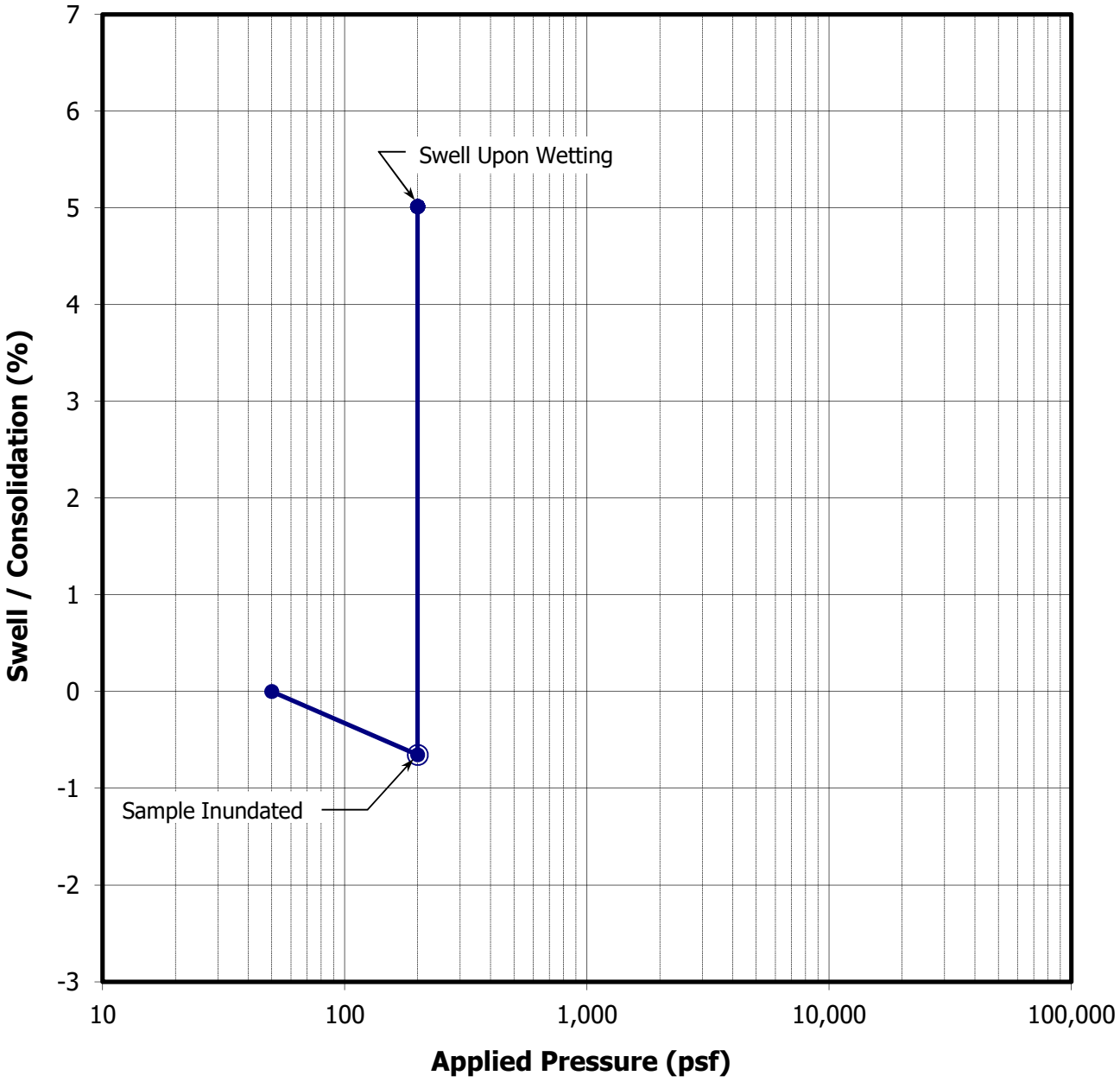
SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (feet)	Lab ID Number: 182944 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-8	4	CLAYSTONE, mottled, gray	124.2	11.8	200	5.7	N/A

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182944**

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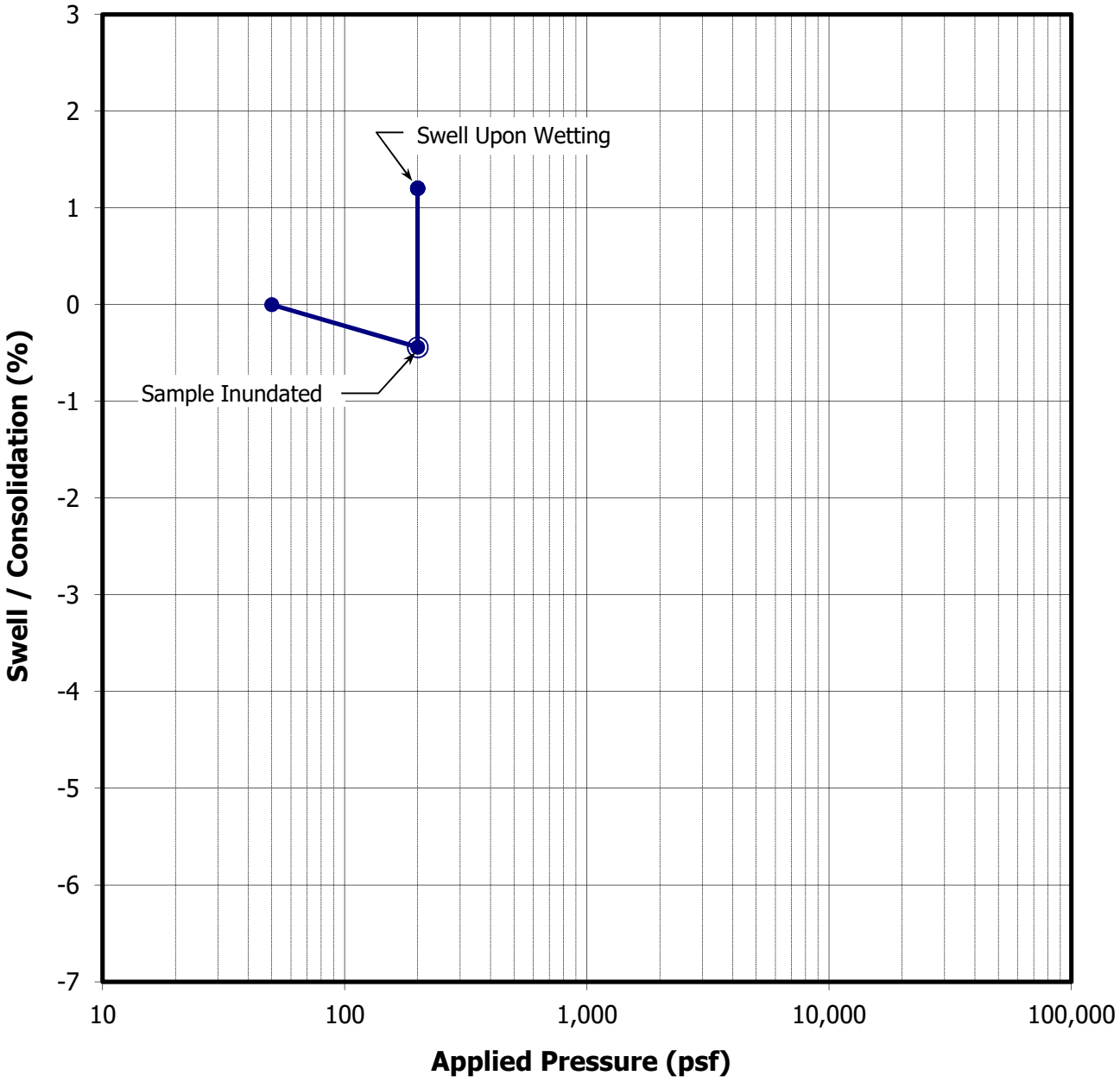
SWELL/CONSOLIDATION PLOT

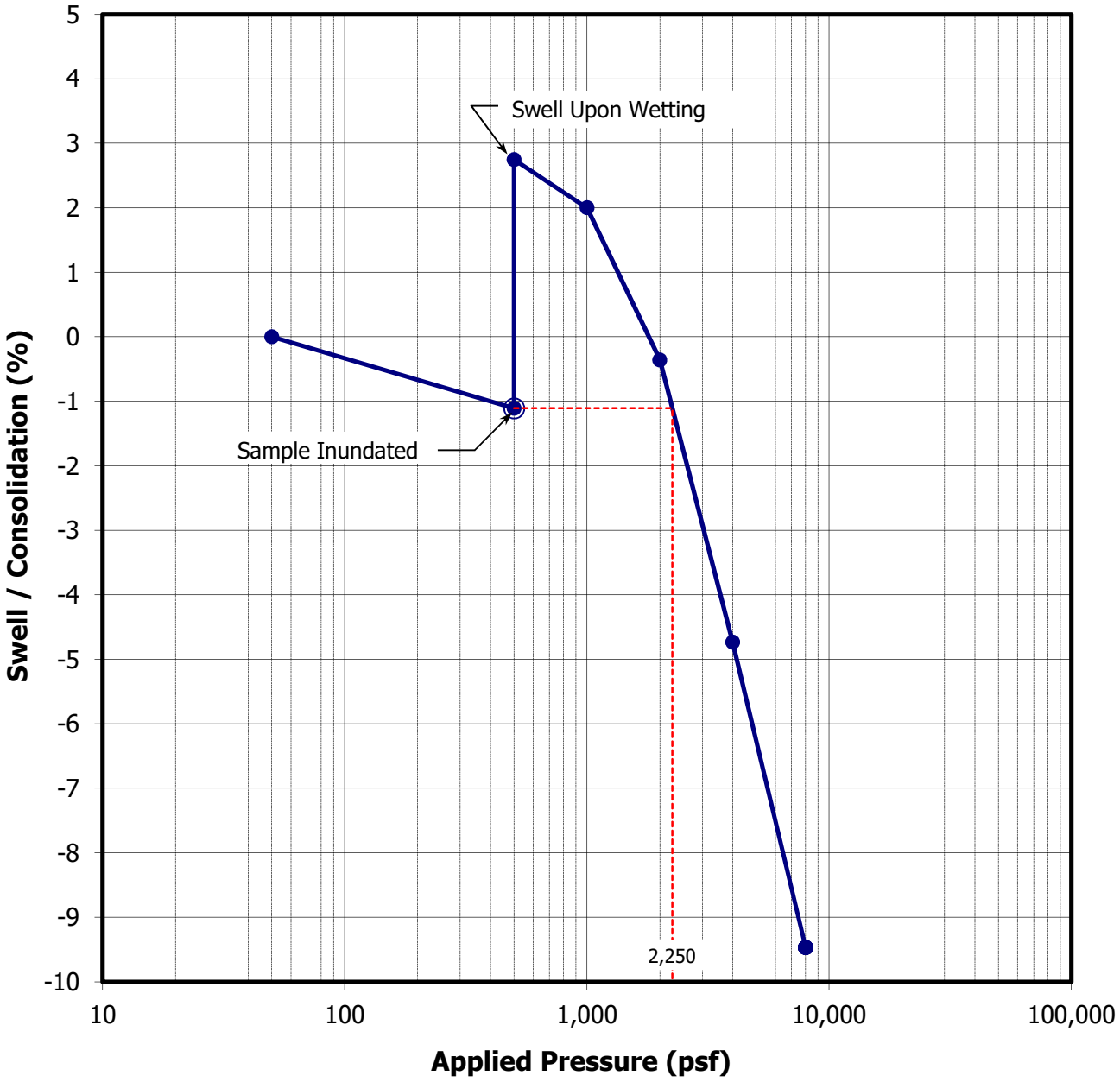


Sample Location	Sample Depth (feet)	Lab ID Number: 182946 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-14	1	CLAY, sandy, brown	86.1	7.8	200	1.6	N/A

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182946**

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

SWELL/CONSOLIDATION PLOT

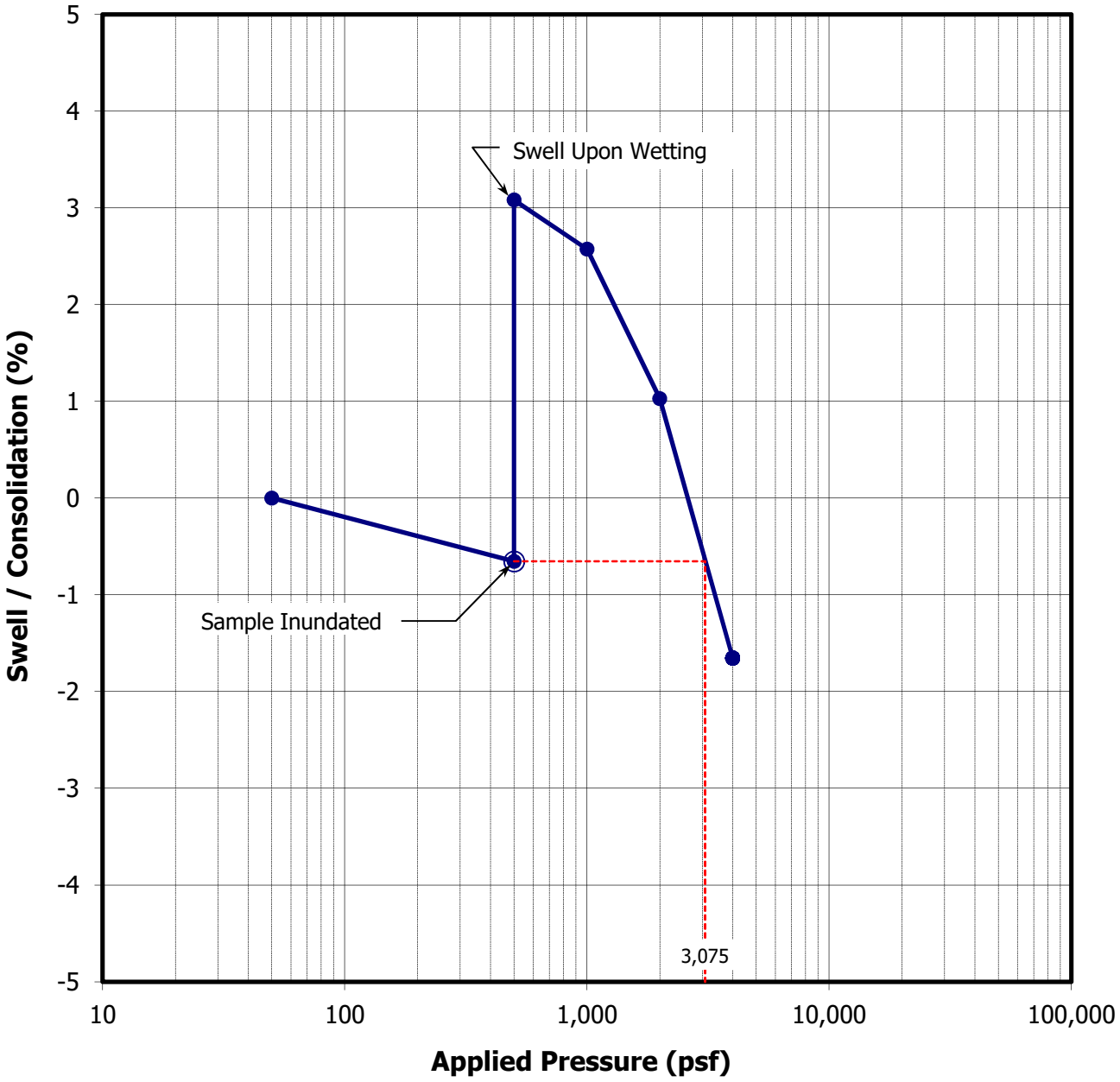


Sample Location	Sample Depth (feet)	Lab ID Number: 182947 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-4 at OMC	15 to 25	CLAY, sandy, brown, remolded 99.4% of D698 and -1.1% of OMC	104.3	18.6	500	3.9	2,250

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182947**

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

SWELL/CONSOLIDATION PLOT

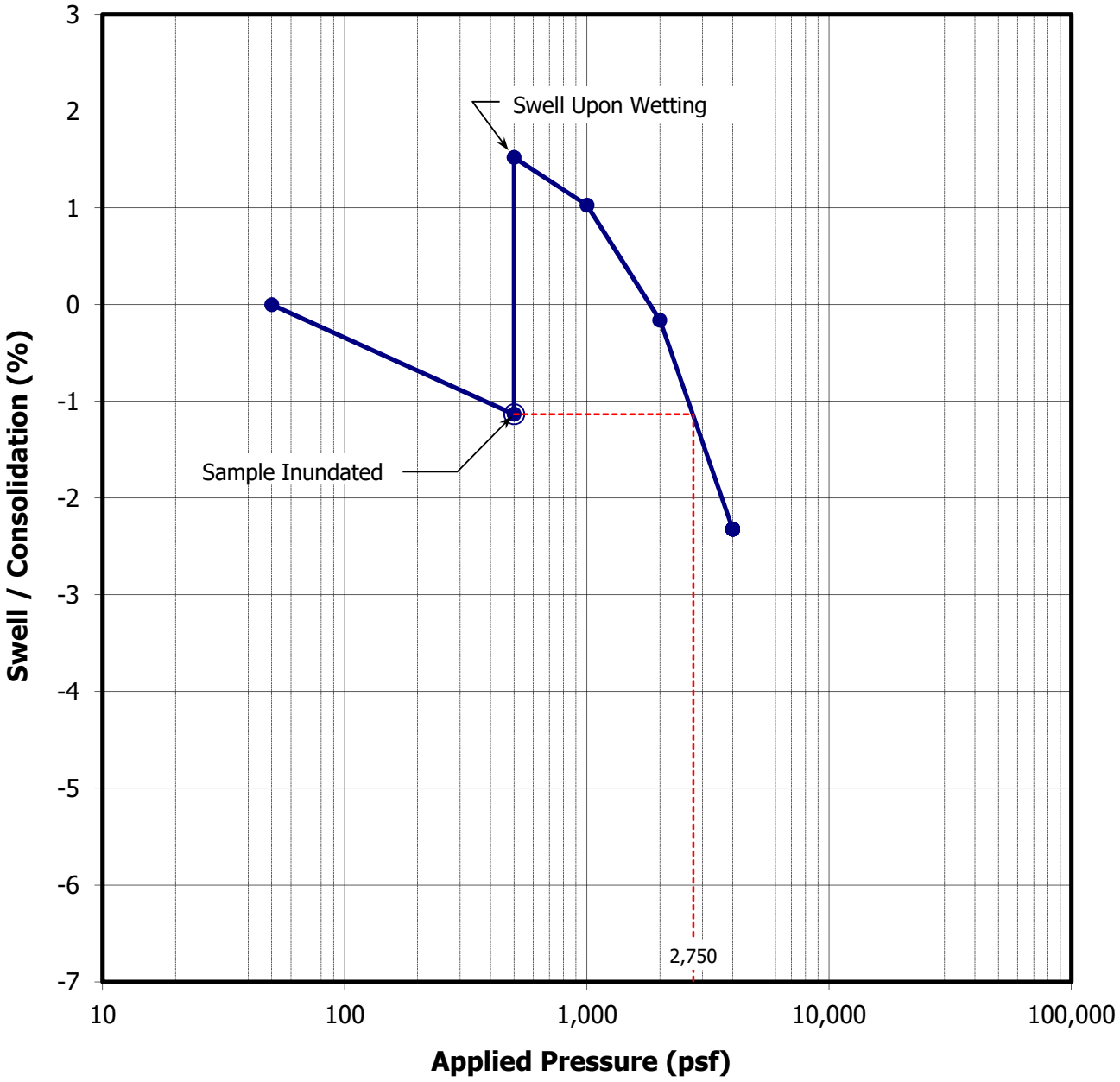


Sample Location	Sample Depth (feet)	Lab ID Number: 182948 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-4	15 to 25	CLAY, sandy, brown, remolded 99.0% of D698 and +1.3% of OMC	103.9	21.0	500	3.7	3,075

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182948**

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

SWELL/CONSOLIDATION PLOT



Sample Location	Sample Depth (feet)	Lab ID Number: 182949 Visual Description of Sample	Dry Density (pcf)	Moisture Content (%)	Inundation Pressure (psf)	Volume Change (%)	Swell Pressure (psf)
B-4	15 to 25	CLAY, sandy, brown, remolded 100.0% of D698 and +2.2% of OMC	104.9	21.9	500	2.7	2,750

Client:	**J&T Consulting**	**Project No.:**	**18.3040**
Project:	**Thunder Valley**	**Figure:**	**182949**

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

APPENDIX B

Pavement Thickness Calculations

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Full Depth

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	2.59 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	6	10	2.64
Total	-	-	-	6.00	-	2.64

Layered Thickness Design

Thickness precision Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(in)	Min Thickness (Di)(in)	Elastic Modulus (psi)	Width (ft)	Calculated Thickness (in)	Calculated SN (in)
Total	-	-	-	-	-	-	-	-	-

*Note: This value is not represented by the inputs or an error occurred in calculation.

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Composite

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	2.59 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	4	10	1.76
2	Composite	0.12	1	8	10	0.96
Total	-	-	-	12.00	-	2.72

Layered Thickness Design

Thickness precision Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(in)	Min Thickness (Di)(in)	Elastic Modulus (psi)	Width (ft)	Calculated Thickness (in)	Calculated SN (in)
Total	-	-	-	-	-	-	-	-	-

*Note: This value is not represented by the inputs or an error occurred in calculation.

Ecological Resource Consultants, Inc.
5672 Juhls Drive ~ Boulder, CO ~ 80301 ~ (303) 679-4820

Screening Report
for
Federal and State Listed Threatened and Endangered Species and General Wildlife

Thunder Valley PUD

Weld County, Colorado

January 26, 2018

Prepared for:

J&T Consulting, Inc.
305 Denver Avenue, Suite D
Fort Lupton, Colorado 80621
Contact: Todd Yee
Phone: (303) 857-6222
Email: toddyee@j-tconsulting.com

ERC Project #420-1707

Screening Report
for
Federal and State Listed Threatened and Endangered Species and General Wildlife

Thunder Valley PUD
Weld County, Colorado

January 26, 2018

Contents

Figures

1.0 INTRODUCTION

Ecological Resource Consultants, Inc. (ERC) has prepared this report at the request of the property representative, J&T Consulting, Inc. The approximately 39.5 acre property referred to herein as the Thunder Valley PUD (survey area) is located in unincorporated Weld County, Colorado. The survey area is under consideration for potential future land use changes which will likely alter a majority of the current survey area landscape, therefore this report has been prepared to specifically identify potential federal and state listed threatened and endangered species and/or habitat that could exist on or immediately surrounding the survey area. In addition, this report provides a cursory screening of general wildlife use characteristics and existing vegetation community types.

This report has been prepared in accordance with the Migratory Bird Treaty Act (MBTA), Endangered Species Act (ESA) and Colorado Parks and Wildlife (CPW) Colorado Statute Title 33.

2.0 GENERAL SURVEY AREA DESCRIPTION

The survey area is located on the west side of County Road 21 approximately 1 mile south of the intersection with Highway 52 in unincorporated Weld County, Colorado in the *Lower Big Dry Creek* watershed (HUC 101900030408). More specifically, the survey area is located in **Section 10, Township 1 North, Range 67 West**, in Weld County **(latitude 40.062475° north, longitude -105.868803° west).** From the intersection of Interstate 25 and Highway 52, the survey area can be accessed by heading east on Highway 52 for approximately 6.2 miles, then south on County Road 21 for approximately 1 mile to the intersection with County Road 10.5. The survey area is then located southwest of the intersection of County Road 21 and County Road 10.5. The survey area is accessible along the west side of County Road 21. Refer to **Figure 1** and **Figure 2** for a location map and a US Geological Survey (USGS) topographic map of the survey area.

The survey area comprises approximately 39.5 acres and has an average elevation of 5,025 feet above mean sea level. The survey area is predominantly comprised of upland herbaceous vegetated lands currently used for the agricultural production of hay. The central portion of the survey area comprises a linear topographic depression that appears to have been historically altered to facilitate water storage which is identified as palustrine emergent (PEM) wetland habitat, and a man-made, concrete lined irrigation ditch known as Bull Ditch 2, Lateral 3 exists along the entire western perimeter of the survey area. Topography across the survey area is generally flat, with topographic highpoints in the northern and southern portions, sloping downward toward the center of the survey area.

Two primary land use class/vegetation cover types exist within the survey area. Upland habitats are primarily characterized as Cultivated Cropland and wetland habitats are characterized as Ruderal Wetland (SWReGAP 2011). In general, the vegetation communities characterized within the survey area are somewhat based on natural vegetation associations in the region (NatureServe 2018) however have been disturbed by historic and current land use practices thus represent somewhat degraded forms of these communities. A summary of habitat types within the survey area is provided as follows.

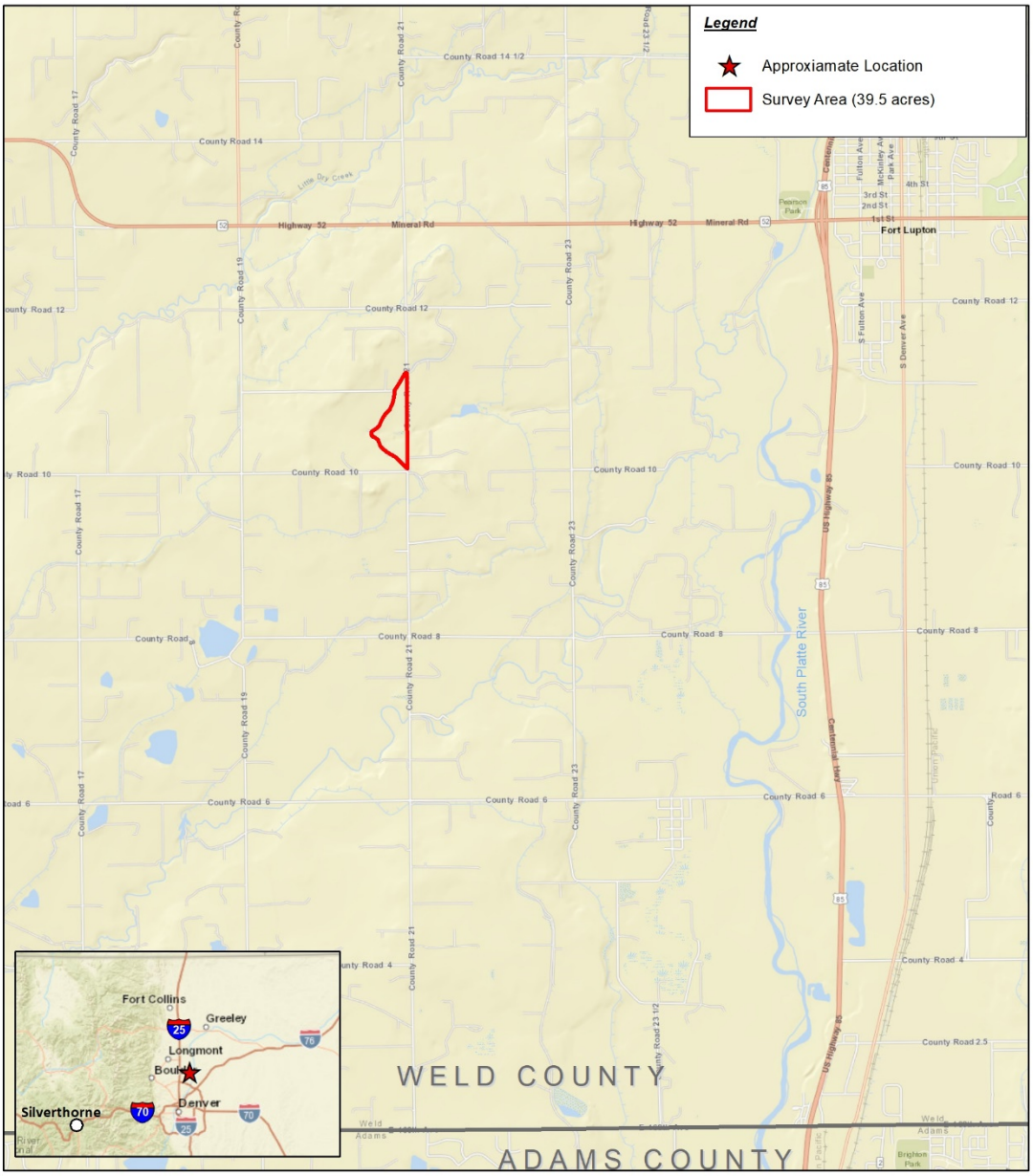
Cultivated Cropland

The cultivated cropland community is characterized as non-natural system which includes lands used for the production of annual crops where crop vegetation accounts for greater than 20 percent of the total vegetation and where the land is actively tilled (SWReGAP 2011). This class also includes all land being actively tilled. The vegetation community across the survey area is dominated by species such as smooth brome (*Bromus inermis*), western wheatgrass (*Pascopyrum smithii*), and cheatgrass (*Bromus tectorum*),

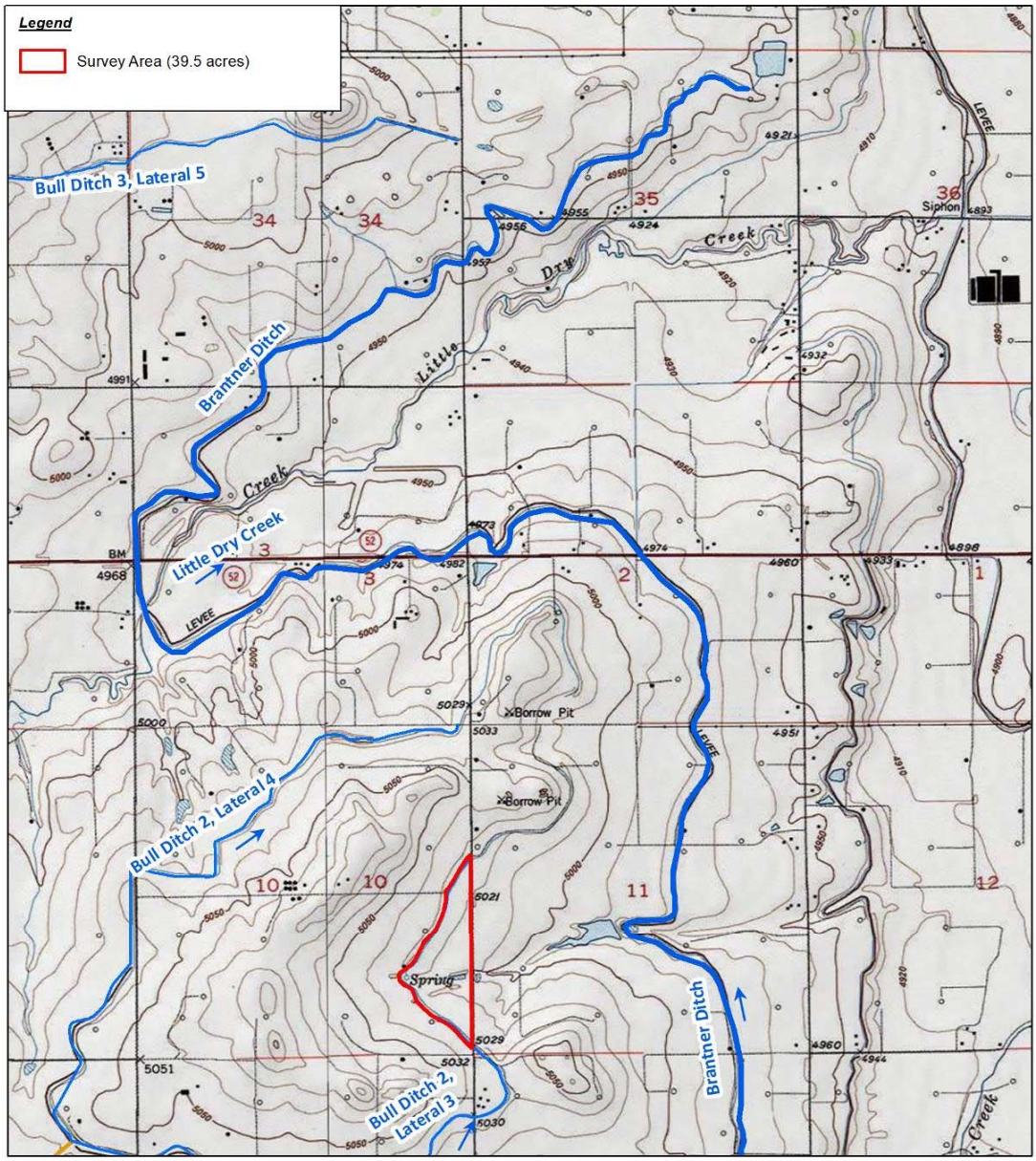
intermixed with a variety of ruderal herbaceous species. Vegetative cover across the survey area generally ranges from 85-100% cover, with the remaining cover comprising exposed surface soil. Generally, species within the hay fields in the northern and southern portions of the survey area have been recently mowed, and this community along the perimeter of the wetland habitat and irrigation ditch are considered fallow uplands with dense, unmowed herbaceous vegetation and few tree/shrub species. One area within the hay fields, located to the south of the wetland habitat, is approximately 200 feet wide spanning the entire survey area from west to east that has been recently plowed/tilled and is currently completely devoid of vegetation. Few mid succession trees are located in upland fallow areas immediately adjacent to the southeastern boundary of the wetland habitat and sporadically along the perimeter of the wetland habitat. These are the only tree/shrub species located within the survey area.

Ruderal Wetland

The ruderal wetland community is also characterized as non-natural system which occurs resulting from succession following significant anthropogenic disturbance of an area. It is generally characterized by unnatural combinations of species (primarily native species, though they often contain slight or substantial numbers and amounts of species alien to the region as well) (SWReGAP 2011). Within the survey area, the wetland habitat occurs as linear topographic depression that appears to have been historically altered to facilitate water storage. Overall, the vegetation community within the wetland is dominated by species such as broadleaf cattail (*Typha latifolia*), reed canary grass (*Phalaris arundinacea*), and dockleaf smartweed (*Persicaria lapathifolia*) intermixed with some non-dominant herbaceous species such as curly dock (*Rumex crispus*) and Hooker's evening primrose (*Oenothera elata*). This area contains a temporarily flooded water regime and no surface water and/or flows were observed within the wetland at the time of the field evaluation. The wetland continues offsite into an agricultural pond, which appears to outlet to an irrigation ditch, identified as Brantner Ditch, approximately 0.5 miles east of the survey area.



Prepared By: ERC *5672 Juhls Drive* *Boulder, CO 80301* *(303) 679-4820* *ERC #420-1707*	**FIGURE 1.** **LOCATION MAP** **THUNDER VALLEY PUD** **WELD COUNTY, COLORADO**	0 0.5 1 Miles



Prepared By:

ERC

5672 Juhls Drive
Boulder, CO 80301
(303) 679-4820

ERC #420-1707

FIGURE 2.
USGS TOPOGRAPHIC MAP

THUNDER VALLEY PUD
WELD COUNTY, COLORADO

0 2,200 4,400 Feet

Refer to **Photos 1-6** below for typical characteristics within the survey area. The overall existing survey area conditions are depicted on the aerial photograph provided as **Figure 3**.

Photo 1. Example of the Cultivated Cropland vegetation community which is currently used as hay field in the southern portion of the survey area.

Photo 2. View southeast of the southern portion of the survey area where it has been recently plowed/tilled and is completely devoid of vegetation.

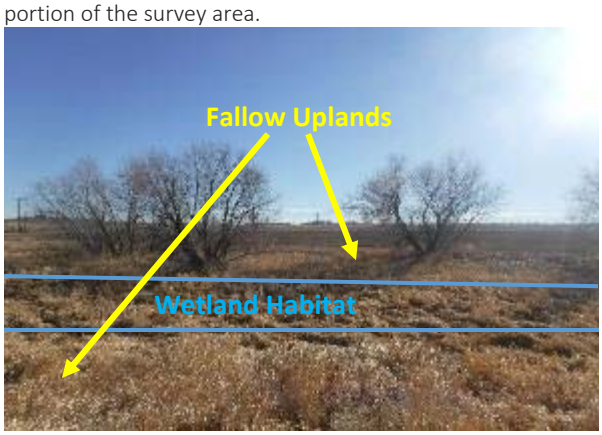
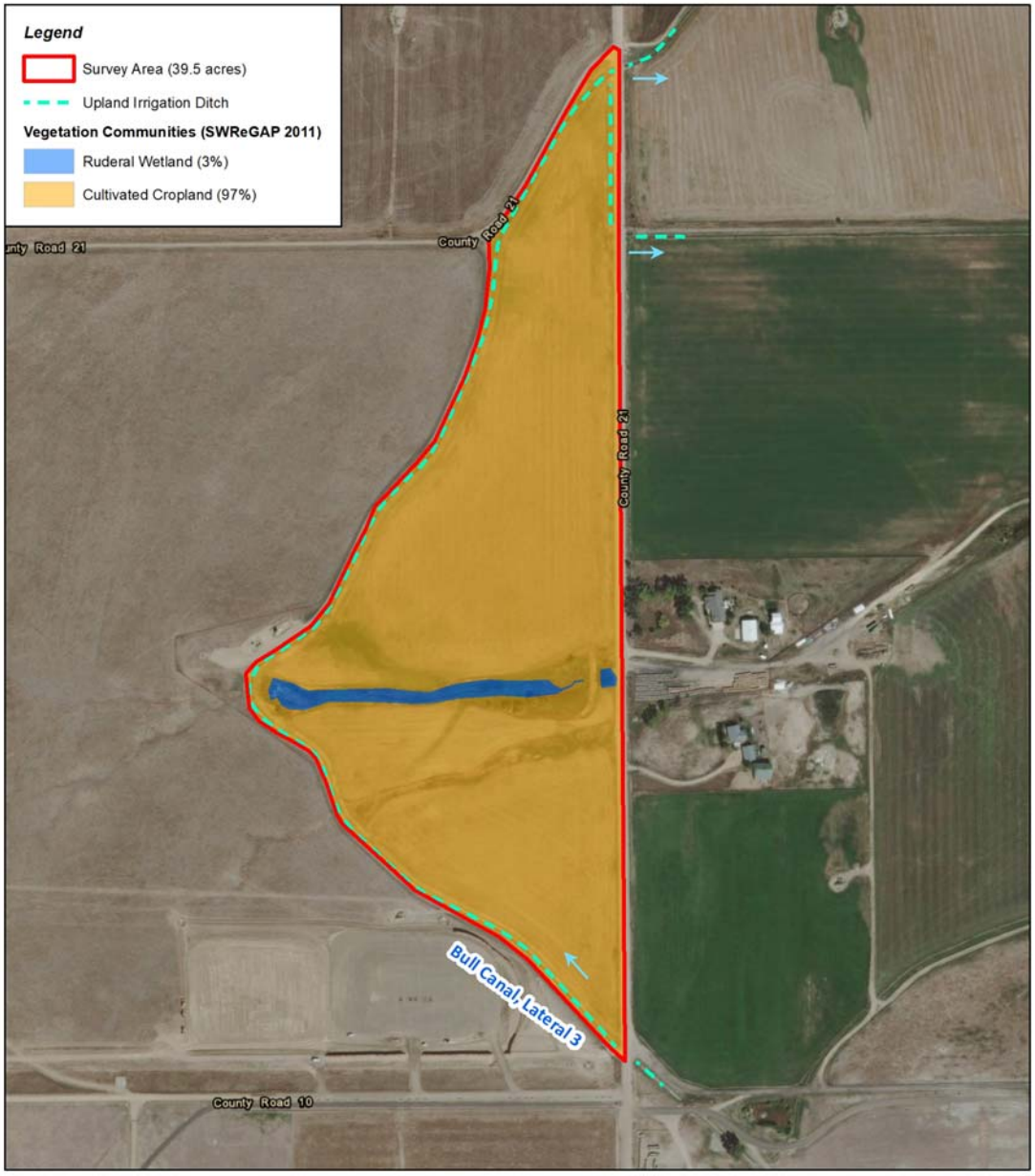


Photo 3. View south of the eastern portion of the Ruderal Wetland community (blue lines above) and adjacent fallow uplands. Few mid succession trees can be seen in the background.

Photo 4. View east from the western boundary of the Ruderal Wetland community within the survey area. The wetland is largely dominated by broadleaf cattail herbaceous vegetation.

Photo 5. View southwest at the man-made, concrete lined irrigation ditch along the western perimeter of the survey area. Unmowed herbaceous vegetated fallow lands along the ditch is evident in this photo.

Photo 6. View of typical upland hay fields (Cultivated Cropland) in the northern portion of the survey area. This photo is representative of the entire northern portion of the survey area.



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Boulder, CO 80301
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ERC #420-1707

FIGURE 3.
VEGETATION COMMUNITIES

THUNDER VALLEY PUD
WELD COUNTY, COLORADO

0 425 850
Feet

3.0 SCREENING METHODOLOGY

ERC conducted a literature review as part of initial data collection for preparation of this report. Among others, ERC reviewed the available literature sources including; CPW information and the US Fish and Wildlife Service (USFWS) Federal Register.

A field inspection was subsequently conducted on January 9, 2018 to identify and document the presence of natural vegetation communities, general wildlife use and potential for threatened and endangered species/habitat. Upon review of all available resources, including literature and field inspections, ERC provides the following determination for the survey area.

4.0 GENERAL WILDLIFE HABITAT (NON-REGULATED)

Wildlife utilizes the general landscape in a multitude of ways and uses a variety of habitats as areas of permanent inhabitance, seasonal inhabitance, breeding grounds, migratory routes, for foraging purposes, or as temporary shelter. Potential wildlife habitat includes agricultural land (hay field), fallow uplands, and herbaceous wetland communities.

Historic and current land use associated with agricultural practices have restricted and/or degraded the development of any significant natural vegetation communities within a majority the survey area, which limits the overall quality of potential wildlife habitat. The predominant habitat type which occupies 97% of the survey area is characterized by the Cultivated Cropland community which comprises agricultural land currently used for the agricultural production of hay that is regularly mowed. Fallow uplands occupy a portion of this community immediately around the perimeter of the wetland and irrigation ditch. This vegetation type which is dominated by non-native or weedy species is not typically considered of high ecological value to wildlife; however, agricultural lands can have beneficial values to certain wildlife species. These areas at a minimum are considered “open space” providing limited foraging and hunting grounds, refuge and limited areas for nesting (Kingery 1998). Such lands often serve as a buffer between natural areas, providing food, cover, nesting and open-space habitat which allow movement and exchange of plant and animal populations. In addition, there are few mid succession trees/shrubs and dense herbaceous vegetation located within the fallow uplands around the perimeter of the wetland habitat. Overstory canopy trees and midstory shrubs, situated near an agricultural landscape, can provide potential roosting and nesting habitat for visiting and residential raptors and smaller migratory birds. The agricultural land which is present across the survey area has largely replaced the native shortgrass prairie habitat which would have been present in this region. Herbaceous non-native species or ruderal native species which permeate the vegetation communities generally do not provide quality habitat for most wildlife. In general, agriculture practices have altered the structure, function, community composition, and habitat value of land within a majority of the survey area; however, this area does provide a variety of important wildlife habitat values in an otherwise agricultural landscape. Within the survey area, significant limitations for wildlife use exist due to land use activities such as regular mowing, habitat fragmentation from fences and roadways, and noise disturbances from oil and gas production equipment on adjacent land to the southwest.

The Ruderal Wetland habitat within the survey area occupies a smaller percentage (3%) bisecting the central portion of the survey area from west to east. Wetlands can provide a variety of wildlife habitat features such as cover, forage or nesting habitat, and can act as a movement corridor for various small mammals, amphibians, birds, and reptiles. The general structural characteristics of the wetland habitat

including a seasonal water source and dense emergent vegetation does create a relatively unique habitat in an otherwise arid and agricultural landscape. The wetland habitat appears to be inundated for at least some portion of the growing season which provides added wildlife benefits and habitat variety within the survey area; however, hydrology within the wetland habitat appears to be largely supported by irrigation water and no flows and/or surface water were present at the time of the field inspection, which severely limits habitat value for wildlife that requires a year-round water source such as certain amphibians and reptiles. Within the survey area, some limitations for wildlife use exist due to habitat fragmentation from roadways, upland berms, fences, and restricted culverts; however, overall wetland habitat of the survey area provides a variety of important wildlife habitat values.

Some local wildlife species that may use this habitat within the survey area includes coyote (*Canis latrans*), red fox (*Vulpes vulpes*), rabbit (*Lepus sp*.), cottontail (*Sylvilagus sp.*), raccoon (*Procyon lotor*), black tailed prairie dog (*Cynomys ludovicianus*), white-tailed deer (*Odocoileus virginianus*), deer mouse (*Peromyscus maniculatus*), meadow vole (*Microtus pennsylvanicus*), red-winged blackbird (*Agelaius phoeniceus*), mourning dove (*Zenaida macroura*), killdeer (*Charadrius vociferous*), western meadowlark (*Sturnella neglecta*), killdeer (*Charadrius vociferous*), barn owl (*Tyto alba*), hawks (*Buteo sp*.), and garter snake (*Thamnophis sp.*).

- Generally, there are features within the survey area and the surrounding area that provide general habitat for local songbirds, raptors, and small to mid-size mammals; however, the majority of habitat on the Site (approximately 97%) comprises cultivated cropland which is highly degraded from a wildlife perspective by historic and current land use practices. Within the survey area, the ruderal wetland habitat occupies a smaller percentage of the survey area (3%) but still provides a variety of important wildlife habitat values.

5.0 MIGRATORY BIRD TREATY ACT

Migratory birds are protected under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 730-712). The MBTA makes it illegal for anyone to take, possess, import, export, transport, sell, purchase barter, or offer for sale, purchase, or barter any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to Federal regulations. In Colorado, all birds except for the European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*) and rock pigeon (*Columba livia*) are protected under the MBTA. A total of 523 migratory bird species are known to occur in the Mountain-Prairie Region (USFWS Region 6, Montana, Wyoming, Utah, North Dakota, South Dakota, Nebraska, Kansas and Colorado); 320 of the 523 migratory bird species are known to breed in USFWS Region 6.

Migratory birds likely exist within the survey area. The ruderal wetland and fallow upland habitats exhibit few overstory canopy trees/midstory shrubs within the survey area that provide at the very least, potential nesting and foraging habitat for migratory birds. Several red-winged blackbird (*Agelaius phoeniceus*), black-billed magpie (*Pica hudsonia*), and European starling (*Sturnus vulgaris*) individuals, and one inactive migratory bird nest were directly observed on the survey area during the field inspection. Such birds are protected under the MBTA, and killing or possession of these birds (or their parts and nests) is prohibited under the MBTA. The migratory birds observed likely utilize the survey area primarily for foraging and seasonal nesting.

- Based upon literature review and an onsite assessment of the survey area, ERC has determined that some migratory birds likely utilize the survey area. These birds are protected under the MBTA, and

killing or possession of these birds is prohibited. Future land use changes that may occur on the survey area which remove the more permanent vegetation should first ensure that active nests are not disturbed. Generally, the active nesting season for most migratory birds in this region of Colorado occurs between April 1 and August 31.

- In addition, raptor nest sites are further protected by the CPW. The CPW has established recommended buffer zones and seasonal activity restrictions for a variety of Colorado raptors. While no active nests were observed and no CPW mapped buffer zones are located within the survey area (CPW 2017a), raptors could potentially establish nesting in the vicinity of the survey area. Future land use changes should ensure that no active raptor nest sites have established generally (depending on species) within a ½ mile of the survey area.

6.0 SPECIES PROTECTED UNDER THE ENDANGERED SPECIES ACT OF 1973

The ESA of 1973 was enacted by the United States to conserve endangered and threatened species and the ecosystems that they depend on. Under the ESA, species may be listed as either "endangered" or "threatened"; both designations are protected by law. The ESA is administered by the USFWS. The USFWS has developed project specific species lists, available online by request, identifying threatened, endangered, and proposed species, designated critical habitat, and candidate species protected under the ESA that may occur within the boundary of the proposed project and/or may be affected by the proposed project (USFWS 2018) (Tracking Number: 06E24000-2018-SLI-0449). The species list for the survey area has identified a total of 9 threatened or endangered species within the survey area.

Species Not Present

The following federally listed threatened and endangered species are identified to occur within Weld County. However, these species are not known to exist within the specific vicinity of the survey area and/or have specific habitat requirements (i.e., elevation range) that are not common in the vicinity of the survey area.

Common Name	Scientific Name	Status*	Determination
Mexican spotted owl	*Strix occidentalis lucida*	FT	NO EFFECT

*Status key:
FT – Federally listed as threatened

- The survey area does not contain the specific habitat characteristics necessary to support the species listed above. These species and/or critical habitat is not present within the survey area. Therefore the project will have no effect on the species, their habitats, or proposed or designated critical habitat.

Water Depletions Species

The USFWS under the ESA has determined that water depletions in the South Platte River Basin are considered an adverse effect to the listed species identified below. The survey area is considered to be located within the South Platte River Basin.

Common Name	Scientific Name	Status*	Determination
Least tern	*Sternula antillarium*	FE	NOT PRESENT, MAY BE AFFECTED BY DEPLETIONS
Pallid sturgeon	*Scaphirhycchus albus*	FE	NOT PRESENT, MAY BE AFFECTED BY DEPLETIONS

Common Name	Scientific Name	Status*	Determination
Piping plover	*Charadrius melodus*	FT	NOT PRESENT, MAY BE AFFECTED BY DEPLETIONS
Western prairie fringed orchid	*Platanthera praeclara*	FT	NOT PRESENT, MAY BE AFFECTED BY DEPLETIONS
Whooping crane	*Grus Americana*	FE	NOT PRESENT, MAY BE AFFECTED BY DEPLETIONS

*Status key:
FT – Federally listed as threatened
FE – Federally listed as endangered

Any water related project conducted in the Platte River Basin that has a federal nexus; such as federal funding or a federal permits (i.e., Clean Water Act (CWA) Section 404 Permit), is subject to ESA Section 7 Consultation with the USFWS. The consultation is a mandate for water depletion projects that may affect threatened and endangered species that rely on the South Platte River.

- The survey area does not contain the specific habitat characteristics necessary to support the species listed above. These species and/or critical habitat is not present within the survey area. Therefore the project will have no effect on these listed species, their habitats, or proposed or designated critical habitat.
- Any future project which may be water related or determined to be a water depletion to the South Platte River Basin may potentially be considered an adverse effect to these species. Generally non-water dependent projects such as residential developments (which are supplied by municipal water) are not considered water depletions and therefore would have no effect on these species.

Species Potentially within Range

The following federally listed threatened and endangered species are identified to occur or historically occur within Weld County (USFWS 2018). The survey area is located within the potential known range for these species to occur. Further analysis was conducted to determine if the species or habitat has the potential to exist within the survey area considering site-specific conditions and characteristics. A brief explanation is provided as to the species life cycle, habitat requirements and potential occurrence within the survey area. The survey area is not within designated critical habitat of any federally listed species.

Common Name	Scientific Name	Status*	Determination
Colorado butterfly plant	*Gaura neomexicana var. coloradensis*	FT	NO EFFECT
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	FT	NO EFFECT
Ute Ladies'-tresses orchid	*Spiranthes diluvialis*	FT	NO EFFECT

*Status key:
FT – Federally listed as threatened

COLORADO BUTTERFLY PLANT (GAURA NEOMEXICANA VAR. COLORADENSIS)

The Colorado butterfly plant is listed as federally threatened under the ESA. This plant species is a short-lived, perennial herb endemic to moist soils in mesic or wet meadows of floodplain areas in southeastern Wyoming, north central Colorado, and extreme western Nebraska. This early to mid-seral stage species occurs primarily in habitats created and maintained by streams active within their floodplains, with vegetation that is relatively open and not overly dense or overgrown. The conversion of natural wet

meadows and natural riparian corridors to agricultural land and urban development is the primary threat to the continued existence of the species (Federal Register 2000).

- The densely vegetated herbaceous wetland habitat within the survey area does not provide typical habitat conducive to this species. Neither individuals nor potential habitat for the Colorado butterfly plant were observed on or immediately surrounding the survey area. The survey area is not located within designated critical habitat for this species (Federal Register 2005). This species and/or critical habitat is not present within the survey area. Therefore the project will have no effect on the Colorado butterfly plant, its habitat, or proposed or designated critical habitat.

PREBLE'S MEADOW JUMPING MOUSE (ZAPUS HUDSONIUS PREBLEI)

On May 13, 1998 the US Fish and Wildlife Service issued a final rule to list the Preble's meadow jumping mouse (PMJM) as a federally threatened species under the ESA. PMJM range extends from southwestern Wyoming through eastern Colorado generally below 7,600 feet. Armstrong et al. (1997) described typical PMJM habitats as "well-developed plains riparian vegetation with relatively undisturbed grassland and a water source in close proximity." Also noted was a preference for "dense herbaceous vegetation consisting of a variety of grasses, forbs and thick shrubs" (USFWS 1999). This species is known to regularly travel into adjacent uplands to feed and hibernate. The PMJM hibernates in an underground burrow from September to May. PMJM bears two to three litters per year, averaging five young per litter, in a grass-lined nest. In general, PMJM surveys are recommended for areas with suitable habitat in Weld County below 7,600 feet and within 300 feet of vegetated irrigation canals, ditches, and wetlands. Areas that are highly disturbed or modified (including landscaped lots and paved areas) or wetland areas dominated by cattails are excluded from this recommendation.

No populations of the PMJM are known to occur within the vicinity of the survey area (UDFCD 2010). Further, the survey area and immediate vicinity is not designated (or proposed) as Critical Mouse Habitat by the USFWS (USFWS 2017a). The USFWS Mouse Block Clearance Map for the Denver Metro Area (USFWS 2010) which identifies areas exempt from further review for PMJM habitat, shows the survey area occurs outside the Block Clearance Zone.

- No PMJM individuals were observed on or surrounding the survey area. The majority of the survey area is comprised of agricultural land that is regularly mowed thus does not provide habitat suitable for this species. The wetland habitat and adjacent fallow uplands within the survey area does exhibit some dense herbaceous vegetation; however, the wetland habitat is largely dominated by cattails, lacks shrub cover, and has been historically altered to facilitate water storage which would not be considered suitable habitat conducive to the PMJM. The USFWS also states that sites where wetlands are entirely composed of dense stands of cattails are exempt from trapping survey. This species and/or critical habitat is not present within the survey area. Therefore the project will have no effect on the PMJM, its habitat, or proposed or designated critical habitat.

UTE LADIES'-TRESSES (SPIRANTHES DILUVIALIS)

The Ute ladies-tresses is listed as federally threatened under the ESA. The Ute ladies-tresses occurs in seasonally moist soils and wet meadows near springs, lakes, or perennial streams and their associated floodplains below 6,500 feet in elevation in certain areas of Utah, Colorado, Idaho, Wyoming, and Nevada. Typical sites include early successional riparian habitats such as point bars, sand bars, and low lying gravelly, sandy, or cobbly edges. They seem to require "permanent subirrigation", conditions where the

water table is close to the surface, but they are not tolerant of permanent standing water. Typical habitat is open and sparsely vegetated, populations decline if trees and shrubs invade the habitat. They do not compete well with aggressive species such as reed canary grass or monocultures of cattails.

- The densely vegetated wetland habitat within the survey area dominated by dense cattail vegetation which is not typical habitat conducive to the Ute ladies-tresses. No Ute ladies-tresses or suitable habitat was identified within the survey area. This species and/or critical habitat is not present within the survey area. Therefore the project will have no effect on the Ute ladies-tresses, its habitat, or proposed or designated critical habitat.

7.0 STATE THREATENED AND ENDANGERED SPECIES

Species identified as state threatened or endangered are protected by the CPW under Colorado Statute Title 33. State regulations prohibit "*any person to take, possess, transport, export, process, sell or offer for sale, or ship and for any common or contract carrier to knowingly transport or receive for shipment*" any species or subspecies listed as state endangered or threatened. The CPW also has identified State Species of Special Concern, which are species or subspecies of native wildlife that are currently vulnerable in their Colorado range and have the potential to become threatened or endangered (CPW 2010). Species of Special Concern are not protected under State regulations but the 'take' of individuals and disturbance of their habitat is strongly discouraged.

All state listed species were screened as potential inhabitants of the survey area based on general habitat requirements and CPW Species Profiles (CPW 2017b). ERC evaluated the species listed by CPW as threatened or endangered that could potentially exist within the survey area. All animal species listed above as threatened or endangered by the USFWS are also listed by the CPW as threatened or endangered, respectively, therefore were not duplicated below.

Species Not Present

The following listed threatened and endangered species are identified to occur within the state (CPW 2017b). However, these species are not known to exist within the specific vicinity of the survey area and/or have specific habitat requirements (i.e., elevation range) that are not common in the vicinity of the survey area (CPW 2017b and USFWS 2017).

Common Name	Scientific Name	Status*
Boreal toad	*Bufo boreas boreas*	SE
Southwestern willow flycatcher	*Empidonax traillii extimus*	SE
Lesser prairie-chicken	*Tympanuchus pallidicinctus*	ST
Plains sharp-tailed grouse	*Tympanuchus phasianellus jamesii*	SE
Arkansas darter	*Etheostoma cragini*	ST
Bonytail	*Gila elegans*	SE
Razorback sucker	*Xyrauchen texanus*	SE
Humpback chub	*Gila cypha*	ST
Colorado pikeminnow	*Ptychocheilus lucius*	ST
Greenback cutthroat trout	*Oncorhynchus clarki stomias*	ST
Rio grande sucker	*Catostomus plebeius*	SE
Lake chub	*Couesius plumbeus*	SE
Plains minnow	*Hybognathus placitus*	SE

Common Name	Scientific Name	Status*
Suckermouth minnow	*Phenacobius mirabilis*	SE
Northern redbelly dace	*Phoxinus eos*	SE
Southern redbelly dace	*Phoxinus erythrogaster*	SE
Brassy minnow	*Hybognathus hankinsoni*	ST
Common shiner	*Luxilus cornutus*	ST
Gray wolf	*Canis lupus*	SE
Grizzly bear	*Ursus arctos*	SE
Lynx	*Lynx canadensis*	SE
Wolverine	*Gulo gulo*	SE
Kit fox	*Vulpes macrotis*	SE
River otter	*Lontra canadensis*	ST

*Status key:
ST – State listed as threatened
SE – State listed as endangered

- The survey area does not contain the specific habitat characteristics necessary to support the species listed above. These species and/or critical habitat is not present within the survey area. Therefore the project will have no effect on the species, their habitats, or proposed or designated critical habitat.

Species Potentially within Range

The following state listed threatened and endangered species are identified to occur or historically occur within Weld County. The survey area is located within the potential known range for these species. Further analysis was conducted to determine if the species or habitat has the potential to exist on the survey area considering site-specific conditions and characteristics. A brief explanation is provided as to the species life cycle, habitat requirements and potential occurrence within the survey area.

Common Name	Scientific Name	Status*
Burrowing owl	*Athene cunicularia*	ST
Black-footed ferret	*Mustela nigripes*	SE

*Status key:
ST – State listed as threatened
SE – State listed as endangered

BURROWING OWL (ATHENE CUNICULARIA)

The burrowing owl (Owl) is listed as a state threatened species in Colorado. The Owl is small (length of 24 centimeters), long-legged, boldly spotted, and barred with brown and white. The Owl is a breeding species across the plains of eastern Colorado however rarely winters in the state. Nesting habitat is abandoned burrows, especially prairie dog colonies, located in grasslands, mountain parks, well-drained steppes, deserts, prairies and agricultural lands from late March through October. The Owl can usually be observed on low perches such as fence posts, dirt mounds or the ground. Clutch size of this Owl averages six to seven and incubation lasts up to 30 days. The owlets usually run and forage at 4 weeks and fly at 6 weeks. Primary threats to existence of this species are habitat loss due to intensive agriculture, habitat degradation and fragmentation due to control of burrowing mammals and predation by cats and dogs.

- No Owl individuals were observed on or surrounding the survey area. The survey area is located within the overall range of the black-tailed prairie dog; however, no colonies were observed within the

survey area. Much of the agricultural land within the survey area is regularly mowed or tilled further limiting the potential use of the survey area by this species. Any future land use changes within the survey area should not adversely affect the continued existence or potential habitat of this species.

BLACK-FOOTED FERRET (MUSTELA NIGRIPES)

The black-footed ferret (BFF) *(Mustela nigripes)* is a medium-sized mustelid (a member of the weasel family). The BFF is the only ferret species native to the Americas. Its historical range spanned much of western North America's intermountain and prairie grasslands, extending from Canada to Mexico. Historically, BFF habitat coincided with habitats of black-tailed prairie dog *(C. ludovicianus)*, Gunnison's prairie dog *(C. gunnisoni)*, and white-tailed prairie dog *(C. leucurus)*. Prairie dogs make up more than 90% of the BFF's diet. BFF's are limited to open habitat, the same habitat used by prairie dogs: grasslands, steppe, and shrub steppe. It depends largely on prairie dogs: ferrets prey on prairie dogs and utilize their burrows for shelter and denning (Hillman and Clark, 1980). It has been estimated that about 40-60 hectares of prairie dog colony are needed to support one ferret (Belant and Biggins 2008). BFF's once numbered in the tens of thousands, but due to a combination of human-induced threats they were believed to be extinct twice in the 20th century. As of 2015, BFFs have been reintroduced in the wild at 24 sites across 8 states, Canada, and Mexico.

- No BFF individuals were observed on or surrounding the survey area. The survey area is located within the overall range of the black-tailed prairie dog; however, no colonies were observed within the survey area. Further, the survey area occurs within the block clearance zone for black-footed ferret surveys (USFWS 2009). Any future land use changes within the survey area should not adversely affect the continued existence or potential habitat of this species.

8.0 SUMMARY

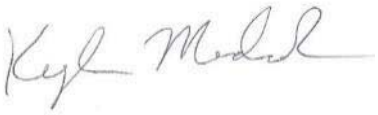
ERC has conducted this screening for federal and state listed threatened and endangered species for the approximately 39.5 acre survey area. The following provides key items identified as part of this report:

1. Two primary land use class/vegetation cover types exist within the survey area. Upland habitats are primarily characterized as Cultivated Cropland and wetland habitats are characterized as Ruderal Wetland. Historic land use for agricultural practices has led to degradation of the native vegetation community.
2. Generally, there are features on the survey area and the surrounding area that provide general habitat for local songbirds, raptors, and small to mid-size mammals. However, habitat within the survey area is somewhat degraded and of lower ecological value from a wildlife perspective due to historic and current land use for agriculture, which has restricted overall growth and establishment of vegetation.
3. Based upon literature review and field evaluation of the survey area, ERC has determined that some migratory birds likely utilize the survey area to a limited degree. These birds are protected under the MBTA, and killing or possession of these birds is prohibited. Generally, the active nesting season for most migratory birds in this region of Colorado occurs between April 1 and August 31. Any future land use changes that may occur within the survey area that remove vegetation during the active nesting season should first ensure that active nests are not disturbed. A nest survey can be conducted prior to vegetation removal that may occur during this time frame.

4. In addition, raptor nest sites are further protected by the CPW. The CPW has established recommended buffer zones and seasonal activity restrictions for a variety of Colorado raptors. While no active nests were observed and no CPW mapped buffer zones are located within the survey area (CPW 2017a), raptors could potentially establish nesting in the vicinity of the survey area. Future land use changes should ensure that no active raptor nest sites have established generally (depending on species) within a ½ mile of the survey area.
5. No federally listed threatened and endangered species and/or habitat protected under the ESA were identified within the survey area. The survey area is not within designated critical habitat of any federally listed species. The vegetation communities and features within the survey area were investigated as potential habitat for federally listed species. Potential threatened and endangered species habitat was found to lack one or more habitat components critical for the federally listed species likely to occur in the area. Furthermore, connectivity to known populations was limited due to geographic, hydrologic, and other habitat constraints. Therefore the project will have no effect on federal listed species, their habitats, or proposed or designated critical habitat.
6. Any future project which may be water related or determined to be a water depletion to the South Platte River Basin may potentially be considered an adverse effect to water depletion species. Generally non-water dependent projects such as residential developments (which are supplied by municipal water) are not considered water depletions and therefore would have no effect on these species.
7. No State listed threatened or endangered species and/or habitat protected under CPW under Colorado Statute Title 33 were identified within the survey area. The vegetation communities within the survey area were investigated as potential habitat for state listed species. Potential threatened and endangered species habitat was found to lack one or more habitat components critical for the state listed species likely to occur in the area. Furthermore, connectivity to known populations was limited due to geographic, hydrologic, and other habitat constraints. No other individuals or habitat for state listed threatened and endangered species would likely be impacted by any future land use changes.

This report has been prepared by:

ECOLOGICAL RESOURCE CONSULTANTS, INC.



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Reviewed and approved by:

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AQUATIC RESOURCE DELINEATION REPORT

FOR

THUNDER VALLEY PUD

WELD COUNTY, COLORADO

JANUARY 26, 2018

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ERC Project #420-1707

EXECUTIVE SUMMARY

This report summarizes the delineation of aquatic resources completed by Ecological Resource Consultants, Inc. (ERC) for the Thunder Valley PUD. ERC conducted a formal routine onsite delineation of aquatic resources within the approximately 39.5 acre survey area located in unincorporated Weld County, Colorado on January 9, 2017. A total of 1.01 acres of aquatic resources were identified and mapped within the survey area characterized as palustrine emergent (PEM) wetland habitat. The aquatic resource area was mapped as Aquatic Resource A. Aquatic Resource A continues offsite to Brantner Ditch which crosses Little Dry Creek approximately 3 miles north from the survey area and appears to terminate in an isolated agricultural pond approximately 6 miles north of the survey area (USGS 2017). From the crossing with Brantner Ditch, Little Dry Creek flows east for approximately 3 miles to Lupton Bottom Ditch which (based on USGS topographic mapping) also appears to terminate in uplands approximately 10 miles to the north. Based on review of available aerial imagery and topographic mapping, Aquatic Resource A appears to ultimately terminate in uplands (via Brantner Ditch and Little Dry Creek/Lupton Bottom Ditch) with no downstream connection to other waters of the US.

In addition, approximately 3,832 linear feet of man-made, concrete lined irrigation ditch known as Bull Ditch 2, Lateral 3 exists along the entire western perimeter of the survey area. Available mapping (Google Earth 2015) depicts the ditch terminates in uplands to the north of survey area. A headgate on Bull Ditch 2, Lateral 3 diverts flows to Aquatic Resource A within the survey area.

An unnamed irrigation lateral is diverted from Bull Ditch 2, Lateral 3 at the northern boundary of the survey area that flows 460 feet through the survey area, then continues offsite to the east where it terminates in uplands.

All areas that have been investigated in the field are mapped on the enclosed Aquatic Resource Delineation Map dated January 26, 2018 (**Appendix A**).

CONTENTS

APPENDIX A

Aquatic Resource Delineation Map

APPENDIX B

ERC Wetland Determination Data Forms

1.0 INTRODUCTION

This report summarizes the delineation of aquatic resources completed by Ecological Resource Consultants, Inc. (ERC) for the Thunder Valley PUD. The purpose of this report is to provide a formal delineation of aquatic resources within the approximately 39.5 acre survey area established for this site. This report facilitates efforts to document aquatic resource boundary determinations for verification and jurisdictional review by the US Army Corps of Engineers (USACE).

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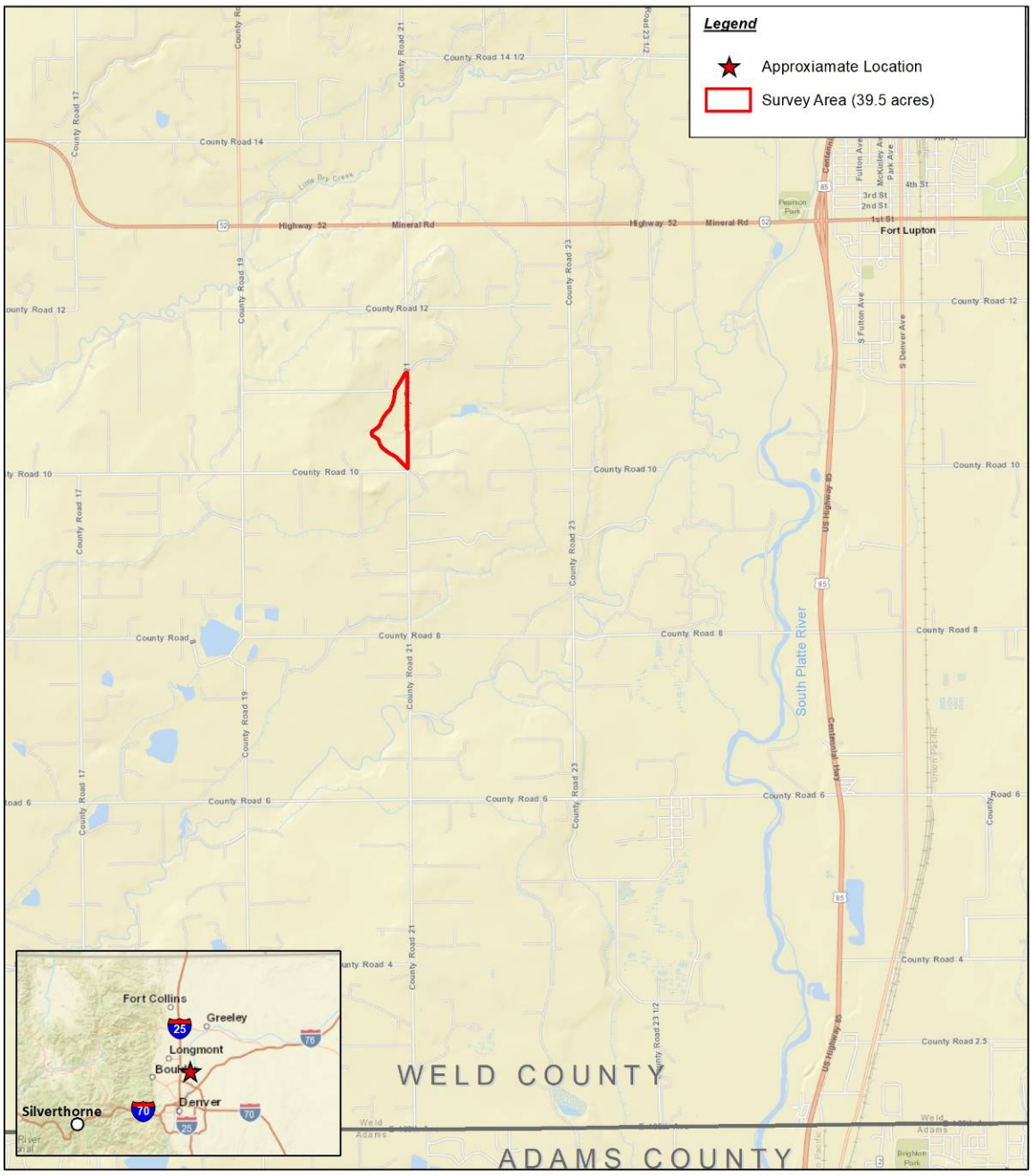
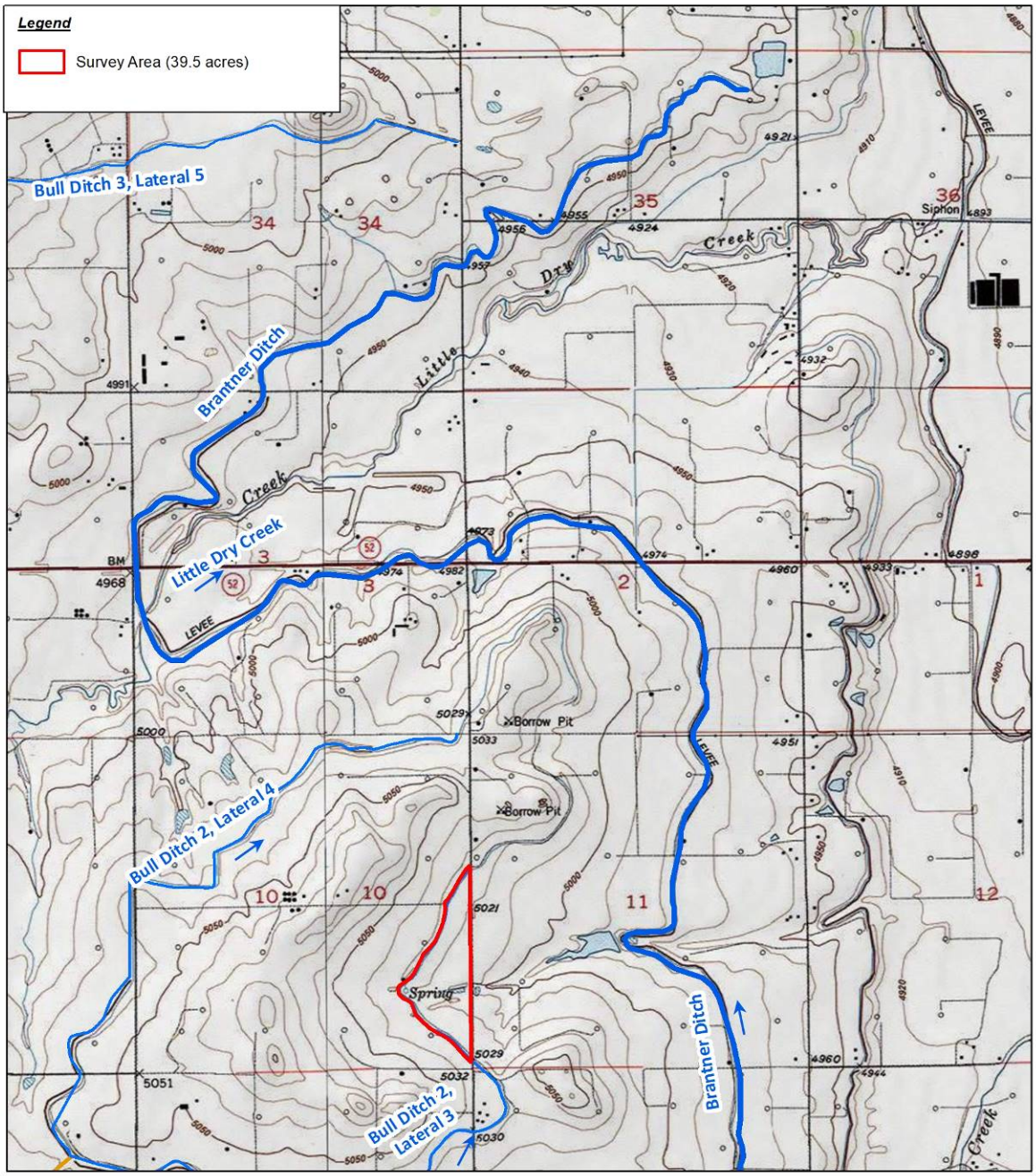
2.0 LOCATION

The survey area is located on the west side of County Road 21 approximately 1 mile south of the intersection with Highway 52 in unincorporated Weld County, Colorado in the *Lower Big Dry Creek* watershed (HUC 101900030408). More specifically, the survey area is located in **Section 10, Township 1 North, Range 67 West**, in Weld County **(latitude 40.062475° north, longitude -105.868803° west).** From the intersection of Interstate 25 and Highway 52, the survey area can be accessed by heading east on Highway 52 for approximately 6.2 miles, then south on County Road 21 for approximately 1 mile to the intersection with County Road 10.5. The survey area is then located southwest of the intersection of County Road 21 and County Road 10.5. The survey area is accessible along the west side of County Road 21. The survey area is mainly upland herbaceous vegetated agricultural land that is currently used for the agricultural production of hay. In addition, a man-made, concrete lined irrigation ditch (Bull Ditch 2, Lateral 3) exists along the entire western perimeter of the survey area. Refer to **Figure 1** and **Figure 2** for a location map and a US Geological Survey (USGS) topographic map of the survey area.



Prepared By: ERC *5672 Juhls Drive* *Boulder, CO 80301* *(303) 679-4820* *ERC #420-1707*	**FIGURE 1.** **LOCATION MAP** **THUNDER VALLEY PUD** **WELD COUNTY, COLORADO**	0 0.5 1 Miles



Prepared By:	FIGURE 2. USGS TOPOGRAPHIC MAP THUNDER VALLEY PUD WELD COUNTY, COLORADO	
ERC 5672 Juhls Drive Boulder, CO 80301 (303) 679-4820 ERC #420-1707		

3.0 METHODOLOGY

The aquatic resource delineation was conducted following the methodology enumerated in the *1987 Corps of Engineers Wetlands Delineation Manual and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0) (herein referred to as "Supplement") (Environmental Laboratory 1987, USACE 2010).* During the field inspection, dominant vegetation was recorded, representative hydrologic indicators were noted and soil samples were examined for hydric indicators. Delineation field work for the survey area was completed on January 9, 2018. The weather during the delineation was sunny at approximately 60 degrees Fahrenheit. At the time of the field evaluation, the conditions observed within the survey area were typical for the region and sufficient indicators of vegetation, soils and hydrology were observed to make a wetland determination.

The USACE and the Environmental Protection Agency (USEPA) jointly define wetlands as: "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" [40 CFR 230.3(t)]. Three general environmental parameters define a wetland. These parameters must include the presence of hydrophytic vegetation, hydric soils, and wetland hydrology. Except under certain situations, evidence of a minimum of one positive wetland indicator from each of the above parameters must be identified in order to make a positive wetland determination.

In addition, waters of the US are also defined as areas that *"include essentially all surface waters such as rivers, streams and their tributaries, all wetlands adjacent to these waters, and all ponds, lakes and reservoirs".* The boundaries of some waters of the US (i.e., such as streams or lakes) are further defined by the ordinary high water mark (OHWM). The OHWM is characterized as "the line on the shores established by the fluctuations of water and indicated by physical characteristics such as: a clear natural line impressed on the bank, shelving, changes in the character of the soil, wetland vegetation, the presence of litter and debris, and other appropriate means that consider the characteristics of the surrounding areas" (USACE 2005). These definitions are the basis of this delineation method.

Areas that do not meet any one of the wetland parameters (hydrophytic vegetation, hydric soils and/or wetland hydrology) or non-vegetated stream channel/open water (OHWM) were classified as a non-wetland (upland) and mapped as such.

Any area determined to be potential waters of the US was delineated in the field with pink pin flags and ribbon identified with 'WETLAND BOUNDARY' printed on it and sequentially labeled alpha-numerically (i.e. A1, A2…).

Each wetland determination point was recorded using a hand-held Trimble GeoXH global positioning system (GPS) receiver. The resulting GPS data were post processed using GPS Pathfinder Office 5.85 software. Post processing differential correction provided an average horizontal mapping accuracy of +/- 2 feet. Post-processed GPS data were imported into ArcMap Geographic Information Systems (GIS) (Version 10.5) for spatial analysis and mapping. All aquatic resources delineated within the survey area are depicted on the Aquatic Resource Delineation Maps dated January 26, 2018 are provided as **Appendix A**. Wetland Determination data sheets are provided in **Appendix B**.

4.0 EXISTING CONDITIONS

4.1 LANDSCAPE SETTING

The survey area is situated within the Great Plains ecoregion (Bailey 1976) at an approximate elevation of 5,025 feet above mean sea level (AMSL). The survey area is comprised mainly of agricultural land currently used for the agricultural production of hay, indicated by recent mowing. The vicinity of the survey area is comprised of similar agricultural land, oil and gas wells/production equipment, and rural residential properties. The landscape within the survey area is predominantly characterized by the Cultivated Cropland ecological system (Comer et al. 2003). This non-natural system includes lands used for the production of annual crops where crop vegetation accounts for greater than 20 percent of the total vegetation and where the land is actively tilled.

4.2 AQUATIC RESOURCES

Delineated aquatic resources were classified according to physical and biological characteristics using the Classification of Wetlands and Deepwater Habitats of the United States (Cowardin Classification System) (Cowardin et al. 1979). Within the survey area, wetland habitat types were classified based on field evaluation. The wetland habitats within the survey area were classified using the Cowardin Classification System and are summarized below in **Table 1**.

Table 1. Summary of Aquatic Resources Delineated within the Survey Area.

Aquatic Resource Name	Classification		Acres
	[1]Cowardin	Location (lat/long)	
Aquatic Resource A	PEM	40.061667°N, -104.868956°W	1.01
TOTAL (ACRES)			**1.01**

Notes:

[1] Habitat Type based on Cowardin et al. 1979.

A total of 1.01 acres of aquatic resources were delineated by ERC within the survey area. A description of aquatic resource habitat types is provided as follows. Refer to **Table 2** for a list of vegetation identified within the survey area (Lichvar et al. 2016). The Aquatic Resource Delineation Maps dated January 26, 2018 are provided as **Appendix A**. Wetland Determination data sheets are provided in **Appendix B.**

AQUATIC RESOURCE A (1.01 ACRES)

Aquatic Resource A comprises PEM wetland habitat which bisects the central portion of the survey area from west to east. The wetland habitat occurs within a linear topographic depression that appears to have been historically altered to facilitate water storage. Aquatic Resource A is bordered to the north and south by a narrow band of upland fallow lands followed by upland agricultural fields that are currently used for the agricultural production of hay. Hay fields on the north side are completely vegetated and have been recently mowed, and the south side appears to have been recently plowed/tilled and is unvegetated. The eastern border is formed by County Road 21 and the western border is formed by a man-made, concrete lined irrigation ditch, known as Bull Ditch 2, Lateral 3 (ERC 2015). Hydrology within Aquatic Resource A appears to be supported by irrigation water from Bull Ditch 2, Lateral 3 that is diverted into Aquatic Resource A via headgate and culvert located near the western boundary of

Aquatic Resource A. Based on the late season timing of the delineation, it is unknown if the source of hydrology for Aquatic Resource A is solely supported by irrigation water, or if it is from a combination of diverted irrigation water and groundwater within Aquatic Resource A. The USGS topographic map identifies a spring within Aquatic Resource A at the approximate location of the headgate on Bull Ditch 2, Lateral 3 (refer to **Figure 2**). No defined characteristics of a spring or groundwater seep were observed in this location at the time of the delineation.

Aquatic Resource A is bisected by a small man-made berm that is situated approximately 75 feet west of County Road 21 which appears to have been constructed to facilitate water storage within Aquatic Resource A. A headgate and culvert beneath the berm conveys flows from Aquatic Resource A east through the survey area. The aquatic resource continues offsite via culvert under County Road 21, daylights into a small settling basin on the east side County Road 21, then appears to be piped underground for approximately 1,400 feet. The aquatic resource then flows into an agricultural pond, which appears to outlet to an irrigation ditch, identified as Brantner Ditch, approximately 0.5 miles east of the survey area. Brantner Ditch flows north crossing Little Dry Creek approximately 3 miles north of the survey area. USGS topographic mapping (USGS 2017) and aerial imagery (Google Earth 2015) depicts Brantner Ditch terminates in an isolated agricultural pond approximately 6 miles north from the survey area (**40.101629°N, -104.850373°W**). From the crossing with Brantner Ditch, Little Dry Creek flows east for approximately 3 miles to Lupton Bottom Ditch which (based on USGS topographic mapping) also appears to terminate in uplands approximately 10 miles to the north (**-40.167526°N, 104.920622°W**). Based on review of available aerial imagery and topographic mapping, Aquatic Resource A appears to ultimately terminate in uplands (via Brantner Ditch and Little Dry Creek/Lupton Bottom Ditch) with no downstream connection to other waters of the US.

No surface water and/or flows were observed within Aquatic Resource A at the time of the delineation. The offsite drainages (Brantner Ditch and Little Dry Creek) are owned by several different entities and access authorization was not obtained, therefore field verification of hydrologic connectivity was not possible. These connections are assumed largely based on aerial imagery (Google Earth 2015) and topographic mapping (USGS 2017). Refer to **Figure 2** above and **Figure 3** below for an approximate geographic overview of the offsite drainages, irrigation ditches and potential termination points.

Overall, the vegetation community within Aquatic Resource A is dominated by species such as broadleaf cattail (*Typha latifolia*), reed canary grass (*Phalaris arundinacea*), and dockleaf smartweed (*Persicaria lapathifolia*) intermixed with some non-dominant herbaceous hydrophytic species such as curly dock (*Rumex crispus*) and Hooker's evening primrose (*Oenothera elata*). This area contains a temporarily flooded water regime. The dominant species within the wetland area consists of hydrophytic species (FACW - OBL).

Soils within Aquatic Resource A are generally silt loam to silty clay loam textured meeting criteria for hydric soil indicators F3 (Depleted Matrix) and F6 (Redox Dark Surface). At the time of the delineation, primary wetland hydrology indicator of C3 (Oxidized Rhizospheres Along Living Roots) was observed within Aquatic Resource A, in addition to secondary hydrology indicators of D2 (Geomorphic Position) and D5 (FAC-Neutral Test). Aquatic Resource A meets the criteria for wetland based on the presence of hydrophytic vegetation, hydric soils, and wetland hydrology.

Aquatic Resource A comprises a total of 1.01 acres within the survey area. Refer to **Photos 1-4** below for characteristics within Aquatic Resource A.

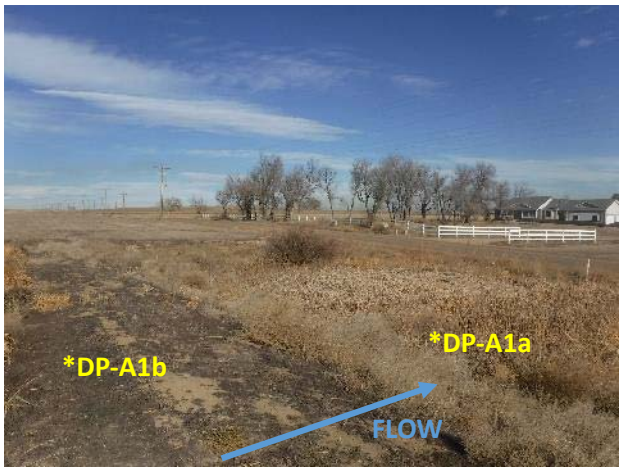


Photo 1. Overview northeast of the eastern portion of Aquatic Resource A within the survey area. The upland berm which bisects the aquatic resource is evident at the left of the photo, and a depression dominated by cattail is evident at the right. Approximate location of wetland data point DP-A1a and paired upland data point DP-A1b shown above.

Photo 2. Overview east from the western boundary of Aquatic Resource A. The culvert that outlets into Aquatic Resource A from the diversion headgate on Bull Ditch 2, Lateral 3 is located in the general area of the flow arrow shown above.

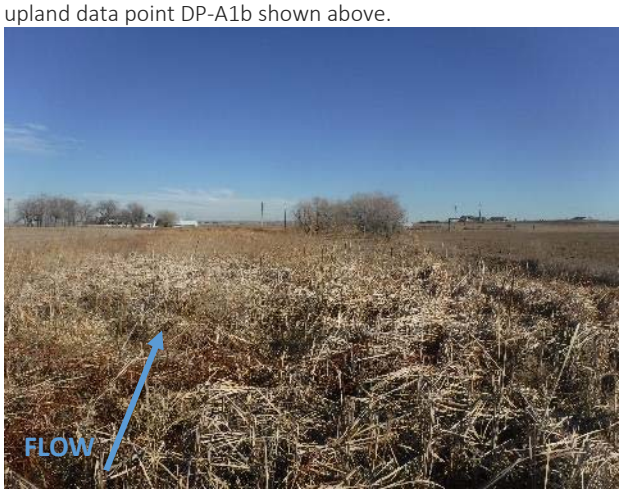


Photo 3. Overview facing east of the central portion of Aquatic Resource A dominated by cattail and dock-leaf smartweed herbaceous vegetation.

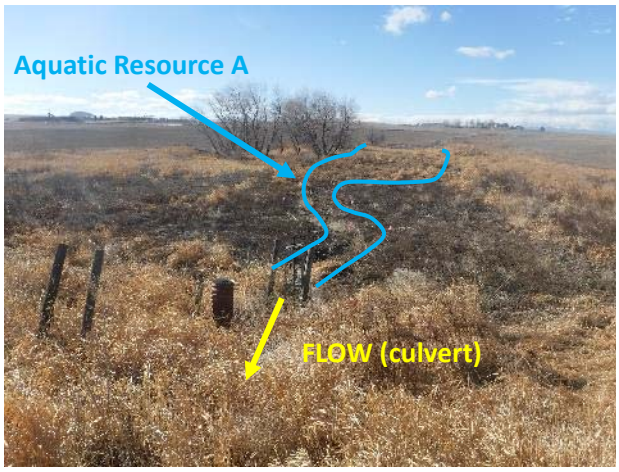
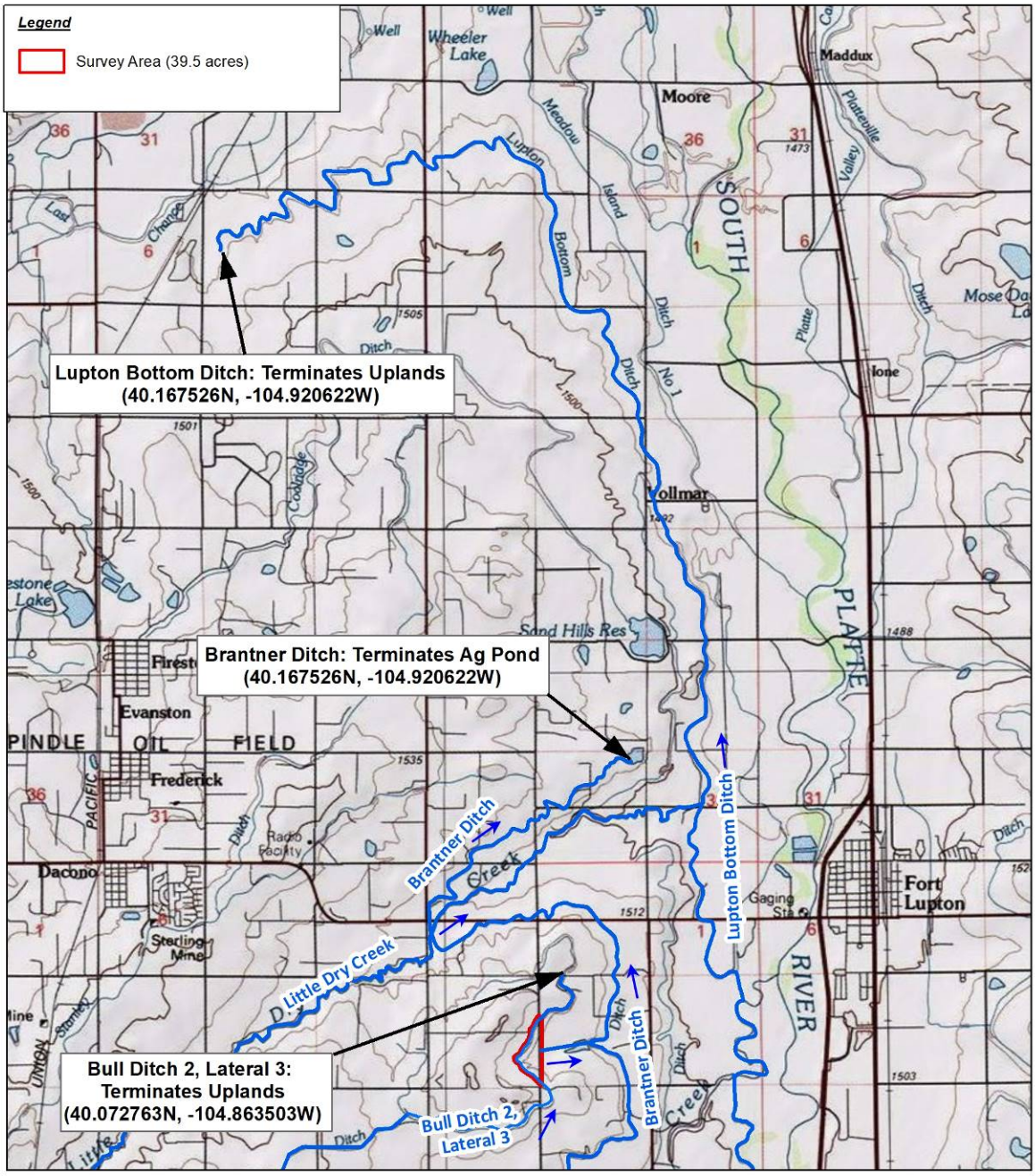


Photo 4. Overview west from atop the upland berm that bisects the eastern portion of Aquatic Resource A (shown in blue). A headgate and culvert divert flows within Aquatic Resource A under the berm (shown above in yellow).



Prepared By: ERC *5672 Juhls Drive* *Boulder, CO 80301* *(303) 679-4820* *ERC #420-1707*	**FIGURE 3.** **OVERVIEW OF CONNECTIVITY** **THUNDER VALLEY PUD** **WELD COUNTY, COLORADO**	0 1 2 Miles

4.3 UPLAND HABITAT

The wetland delineation identified approximately 38.5 acres of upland grassland and ruderal herbaceous vegetation within the survey area. A summary of upland habitat within the survey area is provided as follows.

Upland Grassland and Ruderal Herbaceous Vegetation Community

The upland grassland and ruderal herbaceous vegetation community within the survey area includes land that is currently used for the agricultural production of hay throughout a large majority of the survey area. All the areas used as hay fields have been recently mowed and a portion of this community to the south of Aquatic Resource A appears to have been recently plowed/tilled and is currently completely devoid of vegetation. Only the area immediately surrounding Aquatic Resource A and Bull Ditch 2, Lateral 3 would be considered fallow herbaceous vegetated uplands that have not been recently mowed. Topography across the survey area is generally flat, with topographic highpoints in the northern and southern portions, sloping downward toward the center of the survey area. The vegetation community across the mowed hay fields within the survey area is very similar, mainly dominated by smooth brome (*Bromus inermis*), western wheatgrass (*Pascopyrum smithii*), and cheatgrass (*Bromus tectorum*) comprising approximately 95% ground cover with the remaining cover comprising exposed surface soil. One area of the hay fields located to the south of Aquatic Resource A is approximately 200 feet wide spanning the entire survey area from west to east has been recently plowed/tilled and is currently completely devoid of vegetation (See **Photo 6** below). Areas immediately adjacent to Aquatic Resource A and Bull Ditch 2, Lateral 3 are fallow herbaceous vegetated lands dominated by species such as smooth brome, Dewey's sedge (*Carex deweyana*), Mexican fireweed (*Bassia scoparia*), reed canary grass, and cheatgrass intermixed with non-dominant ruderal herbaceous species comprising approximately 85%-100% ground cover, with the remaining ground cover comprised of exposed surface soil. Few mid succession crack willow (*Salix fragilis*) trees are located in the upland fallow area immediately adjacent to the southeastern boundary of Aquatic Resource A and few other tree/shrub species are located sporadically along the perimeter of Aquatic Resource A. These are the only tree/shrub species located within the survey area.

The upland habitats across the survey area are dominated by FACW-UPL species with dry, light colored silt loam soils. Hydric soils, a dominance of hydrophytic vegetation, and/or wetland hydrology were not present in the upland habitats within the survey area.

Refer to **Photos 5-8** below for characteristics of upland habitat identified within the survey area.

Photo 5. View north across the northern portion of the survey area comprising mowed hay field. This photo is representative of the entire northern portion of the survey area. Approximate location of upland data point DP-U2 shown above.

Photo 6. View east across the southern portion of survey area showing the divide between vegetated mowed hay field (right) and a recently plowed/tilled area that is currently unvegetated (left).

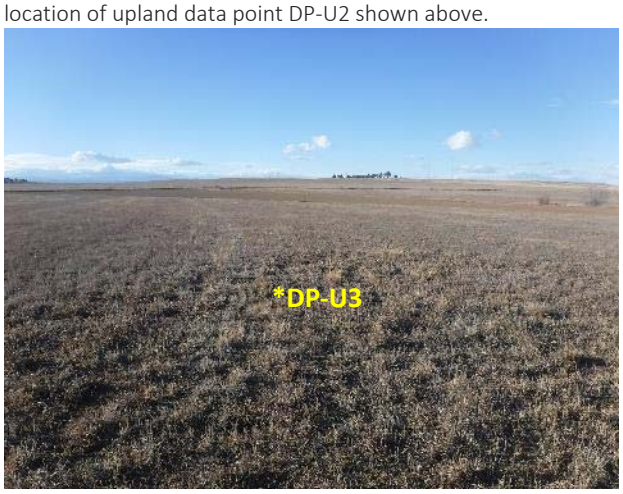


Photo 7. View northwest across the southern portion of the survey comprising mowed hay field. Approximate location of upland data point DP-U3 shown above.

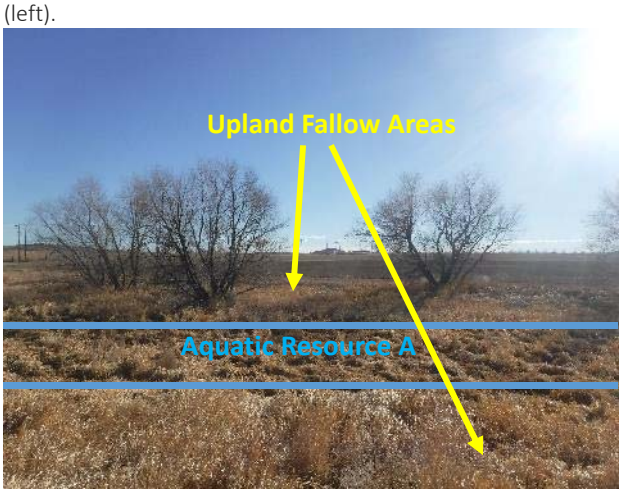


Photo 8. View south at upland fallow areas vegetated with grasses and ruderal herbaceous species along the perimeter of Aquatic Resource A (blue line). Few mid succession crack willow trees are evident in the background of this photo.

Table 2. Plant Species Found Within the Survey Area.

Scientific Name	Common Name	WIS*
Asclepias speciosa	Showy Milkweed	FAC
Bassia scoparia	Mexican-Fireweed	FACU
Bromus inermis	Smooth Brome	UPL
Bromus tectorum	Cheatgrass	UPL
Carex deweyana	Dewey's Sedge	FACU
Latuca serriola	Prickly Lettuce	FAC
Oenothera elata	Hooker's Evening Primrose	FACW

Scientific Name	Common Name	WIS*
Panicum miliaceum	Proso Millet	UPL
Pascopyrum smithii	Western Wheatgrass	FACU
Persicaria lapathifolia	Dock-Leaf Smartweed	OBL
Phalaris arundinacea	Reed Canary Grass	FACW
Rumex crispus	Curly Dock	FAC
Salix fragilis	Crack Willow	FAC
Typha latifolia	Broadleaf Cattail	OBL

* Wetland Indicator Status (WIS) – Great Plains Regions:

OBL = occurs in aquatic resources > 99% of time
FACW = occurs in aquatic resources 67-99% of time
FAC = occurs in aquatic resources 34-66% of time
FACU = occurs in aquatic resources 1-33% of time
UPL = occurs in uplands > 99% of time

WIS Source: Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *The National Wetland Plant List*: 2016 wetland ratings. Phytoneuron 2016-30: 1-17. Published 28 April 2016. ISSN 2153 733X http://www.phytoneuron.net/

4.4 UPLAND DITCH

Approximately 3,832 linear feet of man-made, concrete lined irrigation ditch, identified as Bull Ditch 2, Lateral 3 occurs along the western perimeter of the survey area (ERC 2015). Lateral 3 originates from Bull Ditch 2, which originates from Bull Canal 1. Bull Canal 1 diverts water directly from Big Dry Creek. All flows within Bull Ditch 2, Lateral 3 are for agricultural use. Bull Ditch 2, Lateral 3 was observed in the field as continuing offsite as an earthen lined channel on the east side of County Road 21. Aerial imagery (Google Earth 2015) shows the ditch terminates in an upland agricultural field to the north of the survey area. A headgate is present on Bull Ditch 2, Lateral 3 which diverts flows to Aquatic Resource A via culvert in the western portion of the survey area.

In addition, an unnamed irrigation lateral is diverted from Bull Ditch 2, Lateral 3 at the northern boundary of the survey area that flows south along County Road 21 for approximately 460 feet to a culvert under County Road 21 and continues east before terminating in uplands. The lateral was dry, filled with debris, with no indicators of regular flow were observed at the time of the delineation. Refer to the Aquatic Resource Delineation Map in **Appendix A** for the approximate location of this lateral. Bull Ditch 2, Lateral 3 and the unnamed lateral are approximately 5 to 7 feet wide at the top, and 1 to 2 feet wide at the ditch bottoms within the survey area, appear to have been excavated/constructed wholly in uplands for irrigation purposes, and terminate in upland agricultural fields; therefore, have been considered upland ditches as part of this report. Refer to **Photos 9-10** below for characteristics of Bull Ditch 2, Lateral 3 within the survey area. **Figure 3** provides a geographic overview of the network of irrigation ditches and drainages, flow directions and potential termination points within the vicinity of the survey area.

Photo 9. Overview northwest of Bull Ditch 2, Lateral 3 within the southern portion of the survey area. A man-made, concrete lined channel and no flow is evident in this photo.

Photo 10. Overview east from the western boundary of the survey area showing Bull Ditch 2, Lateral 3 and the headgate that diverts flows into Aquatic Resource A.

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Reviewed and approved by:

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5.0 REFERENCES

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APPENDIX A

NOTES:

1.THE SURVEY AREA IS LOCATED IN UNINCORPORATED WELD COUNTY, COLORADO. SECTION 10, TOWNSHIP 1 NORTH, RANGE 67 WEST (LATITUDE 40.062475° NORTH, LONGITUDE -105.868803° WEST).

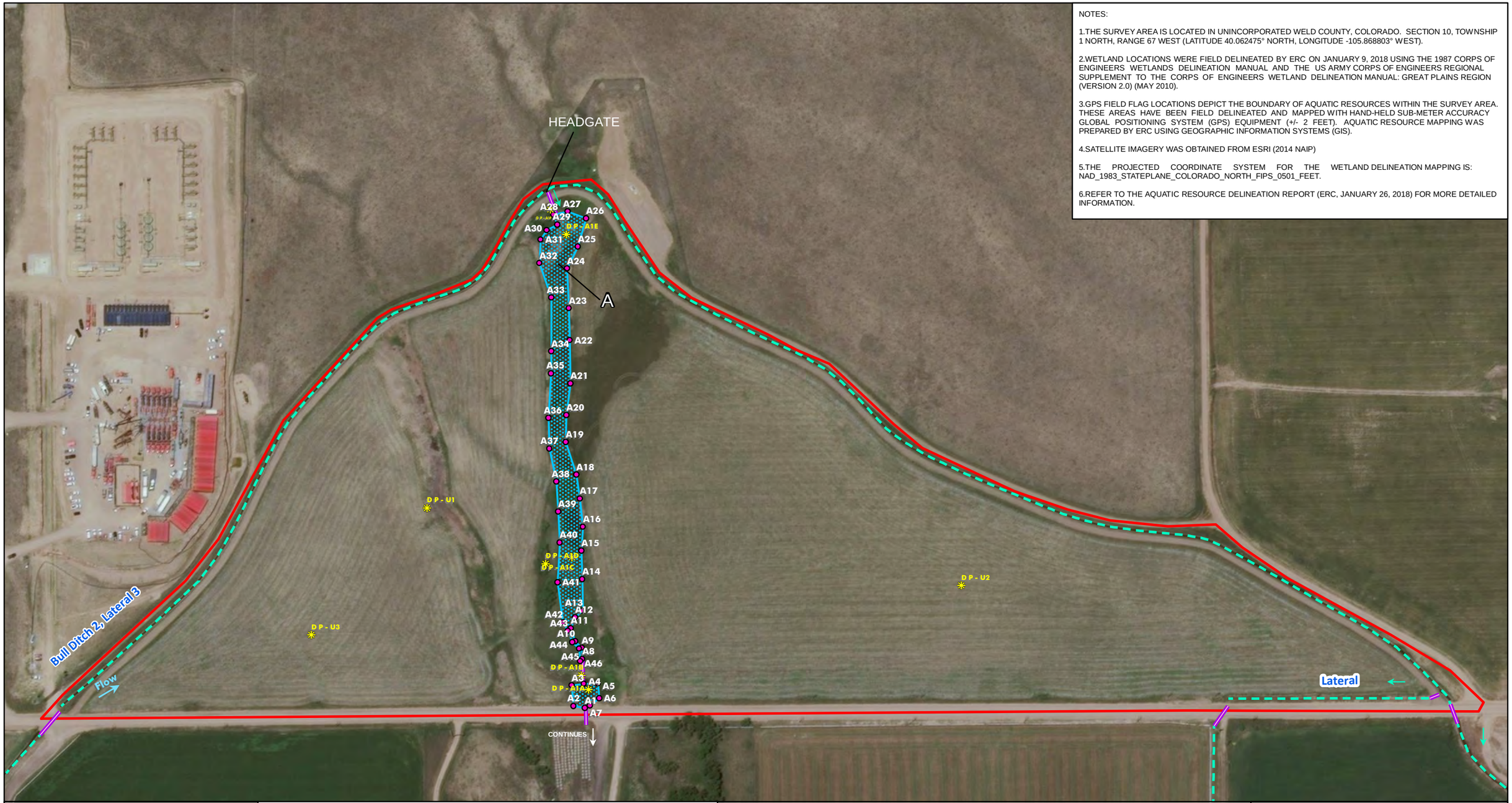
2.WETLAND LOCATIONS WERE FIELD DELINEATED BY ERC ON JANUARY 9, 2018 USING THE 1987 CORPS OF ENGINEERS WETLANDS DELINEATION MANUAL AND THE US ARMY CORPS OF ENGINEERS REGIONAL SUPPLEMENT TO THE CORPS OF ENGINEERS WETLAND DELINEATION MANUAL: GREAT PLAINS REGION (VERSION 2.0) (MAY 2010).

3.GPS FIELD FLAG LOCATIONS DEPICT THE BOUNDARY OF AQUATIC RESOURCES WITHIN THE SURVEY AREA. THESE AREAS HAVE BEEN FIELD DELINEATED AND MAPPED WITH HAND-HELD SUB-METER ACCURACY GLOBAL POSITIONING SYSTEM (GPS) EQUIPMENT (+/- 2 FEET). AQUATIC RESOURCE MAPPING WAS PREPARED BY ERC USING GEOGRAPHIC INFORMATION SYSTEMS (GIS).

4.SATELLITE IMAGERY WAS OBTAINED FROM ESRI (2014 NAIP)

5.THE PROJECTED COORDINATE SYSTEM FOR THE WETLAND DELINEATION MAPPING IS: NAD_1983_STATEPLANE_COLORADO_NORTH_FIPS_0501_FEET.

6.REFER TO THE AQUATIC RESOURCE DELINEATION REPORT (ERC, JANUARY 26, 2018) FOR MORE DETAILED INFORMATION.



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Legend

- Survey Area Boundary (~39.5 acres)
- D P - A1a — Data Point Location & ID
- Upland Ditch
- Culvert
- Delineated Aquatic Resource Boundary (1.01 acres)

AQUATIC RESOURCE DELINEATION MAP

THUNDER VALLEY PUD
WELD COUNTY, COLORADO

Date: January 26, 2018

1 inch = 200 feet

0 200 400 Feet

APPENDIX B

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-A1a

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Depression Local relief (concave, convex, none): Concave Slope (%): 1-3%

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.061810° N Long: -104.867562° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 3 to 5 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No _____	**Is the Sampled Area within a Wetland?** Yes ✓ No _____
Hydric Soil Present?	Yes ✓	No _____	
Wetland Hydrology Present?	Yes ✓	No _____	

Remarks:

PEM wetland within a low-lying topographic depression on the west side of County Road 21, wetland continues offsite via culvert under County Road 21. Area appears to have been historically altered to facilitate water storage. Pair with upland data point DP-A1b.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Typha latifolia	100	Yes	OBL
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 0%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

✓ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No _____

Remarks:

Vegetation community exhibits a monoculture of broadleaf cattail which is characteristic of the entire wetland area to the east of the upland berm. Meets the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-A1a

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 2/1	100					Silt loam	
6-12	10YR 4/2	80	7.5YR 4/6	20	C	PL, M	Silty clay loam	Prominent concentrations
12-20	10YR 4/1	90	7.5YR 4/6	10	C	M	Silty clay	Prominent concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ✓ No ___

Remarks:

Soils exhibited a dark organic layer at the surface, underlain by clay material depleted in matrix color. Meets the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ✓ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- ✓ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): _____

Water Table Present? Yes ___ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Hydrology within the wetland appears to be supported by irrigation water that is controlled by a headgate to the west. No surface water was present and irrigation water was not being diverted into the wetland at the time of the delineation; however, is likely diverted for some periods during the growing season which allows hydrology indicators to persist throughout the year. Meets the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-A1b

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Berm Local relief (concave, convex, none): Convex Slope (%): 0-1

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.061763° N Long: -104.867678° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 3 to 5 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:

Upland data point located on a man made berm. Berm was likely historically constructed to facilitate water storage in Aquatic Resource A to the west. A culvert is located under the berm connecting portions of Aquatic Resource A within the survey area. Pair with wetland data point DP-A1a.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Bromus tectorum	50	Yes	UPL
2. Bassia scoparia	20	Yes	FACU
3. Panicum miliaceum	10	No	UPL
4. Lactuca serriola	5	No	FAC
5.			
6.			
7.			
8.			
9.			
10.			
	85 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 15%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No ✓

Remarks:

Vegetation community is representative of the upland berm that bisects the eastern portion of Aquatic Resource A. Bare ground comprises exposed surface soil. Does not meet the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-A1b

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-20	10YR 5/3	100					Silt loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

Soils were uniform in color and texture likely due to location on a man-made upland berm. Does not meet the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): _____

Water Table Present? Yes ____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Data point located in a convex landscape position on a upland berm, no hydrology indicators were observed. Does not meet the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-A1c

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Linear Depression Local relief (concave, convex, none): Covcave Slope (%): 2-4

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.061720° N Long: -104.868570° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 3 to 5 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No _____	**Is the Sampled Area within a Wetland?** Yes ✓ No _____
Hydric Soil Present?	Yes ✓	No _____	
Wetland Hydrology Present?	Yes ✓	No _____	

Remarks:

PEM wetland located within a low-lying linear topographic depression that appears to have been historically altered to facilitate water storage. Pair with upland data point DP-A1d.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Phalaris arundinacea	60	Yes	FACW
2. Typha latifolia	30	Yes	OBL
3. Rumex crispus	5	No	FAC
4. Oenothera elata	5	No	FACW
5.			
6.			
7.			
8.			
9.			
10.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 0%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

✓ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No _____

Remarks:

Vegetation community is representative of the central and eastern portion of Aquatic Resource A. Meets the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-A1c

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-20	10YR 3/2	80	7.5YR 4/6	20	C	PL, M	Silty clay loam	Prominent concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ✓ No ___

Remarks:

Soils were deep and uniform throughout the profile, also appeared to have higher clay content lower in the profile. Meets the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ✓ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- ✓ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): _____

Water Table Present? Yes ___ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Hydrology within Aquatic Resource A appears to be supported by irrigation water controlled by a headgate to the west. No surface water was present and irrigation water was not being diverted into the wetland at the time of the delineation; however, is likely diverted for some periods during the growing season which allows hydrology indicators to persist throughout the year. Meets the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-A1d

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 3-5

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.061565° N Long: -104.868525° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 3 to 5 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:
Upland data point in a fallow area that separates Aquatic Resource A and hay fields to the south. Pair with wetland data point DP-A1c.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix fragilis	20	Yes	FAC
2.			
3.			
4.			
	20	= Total Cover	
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	
Herb Stratum (Plot size: _____)			
1. Bromus inermis	30	Yes	UPL
2. Carex deweyana	30	Yes	FACU
3. Phalaris arundinacea	15	No	FACW
4. Asclepias speciosa	15	No	FAC
5. Lactuca serriola	10	No	FAC
6.			
7.			
8.			
9.			
10.			
	100	= Total Cover	
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
		= Total Cover	

% Bare Ground in Herb Stratum 0%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 1 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 33% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No ✓

Remarks:
Vegetation community exhibits some FAC-FACW species of vegetation likely due to location in close proximity to a wetland; however, upland species dominate. Further, indicators of wetland hydrology and hydric soil are not present. Does not meet the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-A1d

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 5/3	100					Silty clay loam	
10-20	10YR 4/3	100					Silty clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

Soils were deep, dry, and light colored throughout the profile. Does not meet the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): _____

Water Table Present? Yes ____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Data point located on a fallow hillside that separates Aquatic Resource A and hay fields to the south. No hydrology indicators were observed. Does not meet the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-A1e

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Depression Local relief (concave, convex, none): Concave Slope (%): 2-4

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.061686° N Long: -104.871028° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 3 to 5 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No _____	**Is the Sampled Area within a Wetland?** Yes ✓ No _____
Hydric Soil Present?	Yes ✓	No _____	
Wetland Hydrology Present?	Yes ✓	No _____	

Remarks:

PEM Wetland located in a linear topographic depression that appears to have been historically altered to facilitate water storage. Pair with upland data point DP-A1f.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Typha latifolia	60	Yes	OBL
2. Persicaria lapathifolia	20	Yes	OBL
3. Rumex crispus	10	No	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	90 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 10%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

✓ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No _____

Remarks:

Vegetation community is representative of the western portion of Aquatic Resource A. Bare ground consists of areas of exposed surface soil. Meets the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-A1e

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 2/1	85	7.5YR 4/6	15	C	PL	Silt loam	Prominent concentrations
6-20	10YR 3/2	70	7.5YR 4/6	30	C	M	Silty clay loam	Prominent concentrations

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ✓ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ✓ No ___

Remarks:

Soils were generally dark in matrix color and exhibited redox concentrations in both the pore linings and matrix. Meets the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ✓ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- ✓ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): _____

Water Table Present? Yes ___ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Hydrology within Aquatic Resource A appears to be supported by irrigation water controlled by a headgate to the west. No surface water was present and irrigation water was not being diverted into the wetland at the time of the delineation; however, is likely diverted for some periods during the growing season which allows hydrology indicators to persist throughout the year. Meets the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-A1f

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Shoulder Local relief (concave, convex, none): None Slope (%): 2-4

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.061604° N Long: -104.871215° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 3 to 5 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:

Data point located in a upland fallow area that separates Aquatic Resource A and a man-made, concrete lined irrigation ditch to the west. A culvert exists under this area that connects the irrigation ditch to Aquatic Resource A. Pair with wetland data point DP-A1e.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Bromus inermis	50	Yes	UPL
2. Bassia scoparia	30	Yes	FACU
3. Lactuca serriola	10	No	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	90 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 10%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No ✓

Remarks:

Vegetation community is representative of fallow areas along the western perimeter of Aquatic Resource A. Bare ground consists of exposed surface soil. Does not meet the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-A1f

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-20	10YR 3/3	100					Silt loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

Soils were dry and light in color throughout the profile. Does not meet the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): _____

Water Table Present? Yes ____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Data point located in an upland fallow area, no hydrology indicators were observed. Does not meet the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-U1

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): Concave Slope (%): 4-6

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.060877° N Long: -104.868950° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 1 to 3 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:

Upland data point in a agricultural field that appears to have been recently plowed/tilled. Google Earth imagery from 2015 shows a narrow band of developed vegetation in this area, however it appears that it has been removed/altered.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	0 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 100%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 0 (A)

Total Number of Dominant Species Across All Strata: 0 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No ✓

Remarks:

This area is completely exposed surface soil that has been recently plowed/tilled. No vegetative cover exists. Does not meet the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-U1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-8	10YR 3/3	100					Silt loam	
8-20	10YR 4/3	100					Silty clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

Soils were dry, light in color, and had higher clay content lower in the profile. Does not meet the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): _____

Water Table Present? Yes ____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Data point located in a recently plowed/tilled agricultural field, no hydrology indicators were observed. Does not meet the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-U2

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 1-3

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.064001° N Long: -104.868332° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 1 to 3 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:
Upland data point in a hay field that has been recently mowed in the northern portion of the survey area.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Bromus inermis	70	Yes	UPL
2. Pascopyrum smithii	25	Yes	FACU
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	95 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 5%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No ✓

Remarks:
Vegetation community is representative of recently mowed hay fields across the northern portion of the survey area. Bare ground consists of exposed surface soil. Does not meet the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-U2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-20	10YR 4/3	100					Silt loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

Soils were dry, light colored, and uniform throughout the profile. Does not meet the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): _____

Water Table Present? Yes ____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Data point located in an upland hay field, no hydrology indicators were observed. Does not meet the criteria for wetland hydrology.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Thunder Valley PUD City/County: Unincorporated Weld County Sampling Date: 1/9/2018

Applicant/Owner: J&T Consulting State: Colorado Sampling Point: DP-U3

Investigator(s): K.Medash Section, Township, Range: S10, T1N, R67W

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 2-4

Subregion (LRR): Western Great Plains (LRR G) Lat: 40.060192° N Long: -104.867980° W Datum: NAD83

Soil Map Unit Name: Wiley-Colby complex, 1 to 3 percent slopes NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? No Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? No (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:
Upland data point located in a recently mowed hay field in the southern portion of the survey area.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: _____)			
1. Bromus inermis	40	Yes	UPL
2. Bromus tectorum	20	Yes	UPL
3. Pascopyrum smithii	20	Yes	FACU
4. Bassia scoparia	15	No	FACU
5.			
6.			
7.			
8.			
9.			
10.			
	95 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum 5%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 0 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes _____ No ✓

Remarks:
Vegetation community is representative of recently mowed hay fields across the southern portion of the survey area. Bare ground consists of exposed surface soil. Does not meet the criteria for hydrophytic vegetation.

SOIL

Sampling Point: DP-U3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 4/3	100					Silt loam	
10-20	10YR 5/3	100					Silty clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

Soils were dry and light in color throughout the profile. Does not meet the criteria for hydric soil.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): _____

Water Table Present? Yes ____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): _____

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Data point located in a hay field, no hydrology indicators were observed. Does not meet the criteria for wetland hydrology.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
DENVER REGULATORY OFFICE, 9307 SOUTH WADSWORTH BOULEVARD
LITTLETON, COLORADO 80128-6901

May 1, 2018

SUBJECT: Approved Jurisdictional Determination, Thunder Valley, Corps File No. NWO-2018-00756-DEN

Mr. Chris Zadel
4Z Investments, LLP
9075 Weld County Road 10
Fort Lupton, CO 80621

Dear Mr. Zadel:

Reference is made to the above-mentioned project located at approximately 40.062475°N, -104.868803°W, in Weld County, Colorado. You have requested an Approved Jurisdictional Determination for all aquatic resources found at this location.

The project area has been reviewed in accordance with Section 404 of the Clean Water Act under which the U.S. Army Corps of Engineers regulates the discharge of dredged and fill material, and any excavation activity associated with a dredge and fill project in waters of the United States.

Reference is made to the November 13, 1986 Federal Register (Page 41217), Parts 328 (a), "Non-tidal drainage and irrigation ditches excavated on dry land," and 328 (b), "Artificially irrigated areas which would revert to upland if the irrigation ceased." The Corps of Engineers generally does not consider these types of aquatic resources waters of the U.S. except on a case-by-case basis. Within the Study Area, the Bull Ditch 2, Lateral 3 conveys flow from south to north and terminates offsite in uplands at approximately 40.072763N, -104.863503W. A head gate located within the lateral diverts flow west to east across the Study Area (Aquatic Resource A). Aquatic Resource A is a wetland which continues to flow off-site towards a stock pond located off-site, which is also constructed in upland, and which does not have a downstream surface connection. Therefore, the Corps has determined that the Bull Ditch 2, Lateral 3 is a non-tidal irrigation ditch excavated in dry land and Aquatic Resource A is an artificially irrigated area which would revert to upland if the irrigation ceased. Neither aquatic resource is a water of the U.S.

At your request, an approved jurisdictional determination (JD) has been completed for this project. The JD is attached to this letter. If you are not in agreement with the JD decision, you may request an administrative appeal under regulation 33 CFR 331, by using the attached Appeal Form and Administrative Appeal Process form. The request for appeal must be received within 60 days from the date of this letter. If you would like more information on the jurisdictional appeal process, contact this office. It is not necessary to submit a Request for Appeal if you do not object to the JD.

This JD is valid for a period of five years from the date of this letter, unless new information warrants revisions of the JDs before the expiration date, or unless the Corps has identified, after a possible public notice and comment, that specific geographic areas with rapidly changing environmental conditions merit re-verification on a more frequent basis.

If there are any additional questions or concerns, please contact **Mr. Nicholas Franke** of my office at **303-979-4120** or by email at Nicholas.A.Franke@usace.army.mil and reference **Corps File No. NWO-2018-00756-DEN**.

Sincerely,

Kiel Downing
Chief, Denver Regulatory Office

Cc: Kyle Medash, Ecological resource Consultants, Inc., 5672 Juhls Drive, Boulder, CO/80301

Attachments:

Approved Jurisdictional Determination (May 1, 2018)
Approved Jurisdictional Determination Appeal Form
Approved Jurisdictional Determination Appeal Form Instruction Sheet

APPROVED JURISDICTIONAL DETERMINATION FORM
U.S. Army Corps of Engineers

This form should be completed by following the instructions provided in Section IV of the JD Form Instructional Guidebook.

SECTION I: BACKGROUND INFORMATION

A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD): May 1, 2018

B. DISTRICT OFFICE, FILE NAME, AND NUMBER: Denver Regulatory Office, Thunder Valley, NWO-2018-00756-DEN

C. PROJECT LOCATION AND BACKGROUND INFORMATION:
State: CO County/parish/borough: Weld City: Unincorporated
Center coordinates of site (lat/long in degree decimal format): Lat. 40.062475°N; Long. -104.868803°W
Universal Transverse Mercator: 511254.65 E x 4434699.71 N; Zone 13N
Name of nearest waterbody: Little Dry Creek, ~1.281 miles
Name of nearest Traditional Navigable Water (TNW) into which the aquatic resource flows: N/A.
Name of watershed or Hydrologic Unit Code (HUC): HUC8: 1019003; HUC12: 101900030408
☒ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.
☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc…) are associated with this action and are recorded on a different JD form.

D. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):
☒ Office (Desk) Determination. Date: May 1, 2018
☒ Field Determination. Date(s): April 30, 2018

SECTION II: SUMMARY OF FINDINGS

A. RHA SECTION 10 DETERMINATION OF JURISDICTION.

There **Are no** "*navigable waters of the U.S.*" within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the review area. [*Required*]
☐ Waters subject to the ebb and flow of the tide.
☐ Waters are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce.
Explain: .

B. CWA SECTION 404 DETERMINATION OF JURISDICTION.

There **Are no** "*waters of the U.S.*" within Clean Water Act (CWA) jurisdiction (as defined by 33 CFR part 328) in the review area. [*Required*]

1. **Waters of the U.S.**
   a. **Indicate presence of waters of U.S. in review area (check all that apply):** [1]
      ☐ TNWs, including territorial seas
      ☐ Wetlands adjacent to TNWs
      ☐ Relatively permanent waters[2] (RPWs) that flow directly or indirectly into TNWs
      ☐ Non-RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands directly abutting RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands adjacent to but not directly abutting RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs
      ☐ Impoundments of jurisdictional waters
      ☐ Isolated (interstate or intrastate) waters, including isolated wetlands

   b. **Identify (estimate) size of waters of the U.S. in the review area:**
      Non-wetland waters: linear feet: width (ft) and/or acres.
      Wetlands: acres.

   c. **Limits (boundaries) of jurisdiction** based on: **Pick List**
      Elevation of established OHWM (if known): .

2. **Non-regulated waters/wetlands (check if applicable):**[3]
   ☒ Potentially jurisdictional waters and/or wetlands were assessed within the review area and determined to be not jurisdictional.
   Explain: Reference is made to the November 13, 1986 Federal Register (Page 41217), Parts 328 (a), "Non-tidal drainage and irrigation ditches excavated on dry land," and 328 (b), "Artificially irrigated areas which would revert to upland if the irrigation ceased." The Corps of Engineers generally does not consider these types of aquatic resources waters of the U.S. except on a case-by-case basis. Within the Study Area, the Bull Ditch 2, Lateral 3 conveys flow from south to north and terminates offsite in uplands at approximately 40.072763N, -104.863503W. A head gate located within the lateral diverts flow west to east across the Study Area (Aquatic Resource A). Aquatic Resource A is a wetland which continues to flow off-site towards a stock pond located off-site, which is also constructed in upland, and which does not have a downstream surface

[1] Boxes checked below shall be supported by completing the appropriate sections in Section III below.
[2] For purposes of this form, an RPW is defined as a tributary that is not a TNW and that typically flows year-round or has continuous flow at least "seasonally" (e.g., typically 3 months).
[3] Supporting documentation is presented in Section III.F.

connection. Therefore, the Corps has determined that the Bull Ditch 2, Lateral 3 is a non-tidal irrigation ditch excavated in dry land and Aquatic Resource A is an artificially irrigated area which would revert to upland if the irrigation ceased. Neither aquatic resource is a water of the U.S.

SECTION III: CWA ANALYSIS

A. TNWs AND WETLANDS ADJACENT TO TNWs

The agencies will assert jurisdiction over TNWs and wetlands adjacent to TNWs. If the aquatic resource is a TNW, complete Section III.A.1 and Section III.D.1. only; if the aquatic resource is a wetland adjacent to a TNW, complete Sections III.A.1 and 2 and Section III.D.1.; otherwise, see Section III.B below.

1. **TNW**
   Identify TNW:

   Summarize rationale supporting determination:

2. **Wetland adjacent to TNW**
   Summarize rationale supporting conclusion that wetland is "adjacent":

B. CHARACTERISTICS OF TRIBUTARY (THAT IS NOT A TNW) AND ITS ADJACENT WETLANDS (IF ANY):

This section summarizes information regarding characteristics of the tributary and its adjacent wetlands, if any, and it helps determine whether or not the standards for jurisdiction established under *Rapanos* have been met.

The agencies will assert jurisdiction over non-navigable tributaries of TNWs where the tributaries are "relatively permanent waters" (RPWs), i.e. tributaries that typically flow year-round or have continuous flow at least seasonally (e.g., typically 3 months). A wetland that directly abuts an RPW is also jurisdictional. If the aquatic resource is not a TNW, but has year-round (perennial) flow, skip to Section III.D.2. If the aquatic resource is a wetland directly abutting a tributary with perennial flow, skip to Section III.D.4.

A wetland that is adjacent to but that does not directly abut an RPW requires a significant nexus evaluation. Corps districts and EPA regions will include in the record any available information that documents the existence of a significant nexus between a relatively permanent tributary that is not perennial (and its adjacent wetlands if any) and a traditional navigable water, even though a significant nexus finding is not required as a matter of law.

If the waterbody[4] is not an RPW, or a wetland directly abutting an RPW, a JD will require additional data to determine if the waterbody has a significant nexus with a TNW. If the tributary has adjacent wetlands, the significant nexus evaluation must consider the tributary in combination with all of its adjacent wetlands. This significant nexus evaluation that combines, for analytical purposes, the tributary and all of its adjacent wetlands is used whether the review area identified in the JD request is the tributary, or its adjacent wetlands, or both. If the JD covers a tributary with adjacent wetlands, complete Section III.B.1 for the tributary, Section III.B.2 for any onsite wetlands, and Section III.B.3 for all wetlands adjacent to that tributary, both onsite and offsite. The determination whether a significant nexus exists is determined in Section III.C below.

1. **Characteristics of non-TNWs that flow directly or indirectly into TNW**

   (i) General Area Conditions:
   Watershed size: **Pick List**
   Drainage area: **Pick List**
   Average annual rainfall: inches
   Average annual snowfall: inches

   (ii) Physical Characteristics:
   (a) Relationship with TNW:
   ☐ Tributary flows directly into TNW.
   ☐ Tributary flows through **Pick List** tributaries before entering TNW.

   Project waters are **Pick List** river miles from TNW.
   Project waters are **Pick List** river miles from RPW.
   Project waters are **Pick List** aerial (straight) miles from TNW.
   Project waters are **Pick List** aerial (straight) miles from RPW.
   Project waters cross or serve as state boundaries. Explain:

[4] Note that the Instructional Guidebook contains additional information regarding swales, ditches, washes, and erosional features generally and in the arid West.

Identify flow route to TNW[5]:
Tributary stream order, if known:

(b) General Tributary Characteristics (check all that apply):

Tributary is: ☐ Natural
☐ Artificial (man-made). Explain:
☐ Manipulated (man-altered). Explain:

Tributary properties with respect to top of bank (estimate):
Average width: feet
Average depth: feet
Average side slopes: **Pick List.**

Primary tributary substrate composition (check all that apply):

☐ Silts	☐ Sands	☐ Concrete
☐ Cobbles	☐ Gravel	☐ Muck
☐ Bedrock	☐ Vegetation. Type/% cover:	
☐ Other. Explain:		

Tributary condition/stability [e.g., highly eroding, sloughing banks]. Explain:
Presence of run/riffle/pool complexes. Explain:
Tributary geometry: **Pick List**
Tributary gradient (approximate average slope): %

(c) Flow:
Tributary provides for: **Pick List**
Estimate average number of flow events in review area/year: **Pick List**
Describe flow regime:
Other information on duration and volume:

Surface flow is: **Pick List.** Characteristics:

Subsurface flow: **Pick List**. Explain findings:
☐ Dye (or other) test performed:

Tributary has (check all that apply):
☐ Bed and banks
☐ OHWM[6] (check all indicators that apply):

☐ clear, natural line impressed on the bank	☐ the presence of litter and debris
☐ changes in the character of soil	☐ destruction of terrestrial vegetation
☐ shelving	☐ the presence of wrack line
☐ vegetation matted down, bent, or absent	☐ sediment sorting
☐ leaf litter disturbed or washed away	☐ scour
☐ sediment deposition	☐ multiple observed or predicted flow events
☐ water staining	☐ abrupt change in plant community
☐ other (list):	

☐ Discontinuous OHWM.[7] Explain:

If factors other than the OHWM were used to determine lateral extent of CWA jurisdiction (check all that apply):

☐ High Tide Line indicated by:	☐ Mean High Water Mark indicated by:
☐ oil or scum line along shore objects	☐ survey to available datum;
☐ fine shell or debris deposits (foreshore)	☐ physical markings;
☐ physical markings/characteristics	☐ vegetation lines/changes in vegetation types.
☐ tidal gauges	
☐ other (list):	

(iii) Chemical Characteristics:
Characterize tributary (e.g., water color is clear, discolored, oily film; water quality; general watershed characteristics, etc.).
Explain:

---

[5] Flow route can be described by identifying, e.g., tributary a, which flows through the review area, to flow into tributary b, which then flows into TNW.
[6] A natural or man-made discontinuity in the OHWM does not necessarily sever jurisdiction (e.g., where the stream temporarily flows underground, or where the OHWM has been removed by development or agricultural practices). Where there is a break in the OHWM that is unrelated to the waterbody's flow regime (e.g., flow over a rock outcrop or through a culvert), the agencies will look for indicators of flow above and below the break.
[7] Ibid.

Identify specific pollutants, if known: .

(iv) Biological Characteristics. Channel supports (check all that apply):

- ☐ Riparian corridor. Characteristics (type, average width): .
- ☐ Wetland fringe. Characteristics: .
- ☐ Habitat for:
  - ☐ Federally Listed species. Explain findings: .
  - ☐ Fish/spawn areas. Explain findings: .
  - ☐ Other environmentally-sensitive species. Explain findings: .
  - ☐ Aquatic/wildlife diversity. Explain findings: .

2. Characteristics of wetlands adjacent to non-TNW that flow directly or indirectly into TNW

(i) Physical Characteristics:

(a) General Wetland Characteristics:

Properties:

Wetland size: acres

Wetland type. Explain: .

Wetland quality. Explain: .

Project wetlands cross or serve as state boundaries. Explain: .

(b) General Flow Relationship with Non-TNW:

Flow is: **Pick List**. Explain: .

Surface flow is: **Pick List**

Characteristics: .

Subsurface flow: **Pick List**. Explain findings: .

- ☐ Dye (or other) test performed: .

(c) Wetland Adjacency Determination with Non-TNW:

- ☐ Directly abutting
- ☐ Not directly abutting
  - ☐ Discrete wetland hydrologic connection. Explain: .
  - ☐ Ecological connection. Explain: .
  - ☐ Separated by berm/barrier. Explain: .

(d) Proximity (Relationship) to TNW

Project wetlands are **Pick List** river miles from TNW.

Project waters are **Pick List** aerial (straight) miles from TNW.

Flow is from: **Pick List**.

Estimate approximate location of wetland as within the **Pick List** floodplain.

(ii) Chemical Characteristics:

Characterize wetland system (e.g., water color is clear, brown, oil film on surface; water quality; general watershed characteristics; etc.). Explain: .

Identify specific pollutants, if known: .

(iii) Biological Characteristics. Wetland supports (check all that apply):

- ☐ Riparian buffer. Characteristics (type, average width): .
- ☐ Vegetation type/percent cover. Explain: .
- ☐ Habitat for:
  - ☐ Federally Listed species. Explain findings: .
  - ☐ Fish/spawn areas. Explain findings: .
  - ☐ Other environmentally-sensitive species. Explain findings: .
  - ☐ Aquatic/wildlife diversity. Explain findings: .

3. Characteristics of all wetlands adjacent to the tributary (if any)

All wetland(s) being considered in the cumulative analysis: **Pick List**

Approximately ( ) acres in total are being considered in the cumulative analysis.

For each wetland, specify the following:

Directly abuts? (Y/N)	Size (in acres)	Directly abuts? (Y/N)	Size (in acres)

Summarize overall biological, chemical and physical functions being performed: .

C. SIGNIFICANT NEXUS DETERMINATION

A significant nexus analysis will assess the flow characteristics and functions of the tributary itself and the functions performed by any wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical, and biological integrity of a TNW. For each of the following situations, a significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or insubstantial effect on the chemical, physical and/or biological integrity of a TNW. Considerations when evaluating significant nexus include, but are not limited to the volume, duration, and frequency of the flow of water in the tributary and its proximity to a TNW, and the functions performed by the tributary and all its adjacent wetlands. It is not appropriate to determine significant nexus based solely on any specific threshold of distance (e.g. between a tributary and its adjacent wetland or between a tributary and the TNW). Similarly, the fact an adjacent wetland lies within or outside of a floodplain is not solely determinative of significant nexus.

Draw connections between the features documented and the effects on the TNW, as identified in the *Rapanos* Guidance and discussed in the Instructional Guidebook. Factors to consider include, for example:

- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to carry pollutants or flood waters to TNWs, or to reduce the amount of pollutants or flood waters reaching a TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), provide habitat and lifecycle support functions for fish and other species, such as feeding, nesting, spawning, or rearing young for species that are present in the TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to transfer nutrients and organic carbon that support downstream foodwebs?
- Does the tributary, in combination with its adjacent wetlands (if any), have other relationships to the physical, chemical, or biological integrity of the TNW?

Note: the above list of considerations is not inclusive and other functions observed or known to occur should be documented below:

1. **Significant nexus findings for non-RPW that has no adjacent wetlands and flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary itself, then go to Section III.D: .

2. **Significant nexus findings for non-RPW and its adjacent wetlands, where the non-RPW flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

3. **Significant nexus findings for wetlands adjacent to an RPW but that do not directly abut the RPW.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

D. DETERMINATIONS OF JURISDICTIONAL FINDINGS. THE SUBJECT WATERS/WETLANDS ARE (CHECK ALL THAT APPLY):

1. **TNWs and Adjacent Wetlands.** Check all that apply and provide size estimates in review area:
   - ☐ TNWs: linear feet width (ft), Or, acres.
   - ☐ Wetlands adjacent to TNWs: acres.

2. **RPWs that flow directly or indirectly into TNWs.**
   - ☐ Tributaries of TNWs where tributaries typically flow year-round are jurisdictional. Provide data and rationale indicating that tributary is perennial: .
   - ☐ Tributaries of TNW where tributaries have continuous flow "seasonally" (e.g., typically three months each year) are jurisdictional. Data supporting this conclusion is provided at Section III.B. Provide rationale indicating that tributary flows seasonally: .

   Provide estimates for jurisdictional waters in the review area (check all that apply):
   - ☐ Tributary waters: linear feet width (ft).
   - ☐ Other non-wetland waters: acres.
     Identify type(s) of waters: .

3. **Non-RPWs[8] that flow directly or indirectly into TNWs.**
   ☐ Waterbody that is not a TNW or an RPW, but flows directly or indirectly into a TNW, and it has a significant nexus with a TNW is jurisdictional. Data supporting this conclusion is provided at Section III.C.

   Provide estimates for jurisdictional waters within the review area (check all that apply):
   ☐ Tributary waters: linear feet width (ft).
   ☐ Other non-wetland waters: acres.
   Identify type(s) of waters: .

4. **Wetlands directly abutting an RPW that flow directly or indirectly into TNWs.**
   ☐ Wetlands directly abut RPW and thus are jurisdictional as adjacent wetlands.
   ☐ Wetlands directly abutting an RPW where tributaries typically flow year-round. Provide data and rationale indicating that tributary is perennial in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

   ☐ Wetlands directly abutting an RPW where tributaries typically flow "seasonally." Provide data indicating that tributary is seasonal in Section III.B and rationale in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

   Provide acreage estimates for jurisdictional wetlands in the review area: acres.

5. **Wetlands adjacent to but not directly abutting an RPW that flow directly or indirectly into TNWs.**
   ☐ Wetlands that do not directly abut an RPW, but when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisidictional. Data supporting this conclusion is provided at Section III.C.

   Provide acreage estimates for jurisdictional wetlands in the review area: acres.

6. **Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs.**
   ☐ Wetlands adjacent to such waters, and have when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisdictional. Data supporting this conclusion is provided at Section III.C.

   Provide estimates for jurisdictional wetlands in the review area: acres.

7. **Impoundments of jurisdictional waters.[9]**
   As a general rule, the impoundment of a jurisdictional tributary remains jurisdictional.
   ☐ Demonstrate that impoundment was created from "waters of the U.S.," or
   ☐ Demonstrate that water meets the criteria for one of the categories presented above (1-6), or
   ☐ Demonstrate that water is isolated with a nexus to commerce (see E below).

E. ISOLATED [INTERSTATE OR INTRA-STATE] WATERS, INCLUDING ISOLATED WETLANDS, THE USE, DEGRADATION OR DESTRUCTION OF WHICH COULD AFFECT INTERSTATE COMMERCE, INCLUDING ANY SUCH WATERS (CHECK ALL THAT APPLY):[10]
☐ which are or could be used by interstate or foreign travelers for recreational or other purposes.
☐ from which fish or shellfish are or could be taken and sold in interstate or foreign commerce.
☐ which are or could be used for industrial purposes by industries in interstate commerce.
☐ Interstate isolated waters. Explain: .
☐ Other factors. Explain: .

Identify water body and summarize rationale supporting determination: .

Provide estimates for jurisdictional waters in the review area (check all that apply):
☐ Tributary waters: linear feet width (ft).
☐ Other non-wetland waters: acres.

---

[8]See Footnote # 3.
[9] To complete the analysis refer to the key in Section III.D.6 of the Instructional Guidebook.
[10] **Prior to asserting or declining CWA jurisdiction based solely on this category, Corps Districts will elevate the action to Corps and EPA HQ for review consistent with the process described in the Corps/EPA *Memorandum Regarding CWA Act Jurisdiction Following Rapanos.***

Identify type(s) of waters:
☐ Wetlands: acres.

F. NON-JURISDICTIONAL WATERS, INCLUDING WETLANDS (CHECK ALL THAT APPLY):

☐ If potential wetlands were assessed within the review area, these areas did not meet the criteria in the 1987 Corps of Engineers Wetland Delineation Manual and/or appropriate Regional Supplements.

☐ Review area included isolated waters with no substantial nexus to interstate (or foreign) commerce.

☐ Prior to the Jan 2001 Supreme Court decision in "*SWANCC*," the review area would have been regulated based solely on the "Migratory Bird Rule" (MBR).

☐ Waters do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction. Explain: .

☒ Other: (explain, if not covered above): Reference is made to the November 13, 1986 Federal Register (Page 41217), Parts 328 (a), "Non-tidal drainage and irrigation ditches excavated on dry land," and 328 (b), "Artificially irrigated areas which would revert to upland if the irrigation ceased." The Corps of Engineers generally does not consider these types of aquatic resources waters of the U.S. except on a case-by-case basis. Within the Study Area, the Bull Ditch 2, Lateral 3 conveys flow from south to north and terminates offsite in uplands at approximately 40.072763N, -104.863503W. A head gate located within the lateral diverts flow west to east across the Study Area (Aquatic Resource A). Aquatic Resource A is a wetland which continues to flow off-site towards a stock pond located off-site, which is also constructed in upland, and which does not have a downstream surface connection. Therefore, the Corps has determined that the Bull Ditch 2, Lateral 3 is a non-tidal irrigation ditch excavated in dry land and Aquatic Resource A is an artificially irrigated area which would revert to upland if the irrigation ceased. Neither aquatic resource is a water of the U.S.

Provide acreage estimates for non-jurisdictional waters in the review area, where the sole potential basis of jurisdiction is the MBR factors (i.e., presence of migratory birds, presence of endangered species, use of water for irrigated agriculture), using best professional judgment (check all that apply):

☐ Non-wetland waters (i.e., rivers, streams): linear feet width (ft).
☐ Lakes/ponds: acres.
☐ Other non-wetland waters: acres. List type of aquatic resource: .
☐ Wetlands: acres.

Provide acreage estimates for non-jurisdictional waters in the review area that do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction (check all that apply):

☐ Non-wetland waters (i.e., rivers, streams): linear feet, width (ft).
☐ Lakes/ponds: acres.
☐ Other non-wetland waters: acres. List type of aquatic resource: .
☐ Wetlands: acres.

SECTION IV: DATA SOURCES.

A. SUPPORTING DATA. Data reviewed for JD (check all that apply - checked items shall be included in case file and, where checked and requested, appropriately reference sources below):

☒ Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant: Fig. 1, Location Map, Fig. 2, USGS Topo Map, Fig. 3, Overview of Connectivity, and Fig. 4, Aquatic Resource Delineation Map

☒ Data sheets prepared/submitted by or on behalf of the applicant/consultant. *Aquatic Resource Delineation Report,* January 26, 2018
  ☒ Office concurs with data sheets/delineation report.
  ☐ Office does not concur with data sheets/delineation report.

☐ Data sheets prepared by the Corps: .
☐ Corps navigable waters' study: .
☒ U.S. Geological Survey Hydrologic Atlas: .
  ☐ USGS NHD data.
  ☒ USGS 8 and 12 digit HUC maps. HUC8: 1019003; HUC12: 101900030408
☒ U.S. Geological Survey map(s). Cite scale & quad name: 1:24000 – Fort Lupton
☐ USDA Natural Resources Conservation Service Soil Survey. Citation: .
☐ National wetlands inventory map(s). Cite name: .
☐ State/Local wetland inventory map(s): .
☐ FEMA/FIRM maps: .
☐ 100-year Floodplain Elevation is: (National Geodectic Vertical Datum of 1929)
☒ Photographs: ☒ Aerial (Name & Date): Google Earth, 2016
  or ☐ Other (Name & Date):
☐ Previous determination(s). File no. and date of response letter: .
☒ Applicable/supporting case law: Rapanos and Carabell cases.
☐ Applicable/supporting scientific literature: .
☐ Other information (please specify):

NOTIFICATION OF ADMINISTRATIVE APPEAL OPTIONS AND PROCESS AND REQUEST FOR APPEAL

Applicant: Chris Zadel, 4Z Investments	File Number: NWO-2018-00756-DEN	Date: May 1, 2018
Attached is:		See Section below
	INITIAL PROFFERED PERMIT (Standard Permit or Letter of permission)	A
	PROFFERED PERMIT (Standard Permit or Letter of permission)	B
	PERMIT DENIAL	C
X	APPROVED JURISDICTIONAL DETERMINATION	D
	PRELIMINARY JURISDICTIONAL DETERMINATION	E

SECTION I - The following identifies your rights and options regarding an administrative appeal of the above decision. Additional information may be found in Corps regulations at 33 CFR Part 331, or at http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/FederalRegulation.aspx

A: INITIAL PROFFERED PERMIT: You may accept or object to the permit.

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- OBJECT: If you object to the permit (Standard or LOP) because of certain terms and conditions therein, you may request that the permit be modified accordingly. You must complete Section II of this form and return the form to the district engineer. Your objections must be received by the district engineer within 60 days of the date of this notice, or you will forfeit your right to appeal the permit in the future. Upon receipt of your letter, the district engineer will evaluate your objections and may: (a) modify the permit to address all of your concerns, (b) modify the permit to address some of your objections, or (c) not modify the permit having determined that the permit should be issued as previously written. After evaluating your objections, the district engineer will send you a proffered permit for your reconsideration, as indicated in Section B below.

B: PROFFERED PERMIT: You may accept or appeal the permit

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- APPEAL: If you choose to decline the proffered permit (Standard or LOP) because of certain terms and conditions therein, you may appeal the declined permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

C: PERMIT DENIAL: You may appeal the denial of a permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

D: APPROVED JURISDICTIONAL DETERMINATION: You may accept or appeal the approved JD or provide new information.

- ACCEPT: You do not need to notify the Corps to accept an approved JD. Failure to notify the Corps within 60 days of the date of this notice, means that you accept the approved JD in its entirety, and waive all rights to appeal the approved JD.
- APPEAL: If you disagree with the approved JD, you may appeal the approved JD under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

E: PRELIMINARY JURISDICTIONAL DETERMINATION: You do not need to respond to the Corps regarding the preliminary JD. The Preliminary JD is not appealable. If you wish, you may request an approved JD (which may be appealed), by contacting the Corps district for further instruction. Also you may provide new information for further consideration by the Corps to reevaluate the JD.

SECTION II - REQUEST FOR APPEAL or OBJECTIONS TO AN INITIAL PROFFERED PERMIT

REASONS FOR APPEAL OR OBJECTIONS: (Describe your reasons for appealing the decision or your objections to an initial proffered permit in clear concise statements. You may attach additional information to this form to clarify where your reasons or objections are addressed in the administrative record.)

ADDITIONAL INFORMATION: The appeal is limited to a review of the administrative record, the Corps memorandum for the record of the appeal conference or meeting, and any supplemental information that the review officer has determined is needed to clarify the administrative record. Neither the appellant nor the Corps may add new information or analyses to the record. However, you may provide additional information to clarify the location of information that is already in the administrative record.

POINT OF CONTACT FOR QUESTIONS OR INFORMATION:

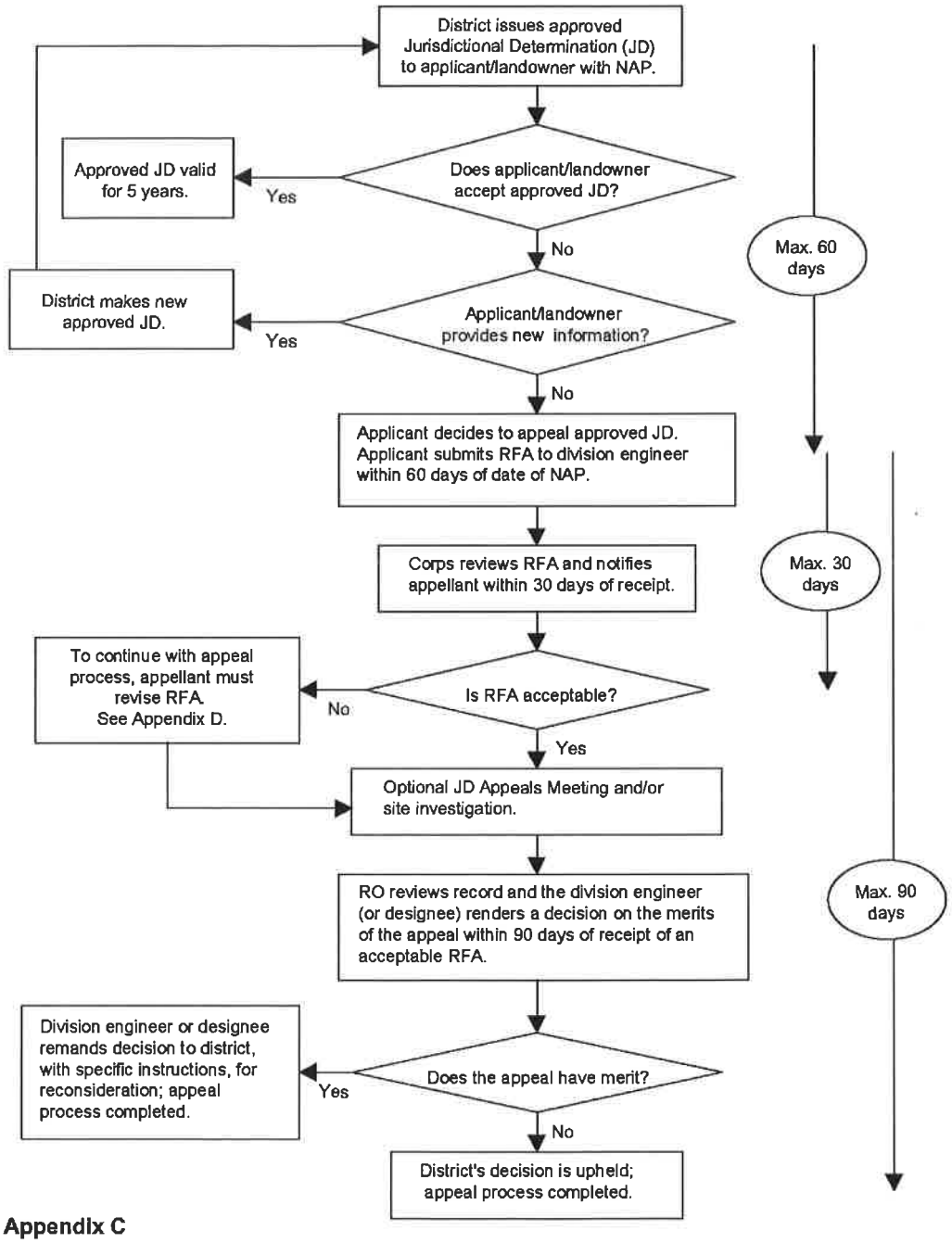
If you have questions regarding this decision and/or the appeal process you may contact:
US Army Corps of Engineers, Denver Regulatory Office
Attn: Nicholas Franke, Regulatory Project Manager
9307 S. Wadsworth Blvd
Littleton, CO 80128 Telephone (303) 979-4120
Nicholas.A.Franke@usace.army.mil

If you only have questions regarding the appeal process you may also contact:
US Army Corps of Engineers, Northwestern Division
Attn: Melinda Witgenstein, Regulatory Appeals Review Officer
1201 NE Lloyd Blvd Ste 400
Portland, OR 97232-1257 Telephone (503) 808-3888
Melinda.M.Witgenstein@usace.army.mil

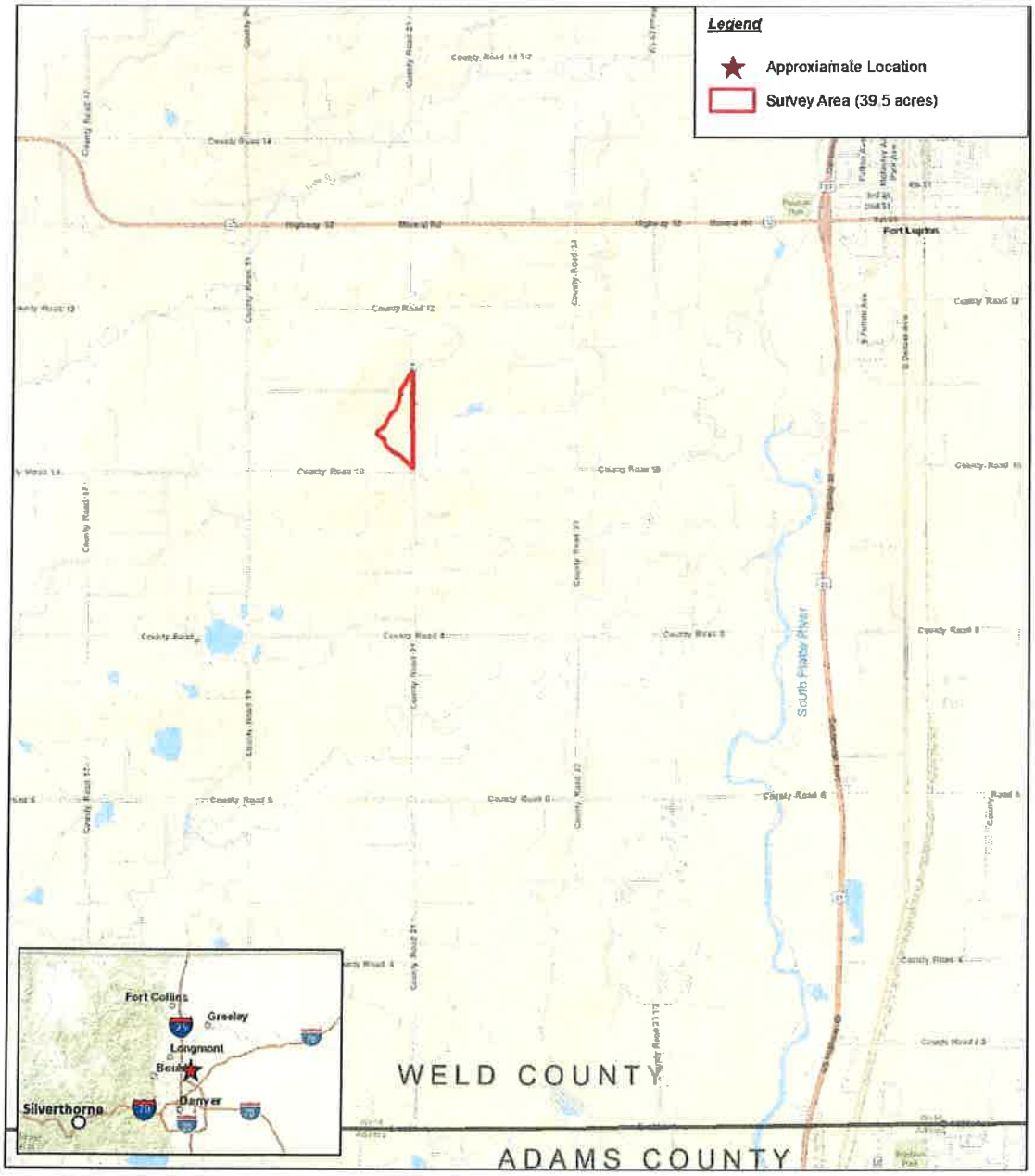
RIGHT OF ENTRY: Your signature below grants the right of entry to Corps of Engineers personnel, and any government consultants, to conduct investigations of the project site during the course of the appeal process. You will be provided a 15 day notice of any site investigation, and will have the opportunity to participate in all site investigations.

	Date:	Telephone number:
_____ Signature of appellant or agent.		

Administrative Appeal Process for Approved Jurisdictional Determinations



Appendix C



Prepared By:

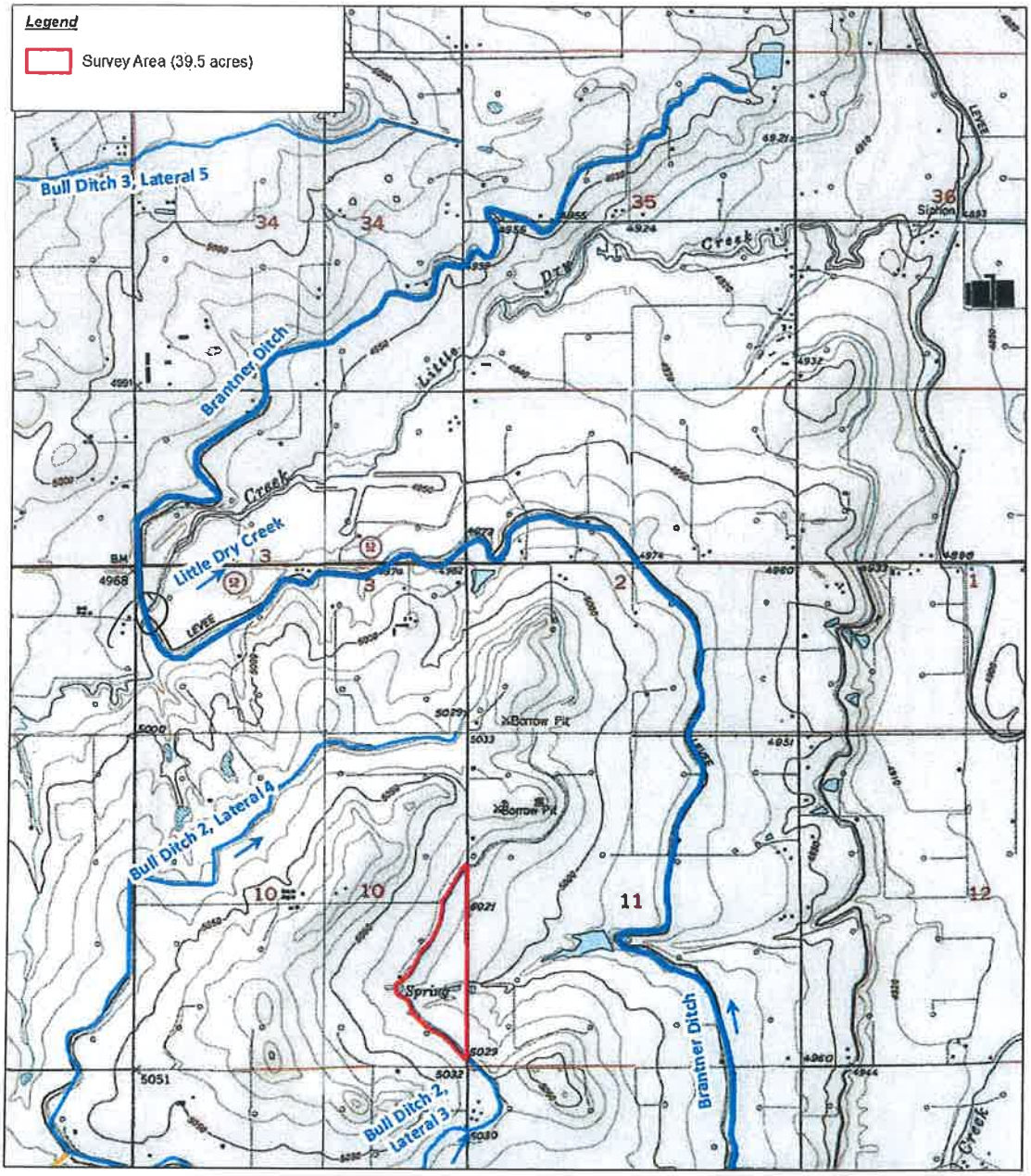
ERC

5672 Juhls Drive
Boulder, CO 80301
(303) 679-4820

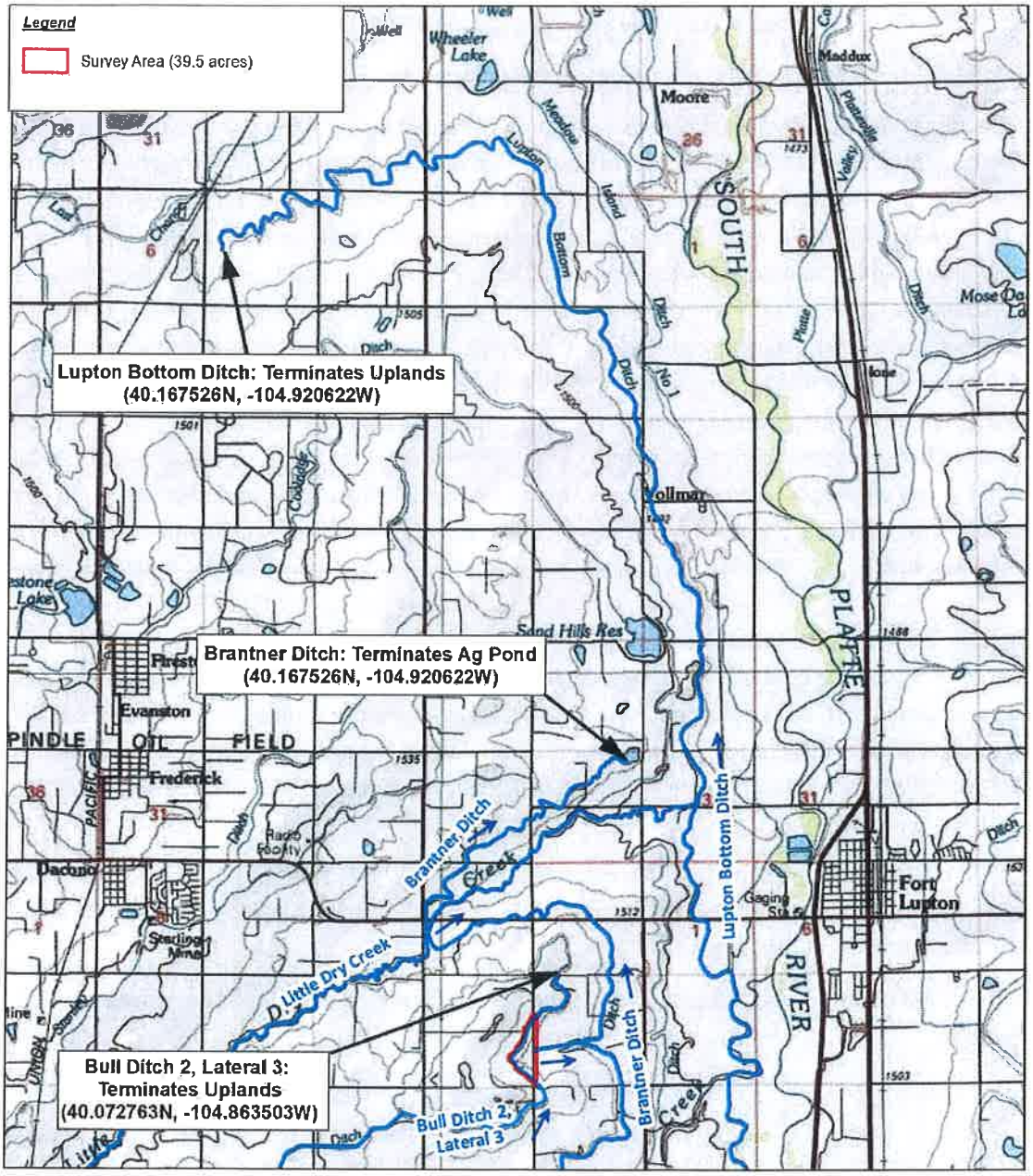
ERC #420-1707

FIGURE 1.
LOCATION MAP

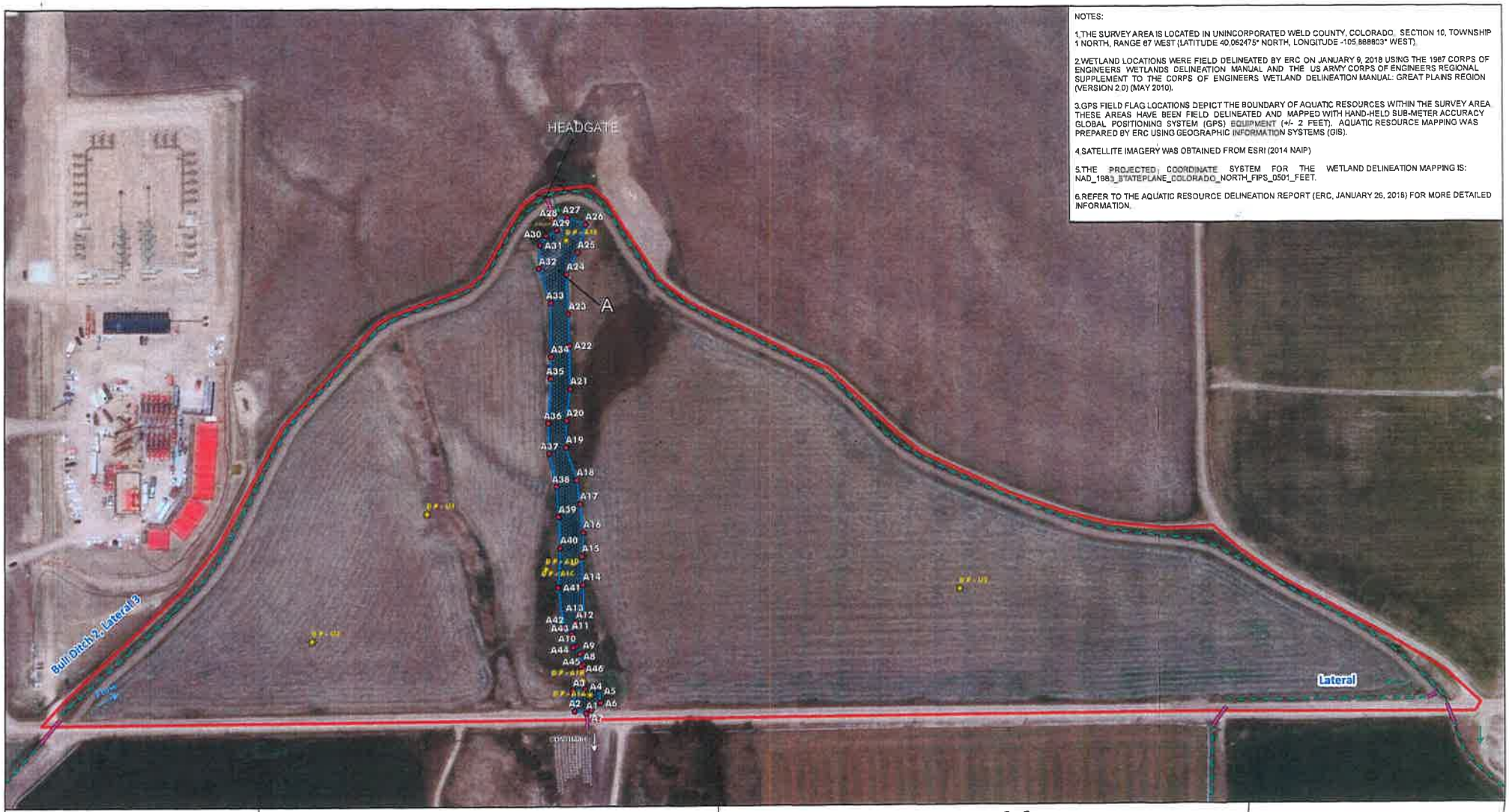
THUNDER VALLEY PUD
WELD COUNTY, COLORADO



Prepared By:	FIGURE 2. USGS TOPOGRAPHIC MAP THUNDER VALLEY PUD WELD COUNTY, COLORADO	0 2,200 4,400 Feet
ERC 5672 Juhls Drive Boulder, CO 80301 (303) 679-4820 ERC #420-1707		



Prepared By:	FIGURE 3. OVERVIEW OF CONNECTIVITY THUNDER VALLEY PUD WELD COUNTY, COLORADO	
ERC 5672 Juhls Drive Boulder, CO 80301 (303) 679-4820 ERC #420-1707		



NOTES:

1.THE SURVEY AREA IS LOCATED IN UNINCORPORATED WELD COUNTY, COLORADO. SECTION 10, TOWNSHIP 1 NORTH, RANGE 67 WEST (LATITUDE 40.062475° NORTH, LONGITUDE -105.888803° WEST).

2.WETLAND LOCATIONS WERE FIELD DELINEATED BY ERC ON JANUARY 9, 2018 USING THE 1987 CORPS OF ENGINEERS WETLANDS DELINEATION MANUAL AND THE US ARMY CORPS OF ENGINEERS REGIONAL SUPPLEMENT TO THE CORPS OF ENGINEERS WETLAND DELINEATION MANUAL: GREAT PLAINS REGION (VERSION 2.0) (MAY 2010).

3.GPS FIELD FLAG LOCATIONS DEPICT THE BOUNDARY OF AQUATIC RESOURCES WITHIN THE SURVEY AREA. THESE AREAS HAVE BEEN FIELD DELINEATED AND MAPPED WITH HAND-HELD SUB-METER ACCURACY GLOBAL POSITIONING SYSTEM (GPS) EQUIPMENT (+/- 2 FEET). AQUATIC RESOURCE MAPPING WAS PREPARED BY ERC USING GEOGRAPHIC INFORMATION SYSTEMS (GIS).

4.SATELLITE IMAGERY WAS OBTAINED FROM ESRI (2014 NAIP)

5.THE PROJECTED COORDINATE SYSTEM FOR THE WETLAND DELINEATION MAPPING IS: NAD_1983_STATEPLANE_COLORADO_NORTH_FIPS_0501_FEET.

6.REFER TO THE AQUATIC RESOURCE DELINEATION REPORT (ERC, JANUARY 26, 2018) FOR MORE DETAILED INFORMATION.

Prepared By:

ERC

5672 Juhls Drive
Boulder, CO 80301
(303) 679-4820

ERC # 240-1707

Legend

- Survey Area Boundary (~39.5 acres)
- Data Point Location & ID
- Upland Ditch
- Culvert
- Delineated Aquatic Resource Boundary (1.01 acres)

FIGURE 4,

AQUATIC RESOURCE DELINEATION MAP

THUNDER VALLEY PUD
WELD COUNTY, COLORADO

Date: January 26, 2018

1 inch = 200 feet

0 200 400 Feet

CENTRAL WELD COUNTY WATER DISTRICT

July 23, 2019

Mr. Chris Zadel
4Z Investments
9075 County Road 10
Fort Lupton, CO 80621

RE: Cost of Water Service – Thunder Valley

Dear Mr. Zadel,
This letter is in response to your request for water service to serve the following property described as follows:

PT E2SE4 10-1-67 BEG SE COR N00D13W 165.81 TO POB N00D13W 2477.63 N00D13W 447.60 S57D28W 35.49 S47D07W 36.39 S41D34W 78.14 S35D33W 59.01 S30D26W 75.09 S29D38W 269.69 S29D17W 35.99 S15D44W 47.41 S06D39W 167.80 S12D35W 57.74 S18D57W 62.09 S22D57W 300.16 S31D42W 85.54 S42D19W 48.49 S46D08W 114.14 S38D55W 55.23 S30D26W 60.11 S26D22W 271.17 S37D49W 62.28 S49D54W 67.57 S57D38W 129.58 S45D44W 38.20 S20D37W 32.97 S00D1610W 31.90 S27D27E 40.91 S45D49E 66.80 S59D18E 42.98 S60D49E 58.39 S51D41E 39.20 S32D27E 69.14 S18D28E 102.84 S24D47E 53.16 S39D18E 50.45 S46D43E 182.56 S50D01E 62.83 S60D26E 66.50 S62D55E 229.43 S54D22E 76.73 S47D43E 51.20 S41D49E 339.48 S46D58E 41.19 TO POB **PARCEL # 146910400017**

Water service can be made available to the above-described property located at County Rd 10 & 21. **Submitted herewith is the cost for infrastructure for Thunder Valley:**

CW materials and labor for 8" line	$39,000.00
TOTAL DUE	**$39,000.00**

Upon receipt of the above "Total Due" for desired tap size and the appropriate documentation being signed in the District's office by all deed holders, the District will prepare a work order for the installation of the meter sets and/or line installation. **This cost and availability of service is good for 30 days.** ***Please note that it is your responsibility to contact Northern Colorado Water Conservancy District at 800-369-7246 for petitioning confirmation into the Northern Colorado Water Conservancy District. Central Weld cannot issue a tap until all requirements are satisfied. This is in accordance with the Rules and Regulations of Northern Colorado Water Conservancy District.*** A water tap installation is for a specific parcel of property and a customer will not be permitted to extend a service line from one parcel or property to another parcel to provide additional water service. *The developer is only responsible for costs as stated above and will be able to provide their own line installation under CWCWD's supervision. The study commitment is good for 30 days once completed. A separate study fee is required per lot and varies per tap size requested. A deed or contract showing specific lot will be required from each lot owner.* **Based on the District's ownership of CBT water, the addition of thirteen (13) lots will be feasible to serve.**

2235 2nd Avenue • Greeley, Colorado 80631 • Phone (970) 352-1284 • Fax (970) 353-5865

The District will not require the developer to transfer CBT water shares. The purchase of the water tap will be the responsibility of each new land/lot owner **Please refer to the District's ownership of CBT water:**

CBT WATER OWNERSHIP	2014-15	2015-16	2016-17	2017-18	2018-19
CWCWD Balance at Beg. of Water Year	5,663	5,663	5,719	5,832	5848
Water Purchased/Transferred in Ownership	0	56	28	0	
Windy Gap	100	100	100	100	100
Greeley/Loveland Irr.	0.3	0.3	0.3	0.3	0.3
CWCWD Ownership Balance	5763.3	5819.3	5847.3	5932.3	5948.3
A.F.ALLOTMENT BY NCWCD:	70%	70%	80%	80%	70%
A.F. Beg. Water Year	4,034	4,074	4,678	4,746	4,164
Water Rented/Transferred	2,896	3,181	2,914	2,607	
District Balance to be Used	6,930	7,255	7,592	7,353	
DISTRICT USAGE	-4,240	-4,924	-4,854	-5,463	
DISTRICT AVAILABILITY	2,690	2,331	2,738	1,891	

Your local Fire Protection Authority has specified fire flow capacity. The District will **not** notify, by separate letter, any prospective landowners or land purchasers of tap fee increases. Surcharge amount is subject to change at the discretion of the Board of Directors. If you have any questions, please contact this office.

Sincerely,
CENTRAL WELD COUNTY WATER DISTRICT

Stan Linker, District Manager
SL/rg

February 21, 2020

Chris Zadel
NC Constructors
9075 WCR 10
Ft Lupton, CO 80621

Dear Mr. Zadel:

United Power is the provider of electric service in the area to the proposed development Thunder Valley PUD with 13 home sites located at the North Corner of CR 10 & CR 21, County of Weld, state of Colorado.
There is electrical distribution in the area that may or may not need to be upgraded, depending on the requirements of the site, in order to provide capacity and safe reliable power to the area.
Service will be provided according to the rules, regulations, and policies in effect by United Power at the time service is requested.
We look forward to this opportunity to provide electric service. If you have any questions, please give me a call at 720-685-5619.

Sincerely,

Bryce Lanckriet

Bryce Lanckriet
Project Coordinator II - West Division
BJL: mz