



Final Drainage Report

WHMD RWRF STORMWATER IMPROVEMENTS El Paso County, Colorado

Prepared for:

Woodmen Hills Metropolitan District
8046 Eastonville Road
Peyton, CO 80831
(719) 495-2500
Contact: Wally Eaves

Prepared by:

Kimley-Horn and Associates, Inc.
2 North Nevada Avenue, Suite 900
Colorado Springs, Colorado 80903
(719) 453-0180
Contact: Kevin Kofford, P.E.

KH Project #: 196013004

PCD Filing No.: CDR268

Prepared: August 7, 2026

Kimley»Horn



CERTIFICATION

DESIGN ENGINEER'S STATEMENT

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparation of this report.

SIGNATURE (Affix Seal): _____

Kevin Kofford, P.E.



_____ Date

OWNER/DEVELOPER'S STATEMENT

I, the developer, have read and will comply with all of the requirements specified in this Drainage Report and Plan.

Woodmen Hills Metropolitan District

Name of Developer

Walter Eaves

8/6/2026

Authorized Signature

Date

Wally Eaves

Printed Name

Director of Wastewater

Title

8046 Eastonville Rd, Peyton CO 80831

Address

EL PASO COUNTY

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code as amended.

Joshua J. Palmer, P.E.

County Engineer/ ECM Administrator

Date

Conditions:

TABLE OF CONTENTS

CERTIFICATION	1
DESIGN ENGINEER'S STATEMENT	1
OWNER/DEVELOPER'S STATEMENT	1
EL PASO COUNTY	1
TABLE OF CONTENTS	2
INTRODUCTION	3
PURPOSE AND SCOPE OF STUDY	3
LOCATION	3
DESCRIPTION OF PROPERTY	3
FLOODPLAIN STATEMENT	4
DRAINAGE BASINS	4
MAJOR BASIN DESCRIPTIONS	4
COMPLIANCE WITH DBPS	4
EXISTING SUB-BASIN DESCRIPTIONS	4
PROPOSED SUB-BASIN DESCRIPTIONS	6
DRAINAGE DESIGN CRITERIA	8
DEVELOPMENT CRITERIA REFERENCE	8
HYDROLOGIC CRITERIA	8
HYDRAULIC CRITERIA	8
TAILWATER CONDITIONS	9
THE FOUR STEP PROCESS	9
DRAINAGE FEES	10
FEES	10
SUMMARY	10
REFERENCES	10
APPENDIX	
APPENDIX A: VICINITY MAP	
APPENDIX B: FEMA MAP	
APPENDIX C: GEOTECHNICAL REPORT	
APPENDIX D: HYDROLOGY	
APPENDIX E: HYDRAULICS	
APPENDIX F: BENNETT RANCH DBPS	
APPENDIX G: DRAINAGE MAPS	

INTRODUCTION

PURPOSE AND SCOPE OF STUDY

The purpose of this Final Drainage Report (“FDR”) is to document the proposed improvements to the drainage design to the Woodmen Hills Metropolitan District Regional Water Reclamation Facility (“WHMD RWRF”). The Project is located within the jurisdictional limits of El Paso County (“the County”). Therefore, the hydrologic and hydraulic design is based on the County’s criteria which is described in further detail within the report.

LOCATION

The Project Site (“Site”) is located in the northeast corner of Meridian Ranch Boulevard and Stapleton Drive within El Paso County, Colorado including parcel 4230312001. More specifically, the site is a Portion of the southwest $\frac{1}{4}$ of the southeast $\frac{1}{4}$ and southeast $\frac{1}{4}$ of the southwest $\frac{1}{4}$ of Section 30, Township 12 South, Range 64 West of the 6th PM, Count of El Paso, State of Colorado. North and east of the Project is the Antler Creek Golf Course, south of the Project is Stapleton Drive, and west of the Project is Meridian Ranch Boulevard. The Site consists of an existing facility building, existing storage building, an existing aerated sludge basin, existing nutrient removal basins, three existing holding ponds, and an existing chlorine contact basin. A vicinity map has been provided in the **Appendix** of this report.

The Site is currently owned by Woodmen Hills Metropolitan District (“WHMD”) and improvements to the Site will be by WHMD.

DESCRIPTION OF PROPERTY

The entire WHMD RWRF Site is approximately 13.96 acres consisting of existing treatment facilities to process wastewater, gravel road, existing underground utilities, and native vegetation. The Site currently routes all storm to roadside ditches in Stapleton Drive, which eventually are captured and flow into the Bennett Ranch Regional Detention Pond.

The existing topography consists of slopes ranging from 1% to 40%, with steeper slopes towards the northwest corner of the Site where a retaining wall extension is proposed. Flows in the existing conditions run off site into existing infrastructure and culverts under Stapleton Road. Detailed description of the existing major drainage basin can be found later in the report.

According to NRCS soil mapping data, USCS Type A soils are the primary soil type within the site. Type A soils have a high infiltration rate when thoroughly wet and have a low runoff potential. These consist of deep, well drained soils that have fine texture. Soil mapping information has been provided in the **Appendix**.

The Project will consist of proposed storm infrastructure, grading, drainage swales, pavement, retaining wall improvements, and curb & gutter to improve the drainage issues happening at the current facility. These improvements are not in coordination with any other site changes but are intended as standalone drainage improvements to enhance the drainage conveyance around the property.

FLOODPLAIN STATEMENT

The Site is located outside the 100-year floodplain and within Zone X (an area of minimal flood hazard) as noted on the FEMA FIRM Map No. 08041C0551G revised on December 7, 2018 (See **Appendix**).

DRAINAGE BASINS

MAJOR BASIN DESCRIPTIONS

The Project Site is tributary to a major drainage basin in the El Paso County Drainage Basin Map, Bennett Ranch. This drainage basin is located in the north central portion of El Paso County. The Site is tributary to the Bennett Ranch Regional Detention Pond located within the Bennett Ranch major drainage basin.

The Bennett Ranch DBPS has been provided in the **Appendix**. A summary of flows in existing and proposed conditions has been added to the **Appendix**.

COMPLIANCE WITH DBPS

The Site is located within the “Bennett Ranch Pilot Project Drainage Basin Planning Study” by Stormwater & Environmental Consultants, Inc. approval date November, 2001, as submitted to the County. Further discussion on compliance with water quality requirements can be found in step 2 of the 4-step process.

EXISTING SUB-BASIN DESCRIPTIONS

Historically the runoff from the Site ultimately drains into the Bennett Ranch Regional Detention Pond. Slopes vary from 1-40% throughout the site with various culverts conveying water offsite to Stapleton Drive and connecting to the storm main in Stapleton Drive. The Site has been divided into 19 onsite basins, EX-1 – EX-19, and 6 offsite basins OF-1 – OF-6. The offsite basins are located generally on the northwest and south sides of the property line where flows are entering the Site. The Site generally flows from the northwest to the southeast towards existing stormwater infrastructure. Descriptions for each individual sub-basin can be found below.

In existing conditions, flows within the existing sub-basins are either collected in existing stormwater infrastructure or bypass the Site. An existing drainage map and hydrologic calculations can be found in the **Appendix**.

Table 1: Existing Stormwater Runoff Calculation and Sub-Basin Outfall Descriptions

DESIGN POINT	TRIBUTARY BASINS	AREA (AC)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)	% IMPERV.	IMMEDIATE OUTFALL				ULTIMATE OUTFALL
						CONVEYANCE	CONVEYANCE DIRECTION	LOCATION	TYPE	
EX-1	EX-1	0.03	0.01	0.09	0%	OVERLAND	SOUTHWEST	OFFSITE	EX. 5' TYPE R INLET	Bennett Ranch Regional Detention Pond
EX-2	EX-2	0.23	0.09	0.69	0%	OVERLAND	SOUTH	EX-1	N/A	Bennett Ranch Regional Detention Pond
EX-3	EX-3	0.03	0.01	0.08	0%	OVERLAND	SOUTHWEST	EX-2	N/A	Bennett Ranch Regional Detention Pond
EX-4	EX-4	0.74	0.19	1.39	0%	OVERLAND	SOUTHWEST	OFFSITE	MERIDIAN RANCH BLVD	Bennett Ranch Regional Detention Pond
EX-5	EX-5	0.84	0.35	1.95	5%	OVERLAND	SOUTHEAST	EX-10	N/A	Bennett Ranch Regional Detention Pond
EX-6	EX-6	1.23	1.26	3.98	26%	OVERLAND	SOUTHEAST	EX-10	N/A	Bennett Ranch Regional Detention Pond
EX-7	EX-7	0.61	0.73	2.06	33%	OVERLAND	SOUTHEAST	EX-14	N/A	Bennett Ranch Regional Detention Pond
EX-8	EX-8	0.35	1.34	2.49	90%	OVERLAND	NORTH	EX-7	N/A	Bennett Ranch Regional Detention Pond
EX-9	EX-9	0.54	2.50	4.48	100%	OVERLAND	N/A	N/A	SANITATION TREATMENT BASIN	Bennett Ranch Regional Detention Pond
EX-10	EX-10	1.37	1.63	4.38	35%	OVERLAND	SOUTHEAST	EX-15	EX. 12" CMP CULVERT	Bennett Ranch Regional Detention Pond
EX-11	EX-11	0.16	0.76	1.37	100%	OVERLAND	N/A	N/A	SANITATION TREATMENT BASIN	Bennett Ranch Regional Detention Pond
EX-12	EX-12	0.45	0.22	1.01	8%	OVERLAND	EAST	EX-15	EX. 15" CMP CULVERT	Bennett Ranch Regional Detention Pond
EX-13	EX-13	0.07	0.03	0.21	0%	OVERLAND	SOUTHEAST	OFFSITE	MERIDIAN RANCH BLVD	Bennett Ranch Regional Detention Pond
EX-14	EX-14	0.77	0.51	1.76	18%	OVERLAND	EAST	EX-17	N/A	Bennett Ranch Regional Detention Pond
EX-15	EX-15	2.28	2.83	7.02	46%	HOLDING POND	SOUTHEAST	N/A	SANITATION TREATMENT HOLDING POND	Bennett Ranch Regional Detention Pond
EX-16	EX-16	1.43	3.62	7.20	80%	HOLDING POND	SOUTHWEST	N/A	SANITATION TREATMENT HOLDING POND	Bennett Ranch Regional Detention Pond
EX-17	EX-17	1.74	0.75	3.42	10%	HOLDING POND	SOUTH	N/A	SANITATION TREATMENT HOLDING POND	Bennett Ranch Regional Detention Pond
EX-18	EX-18	0.44	0.32	1.20	17%	OVERLAND	SOUTHEAST	OFFSITE	EX. 24" RCP CULVERT	Bennett Ranch Regional Detention Pond
EX-19	EX-19	0.62	0.30	1.44	8%	OVERLAND	EAST	OFFSITE	EX. 24" RCP CULVERT	Bennett Ranch Regional Detention Pond
OF-1	OF-1	0.27	0.11	0.78	0%	OVERLAND	SOUTHEAST	EX-2	N/A	Bennett Ranch Regional Detention Pond
OF-2	OF-2	0.05	0.02	0.16	0%	OVERLAND	SOUTH	EX-6	N/A	Bennett Ranch Regional Detention Pond
OF-3	OF-3	0.54	0.13	0.98	0%	OVERLAND	SOUTHEAST	EX-7	N/A	Bennett Ranch Regional Detention Pond
OF-4	OF-4	0.11	0.04	0.29	0%	OVERLAND	SOUTHEAST	EX-14	N/A	Bennett Ranch Regional Detention Pond
OF-5	OF-5	0.06	0.02	0.13	0%	OVERLAND	SOUTH	EX-18	N/A	Bennett Ranch Regional Detention Pond
OF-6	OF-6	0.12	0.03	0.19	0%	OVERLAND	EAST	EX-19	N/A	Bennett Ranch Regional Detention Pond
Total		15.10								

PROPOSED SUB-BASIN DESCRIPTIONS

For the proposed condition, stormwater will generally maintain historic flow patterns. The proposed paving and grading will alter some of the existing flow paths. Proposed swales and inlets will capture runoff from the proposed improvements and be routed into a proposed manhole connection to an existing storm main located in Stapleton Drive. The storm main within Stapleton Drive is owned and maintained by El Paso County.

The proposed Site has been divided into 23 onsite basins, P-1 – P-8 and OS-1 – OS-15. The basins with “P” labels are proposed onsite improvements that will be captured within proposed storm infrastructure. The basins with “OS” labels are onsite basins where there are no improvements proposed. Runoff from basins with this label will either be captured in existing storm infrastructure or bypass the site per existing conditions. Additionally, there are 6 offsite basins, OF-1 – OF-6. These are basins that offsite flowing onsite.

In the proposed conditions, flows within the proposed sub-basins are captured by inlets, swales, and a French drain system. The proposed drainage map and hydrologic analysis can be found in the **Appendix**. Flows will generally follow historic drainage patterns and be captured by proposed storm infrastructure that ties into the existing storm main located in Stapleton Drive.

Final Drainage Report
Overlook Subdivision Filing No. 1, El Paso County, CO

Table 2: Proposed Stormwater Runoff Calculation and Sub-Basin Outfall Descriptions

DESIGN POINT	TRIBUTARY BASINS	AREA (AC)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)	% IMPERV	IMMEDIATE OUTFALL					EMERGENCY OVERFLOW PATH	LOCATION	ULTIMATE OUTFALL
						CONVEYANCE	CONVEYANCE DIRECTION	INLET TYPE	PROPOSED VS EXISTING	PUBLIC VS PRIVATE			
P-1	P-1	0.88	2.86	5.79	67%	C/G	EAST	TYPE C AREA INLET	PROPOSED	PRIVATE	P3	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-2	P-2	0.13	0.04	0.28	0%	CONCRETE PAN	WEST	NYOPLAST AREA INLET	PROPOSED	PRIVATE	P1	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-3	P-3	0.36	0.12	0.90	0%	SWALE	EAST & NORTH	TYPE C AREA INLET	PROPOSED	PRIVATE	P4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-4	P-4	1.08	2.32	5.33	50%	C/G	WEST & NORTH	TYPE D AREA INLET	PROPOSED	PRIVATE	P6	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-5	P-5	0.78	0.28	1.71	3%	SWALE	SOUTHEAST	TYPE C AREA INLET	PROPOSED	PRIVATE	P4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-6	P-6	0.15	0.09	0.40	9%	SWALE	SOUTH	TYPE C AREA INLET	PROPOSED	PRIVATE	P7	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-7	P-7	0.53	0.84	2.22	39%	SWALE	EAST	TYPE C AREA INLET	PROPOSED	PRIVATE	OS-4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
P-8	P-8	0.04	0.04	0.14	19%	OVERLAND	EAST	FRENCH DRAIN	PROPOSED	PRIVATE	P-6	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-1	OS-1	0.08	0.06	0.26	9%	SWALE	EAST	TYPE C AREA INLET	PROPOSED	PRIVATE	OS-3	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-2	OS-2	0.35	1.29	2.40	90%	ROOF DRAIN	NORTH	ROOF DRAIN	EXISTING	PRIVATE	OS-1	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-3	OS-3	0.77	0.40	1.59	15%	SWALE	EAST	N/A	N/A	N/A	OS-6	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-4	OS-4	2.28	2.61	6.45	46%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-8	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-5	OS-5	1.43	3.81	7.58	80%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-8	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-6	OS-6	1.74	0.70	3.17	10%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-7	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-7	OS-7	0.44	0.43	1.59	17%	OVERLAND	SOUTH	EX. 24" RCP CULVERT	EXISTING	PRIVATE	STAPLETON DRIVE	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-8	OS-8	0.62	0.26	1.26	8%	OVERLAND	SOUTH	EX. 24" RCP CULVERT	EXISTING	PRIVATE	STAPLETON DRIVE	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-9	OS-9	0.45	0.22	1.04	8%	OVERLAND	WEST	EX. 15" CMP CULVERT	EXISTING	PRIVATE	OS-4	SUMP	BENNETT RANCH REGIONAL DETENTION POND
OS-10	OS-10	0.74	0.19	1.40	0%	OVERLAND	SOUTH	N/A	N/A	N/A	STAPLETON DRIVE	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-11	OS-11	0.07	0.03	0.21	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	STAPLETON DRIVE	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-12	OS-12	0.03	0.01	0.09	0%	OVERLAND	WEST	EX. 5' TYPE R INLET	EXISTING	PUBLIC	MERIDIAN RANCH BLVD	ON-GRADE	BENNETT RANCH REGIONAL DETENTION POND
OS-13	OS-13	0.25	0.09	0.65	0%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-10	N/A	BENNETT RANCH REGIONAL DETENTION POND
OS-14	OS-14	0.16	0.76	1.37	100%	SEWER TREATMENT TANK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OS-15	OS-15	0.57	2.64	4.73	100%	SEWER TREATMENT TANK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OF-1	OF-1	0.06	0.02	0.14	0%	OVERLAND	WEST	N/A	N/A	N/A	OS-7	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-2	OF-2	0.12	0.03	0.19	0%	OVERLAND	NORTH	N/A	N/A	N/A	OS-8	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-3	OF-3	0.27	0.08	0.61	0%	OVERLAND	SOUTH	N/A	N/A	N/A	OS-13	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-4	OF-4	0.12	0.05	0.37	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	P-1	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-5	OF-5	0.47	0.14	1.04	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	P-2	N/A	BENNETT RANCH REGIONAL DETENTION POND
OF-6	OF-6	0.11	0.04	0.29	0%	OVERLAND	SOUTHWEST	N/A	N/A	N/A	OS-3	N/A	BENNETT RANCH REGIONAL DETENTION POND
Total		15.10											

DESIGN POINT COMPARISON ANALYSIS

Ultimate Design Point

The ultimate design point is the existing Bennett Ranch Regional Detention Pond. As shown in the chart below, the flows in the 5-year and the 100-year increase slightly between the existing and proposed conditions. Although there is a slight increase, per the Bennett Ranch DBPS, the Bennett Ranch Regional Detention Pond was sized to handle a larger runoff from the Site.

Table 3: Design Point Analysis

ULTIMATE DESIGN POINT	TRIBUTARY BASINS (EXISTING)	AREA (AC)	EXISTING 5-YR FLOW (CFS)	EXISTING 100-YR FLOW (CFS)	TRIBUTARY BASINS (PROPOSED)	AREA (AC)	PROPOSED 5-YR FLOW (CFS)	PROPOSED 100-YR FLOW (CFS)
Bennett Ranch Regional Detention pond	EX1-19, OF1-6	15.10	17.81	48.76	P1-8, OS1-15, OF1-6	15.10	20.44	53.22

DRAINAGE DESIGN CRITERIA

DEVELOPMENT CRITERIA REFERENCE

The proposed storm facilities are designed to be in compliance with El Paso County “Drainage Criteria Manual (DCM)” dated October 2018 (“the MANUAL”), El Paso County “Engineering Criteria Manual” (“the Engineering Manual”), Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs Drainage Criteria Manual dated May 2014 (“the Colorado Springs MANUAL”), and Mile High Flood District (MHFD), Urban Drainage and Flood Control District Drainage Criteria Manuals (UDFCDM), (Volumes 1, 2 and 3), prepared by Wright-McLaughlin Engineers, June 2001, with latest revisions.

Site drainage is not significantly impacted by such constraints as utilities or existing development.

HYDROLOGIC CRITERIA

The 5-year and 100-year design storm events were used in determining rainfall and runoff for the proposed drainage system per chapter 6 of the CRITERIA. Table 6-2 of the CRITERIA is the source for rainfall data for the 5-year and 100-year design storm events. Design runoff was calculated using the Rational Method for developed conditions as established in the CRITERIA and MANUAL. Runoff coefficients for the proposed development were determined using Table 6-6 of the CRITERIA by calculating weighted impervious values for each specific site basin as outlined.

HYDRAULIC CRITERIA

The proposed drainage facilities are designed in accordance with the CRITERIA and the MANUAL. Hydraulic calculations for inlet and street capacity were computed using MHFD spreadsheets for the 5-year and 100-year design storm events. The inlet size needed per basin to meet the basin’s developed flow was determined the calculated capacities. The inlet capacity calculations are provided in the **Appendix**.

Pipe flows, capacities, and hydraulic grade line calculations were computed for the 5-year and 100-year design storm events using StormCAD implementing the standard method headloss coefficients from the CRITERIA.

TAILWATER CONDITIONS

County as-built drawings or final drainage report for the existing public storm system is unavailable. Therefore, conservative assumptions were made to approximate the minor or major tailwater elevations of the existing public storm sewer system at the proposed private storm sewer outfall. The tailwater elevation utilized for the 5-year storm was determined using 80% of full flow depth of the existing 48" storm main (7,045.14') and the 100-year storm event was determined using a full flow depth of the existing 48" storm main (7,045.94').

THE FOUR STEP PROCESS

The Project was designed in accordance with the four-step process to minimize adverse impacts of urbanization, as outlined in the El Paso County Engineering Manual for BMP selection as noted below:

Step 1. Employ Runoff Reduction Practices – The Project is proposing stormwater improvements to the existing Site to better enhance runoff and conveyance throughout the Site. One way these drainage improvements increase runoff reduction is by adding natural swales on the edge of parking and drive isles to convey stormwater to area inlets by using natural swales, allowing for more percolation and infiltration. The proposed improvements are not anticipated to have negative impacts to downstream infrastructure.

Step 2. Provide a Water Quality Capture Volume – The use of the existing Bennett Ranch Regional Detention Pond will provide permanent water quality. Per table 7.2 and Figure 2-4 in the DBPS, the planned imperviousness for the Site is 95% with a commercial land use and flows are tributary to the Bennett Ranch Regional Detention Pond. Relevant excerpts from the Bennett Ranch DBPS can be found in the **Appendix**. In existing conditions, the imperviousness onsite is 34.03%, and with the proposed improvements, the imperviousness onsite is 36.47%. Since the overall imperviousness is below the 95% threshold that was planned for the Site, the Bennett Ranch Regional Detention Pond has the capacity to accommodate the additional imperviousness and therefore, runoff proposed.

Per ECM Appendix I Section 1.7.C.1.a., 20% of the development site or less than 1 acre can be excluded from providing water quality. From site calculations, 0.011 acres (490.05 sq ft) of disturbed area will not be able to be treated which is 0.64% of the disturbed area, meeting the requirement that less than 20% of the overall site can be excluded.

Step 3 Stabilize Drainageways– The site is located more than 500 feet away from any major drainageways so channel stabilization will not be provided with the improvements.

Step 4. Implement Site Specific and Other Source Control BMPs – The erosion control construction BMPs of the Project were designed to reduce contamination. Source control BMPs include the use of vehicle tracking control, culvert protection, stockpile management, and stabilized staging areas.

DRAINAGE FEES

FEES

The Project is within the Bennett Ranch (CHWS1200) Drainage Basin and since the Site has already been platted, El Paso County Drainage Basin fees do not apply.

SUMMARY

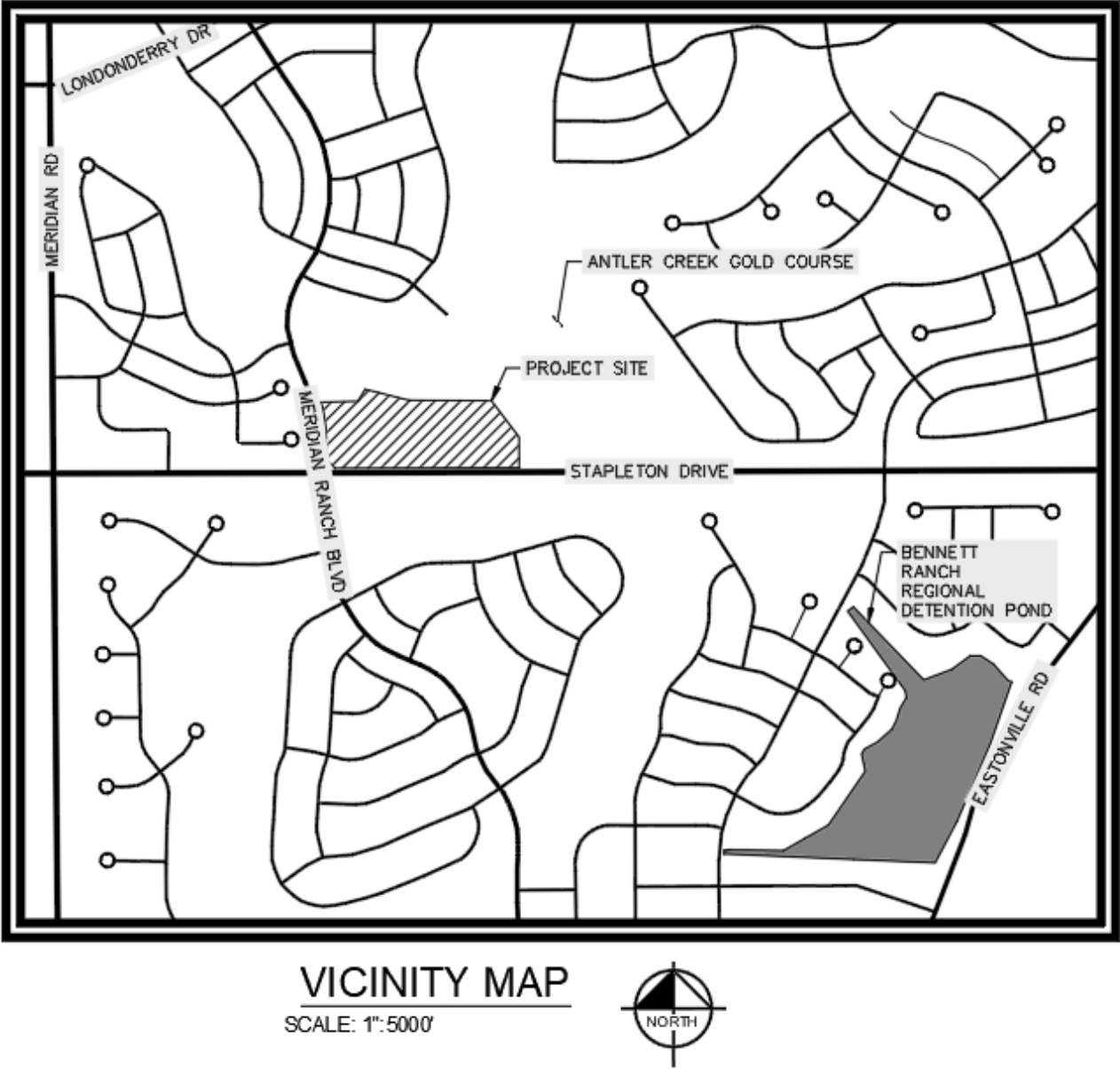
This report has been prepared in accordance with El Paso County stormwater criteria. It outlines the Site design for the 5-year and 100-year storm events drainage system. The drainage design presented within this report conforms to the criteria presented in the MANUAL. Additionally, the Site runoff will not adversely affect the downstream and surrounding developments.

REFERENCES

1. El Paso County "Engineering Criteria Manual" Volumes 1 & 2, dated October 31, 2018
2. Natural Resources Conservation Service, Web Soil Survey, dated June 2, 2026.
3. Urban Drainage and Flood Control District Drainage Criteria Manuals (UDFCDCM), (Volumes 1, 2 and 3), prepared by Wright-McLaughlin Engineers, June 2001, with latest revisions.
4. Flood Insurance Rate Map, El Paso County, Colorado and Incorporated Areas, Map Number 08041C0551G, Effective Date December 7, 2018, prepared by the Federal Emergency Management Agency (FEMA).
5. Bennett Ranch Pilot Project Drainage Basin Planning Study, by Stormwater & Environmental Consultants, Inc., Dated November 2001.
6. Draft Geotechnical Engineering Study Woodmen Hills Metro District Regional Water Reclamation Facility Stormwater Improvements, by Kumar & Associates, Inc., Dated June 19, 2026.

APPENDIX

APPENDIX A – VICINITY MAP

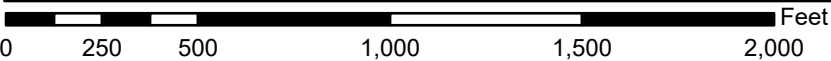
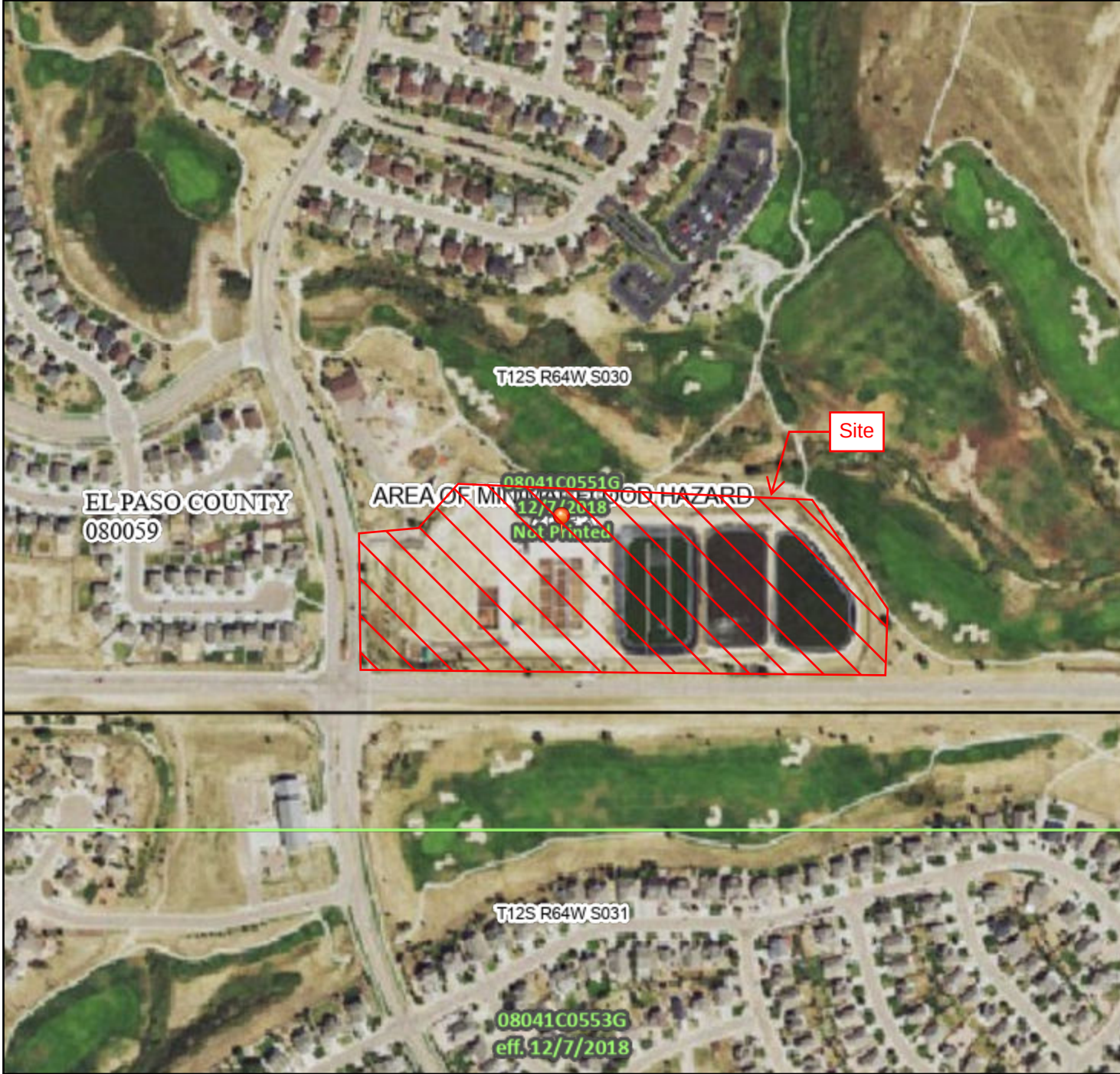


APPENDIX B – FEMA FIRM MAP

National Flood Hazard Layer FIRMette



104°36'16"W 38°58'29"N



1:6,000

104°35'38"W 38°58'1"N

Basemap Imagery Source: USGS National Map 2023

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 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Digital Data Available
MAP PANELS		No Digital Data Available
		Unmapped



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 6/3/2026 at 3:58 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.

APPENDIX C – GEOTECHNICAL REPORT



Kumar & Associates, Inc.®
Geotechnical and Materials Engineers
and Environmental Scientists

6735 Kumar Heights
Colorado Springs, CO 80918
phone: (719) 632-7009
email: kacolospgs@kumarusa.com
www.kumarusa.com

An Employee Owned Company

Office Locations: Denver (HQ), Parker, Colorado Springs, Fort Collins, Glenwood Springs, and Summit County, Colorado

GEOTECHNICAL ENGINEERING STUDY
WOODMEN HILLS METRO DISTRICT
REGIONAL WATER RECLAMATION FACILITY
STORMWATER IMPROVEMENTS
11866 STAPLETON DRIVE, PEYTON, COLORADO

Prepared By:

Arben F. Kalaveshi, P.E.

Reviewed By:


Duane P. Craft, P.E.



Prepared For:

Kimley-Horn
2 North Nevada Avenue, Suite 900
Colorado Springs, Colorado 80903

Attn: Katy Corkill, P.E.

Project No: 26-2-169

July 29, 2026

TABLE OF CONTENTS

SUMMARY	1
PURPOSE AND SCOPE OF STUDY.....	2
PROPOSED CONSTRUCTION	2
SITE CONDITIONS	2
SUBSURFACE CONDITIONS	2
GEOTECHNICAL CONSIDERATIONS.....	4
PIPELINE DESIGN PARAMETERS.....	5
SITE GRADING AND EARTHWORK.....	5
WATER SOLUBLE SULFATES	10
PAVEMENT DESIGN.....	10
SURFACE DRAINAGE	11
DESIGN AND SUPPORT SERVICES.....	12
LIMITATIONS	12

FIG. 1 – LOCATION OF EXPLORATORY BORINGS

FIG. 2 – LOGS OF EXPLORATORY BORINGS

FIG. 3 – LEGEND AND NOTES

FIGS 4, 5 – SWELL-CONSOLIDATION TEST RESULTS

FIGS 6, 7 – GRADATION TEST RESULTS

TABLE I – SUMMARY OF LABORATORY TEST RESULTS

SUMMARY

1. A total of 6 borings were drilled for this study, including 3 for the proposed stormwater line, and 3 for proposed paved areas. Below an intermittent layer of topsoil, existing fill was encountered in all of the borings and extended to depths of 1 to 7 feet below the existing ground surface. The underlying native soils were predominantly clean to silty sand but also included zones/lenses of sandy lean clay and clayey sand. Bedrock consisted of sandstone and claystone and was found at depths ranging from 10 to 21 feet. Bedrock extended to the maximum depth explored of 25 feet where it was encountered.
2. Groundwater was encountered in Borings 5 and 6 when measured the day of drilling, and in Borings 2, 4, 5, and 6 when measured 14 days later. The depth to water during our final measurements ranged from 6.9 to 13.7 feet below the ground surface. Groundwater is expected to fluctuate over time due to seasonal and other factors. Additionally, perched groundwater may develop within the granular soils overlying the less permeable bedrock, especially during wetter seasons, or after precipitation events.
3. Existing undocumented fill is present at this site and should be entirely removed and replaced where it is encountered below new construction such as the proposed RCP storm drain. No over-excavation will be necessary if such structures bear on native soils. Since pavements can generally tolerate settlement better than structures, and are easier to repair if movement occurs, a reduced over-excavation depth of 12 inches can be considered in these areas. Based on the samples of fill collected, it should be suitable for reuse if it is processed, moisture conditioned, and recompacted as described in the "Site Grading and Earthwork" section of this report.
4. For the design of the pipeline and drainpipe, we recommend a horizontal modulus of soil reaction (E') of 2,000 psi be used for initial deflection of the pipe zone material that has been compacted in accordance with the specifications listed in the "Site Grading and Earthwork" section.
5. Above a depth of 10 feet, thrust blocks used to resist thrust forces at horizontal bends in the pipe should be designed using a passive bearing pressure based on an equivalent fluid density of 250 pcf. The passive pressure should be calculated by multiplying the equivalent fluid density value by the depth in feet below the ground surface corresponding to the midpoint height of the face of the thrust block. For thrust blocks with a midpoint depth of 10 feet or more, a maximum allowable soil bearing pressure of 2,500 psf should be used.
6. The following pavement sections (HMA over ABC, and PCC over ABC) were determined using the AASHTO 1993 design method for flexible and rigid pavements. Details regarding binder type, and other considerations can be found within the body of this report.

Area	HMA ¹ over ABC ² (inches)	PCCP ³ over ABC ² (inches)
Site Pavements	5 over 6	6 over 4

1: HMA = Hot mix Asphalt

2: ABC = Aggregate base course

3: PCC = Portland cement concrete pavement

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the regional water reclamation facility expansion project. The project location is shown on Figure 1. The study was conducted in general accordance with the scope of work in our Proposal No. C26-173.R, dated April 14, 2026 for the purpose of providing geotechnical recommendations related to the proposed improvements.

This report has been prepared to summarize the data obtained during this study, and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to the proposed construction are included in the report.

PROPOSED CONSTRUCTION

We understand that the site improvements will include about 1,029 lineal feet of new 18 to 24-inch diameter RCP storm line, which will have invert elevations ranging from about 5 to 20 feet below the ground surface. Paved drive areas will encompass the facility and will include three connecting paths.

If the proposed construction varies significantly from that described above or depicted herein, we should be notified to reevaluate our recommendations.

SITE CONDITIONS

The existing site is located at the northeast corner of Meridian Ranch Boulevard and Stapleton Drive, and is about 12 acres in area. The native topography generally consists of rolling hills and prairie land, but the site has been graded flat to accommodate the facility. Slopes at the pond basins are about 3:1, and a shallower embankment slope exists around the north perimeter of the site. An operations and mechanical building is located near the northeast corner of the site, and is just north of concrete-walled treatment areas. Three aeration basins/polishing ponds are located to the east. An ephemeral tributary branch of the Gieck Ranch Drainage Basin is located just north of the site.

SUBSURFACE CONDITIONS

The field exploration for this study was conducted on June 8, 2026. Six exploratory borings were drilled at the locations shown on Fig. 1 to explore subsurface conditions and estimate groundwater

levels. The borings conducted for this study were advanced through the soils and into the underlying bedrock with 4-inch diameter continuous flight augers. The borings were logged by a representative of Kumar & Associates, Inc.

Samples of the soils and bedrock materials were taken with a 2-inch I.D. California barrel sampler. The sampler was driven into the various strata with blows from a 140-pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM Method D 1586. Penetration resistance values, when properly evaluated, indicate the relative density or consistency of the soils. Depths at which the samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Fig. 2.

Measurements of the water level were made in the borings by lowering a weighted tape measure into the open hole. Measurements were made shortly after completion of drilling, and again 14 days later. The depths at which water was encountered are shown on the following table. Groundwater will fluctuate over time due to seasonal and other factors. Additionally, perched groundwater may develop within the granular soils overlying the less permeable bedrock, especially during wetter seasons, or after precipitation events.

Table: Measured Water Levels

Boring	Water Level at Time of Drilling (feet)	Water Level During Final Measurement (feet)
1	(dry)	(backfilled)
2	(dry)	6.9
3	(dry)	(backfilled)
4	(dry)	9.4
5	19.0	13.1
6	14.0	13.7

Below an intermittent layer of topsoil, existing fill was encountered in all of the borings, and extended to depths of 1 to 7 feet below the existing ground surface. The underlying native soils were predominantly clean to silty sand but also included zones/lenses of clayey sand and sandy lean clay. Bedrock consisted of sandstone and claystone and was found at depths ranging from 10 to 21 feet. Bedrock extended to the maximum depth explored of 25 feet where it was encountered. The following paragraphs provide more detailed descriptions of the major soil and

bedrock types encountered. Figs 2 and 3 provide additional information, and detailed depictions of the depths at which each material was encountered.

The existing fill included clayey sand, clayey silty sand, silty sand, and well graded gravel with silt. These soils were fine to coarse grained, and included gravel. They were dry to moist, and mottled browns and grays. The exact vertical and lateral extents of the existing fill are unknown, and were not considered the scope of this study.

The predominant soil type encountered was well graded sand with silt. This soil was fine to coarse grained, medium dense to dense, moist to wet, and light brown to gray. Occasional lenses/zones of sandy lean clay, clayey sand, and silty sand were also encountered throughout the overburden layer. The sandy lean clay was fine to coarse grained with occasional gravel, medium stiff to very stiff, moist, and dark brown in color. The clayey sand was fine to coarse grained, medium dense, moist to wet, and light gray to brown. The silty sand was fine to coarse grained, loose, moist, and light gray. The samples of sandy lean clay tested exhibited nil to low swell potential upon wetting under a surcharge of 200 psf.

The underlying bedrock was predominantly sandstone, but claystone was found near the bottom of Boring 5. The sandstone was poorly cemented, fine to coarse grained, hard to very hard, moist to very moist, and light gray to brown. The claystone was fine grained, very hard, moist, and blue-gray.

GEOTECHNICAL CONSIDERATIONS

Based on the data collected during our subsurface exploration and the results of our laboratory testing, the subsurface materials do not appear to present a significant risk of heave related movement.

Existing undocumented fill is present at this site and should be entirely removed and replaced where it is encountered below new construction such as the proposed RCP storm drain. No over-excavation will be necessary if such structures bear on native soils. Since pavements can generally tolerate settlement better than structures, and are easier to repair if movement occurs, a reduced over-excavation depth of 12 inches can be considered in these areas. Based on the samples of fill collected, it should be suitable for reuse if it is processed, moisture conditioned, and recompacted as described in the "Site Grading and Earthwork" section of this report. If minor

amounts of clay are encountered, it should be thoroughly mixed with the sand to provide a consistent material, but where large zones of clay is encountered, it should be removed, and should not be reused under pipelines, or other structures that are sensitive to movement.

PIPELINE DESIGN PARAMETERS

As discussed in this report, we understand that the new stormwater line will be an 18 to 24-inch diameter RCP line installed using traditional cut and cover trenching methods. We recommend a horizontal modulus of soil reaction (E') of 2,000 psi be used for initial deflection of the pipe zone material that has been compacted in accordance with the specifications listed in the "Site Grading and Earthwork" section below.

Above a depth of 10 feet, thrust blocks used to resist thrust forces at horizontal bends in the pipe should be designed using a passive bearing pressure based on an equivalent fluid density of 250 pcf. The passive pressure should be calculated by multiplying the equivalent fluid density value by the depth in feet below the ground surface corresponding to the midpoint height of the face of the thrust block. For thrust blocks with a midpoint depth of 10 feet or more, a maximum allowable soil bearing pressure of 2,500 psf should be used.

Where clay is encountered at the base of the proposed pipeline excavation, it should be removed and replaced with suitable material to a depth of at least 3 feet. Clay fill should only be reused if it can be demonstrated to meet the requirements listed in Item 6 (Material Suitability) of the "Site Grading and Earthwork" section.

SITE GRADING AND EARTHWORK

Fill Material Specifications: The following material specifications are presented for fills on the project site.

1. *Select Fill:* The on-site soils, including minor amounts of clay will be suitable for reuse as select fill. Import soils if used, should consist of a non-expansive soil, consisting of a minus 2-inch material that has a maximum of 35 percent passing the No. 200 sieve, and a maximum plasticity index of 15. New fill should extend down from the edges of the foundations at a minimum 1:1 horizontal to vertical projection.

2. *Common Fill:* The sands and clays encountered at this site will be suitable for reuse as backfill material within areas where no structures or movement sensitive construction will occur if it is properly processed and adequately moisture conditioned and compacted. If imported material is needed for common fill areas, additional testing may be necessary to ensure it meets the suitability requirements outlined in Item 6 below.
3. *Pipe Bedding Material:* The use and requirements for bedding material should be in accordance with the pipe manufacturer's recommendations, local building authority, or utility district requirements. In the absence of such guidance, we recommend the pipe bedding consist of imported granular bedding material intended for bedding and pipe embedment zone fill. Bedding and embedment zone material may consist of a rounded granular gravel or sand with a maximum size of 3/8 inch, less than 25% passing the No. 50 sieve, and less than 5% passing the No. 200 sieve. The on-site soils encountered do not meet these criteria. The bedding layer should be of adequate thickness to fully support the pipes when seated on top of the bedding.
4. *Pipe Zone Backfill:* The pipe-zone material placed above the bedding and surrounding the pipe should consist of granular material similar to that described above for pipe bedding, and should be compacted to at least 75% relative density (as determined by ASTM D 4253 and ASTM D 4254), and in accordance with requirements of the pipe manufacturer, to provide the required support around the pipe and to help mitigate potential bedding settlement zones. Portions of the pipeline bedding not below current or proposed roadways should be compacted to at least 70% relative density. Special care should be taken to provide adequate compaction below the haunches of the pipe using a concrete vibrator, vibratory plates or other light compaction equipment as needed. In confined areas of the pipeline where compaction is difficult, placement of a cementitious flowable fill around the pipe should be considered. Seepage collars should also be considered in trenches where a significant flow path may develop.
5. *Trench Backfill:* The on-site soils or suitable soil imported to the site can be used as backfill above the pipe zone. Clays should not be placed within 2 feet below pavement subgrade. The use of claystone bedrock that does not break down into a soil-like material may be considered as trench backfill above the embedment material in undeveloped areas where a greater amount of heave can be tolerated at the surface. The backfill should be compacted according to the specifications listed in the "Compaction Requirements"

subsection below. The moisture content of the in-situ materials will need to be adjusted prior to placement.

6. **Material Suitability:** Unless otherwise defined herein, all fill material should be non- to low-swelling, free of vegetation, brush, sod, trash and debris, and other deleterious substances, and should not contain rocks or lumps having a diameter of more than 4 inches. A fill material should be considered non-expansive if the swell potential under a 200 psf surcharge pressure does not exceed ½ percent when a sample remolded to 95 percent of the standard Proctor (ASTM D 698) maximum dry density at optimum moisture content is wetted.
7. **Subgrade Preparation:** The ground surface shall be stripped of all vegetation/organics or other deleterious material prior to fill placement. The resulting ground surface should be scarified to a depth of 12 inches, moisture conditioned as necessary, and compacted in a manner specified below for the subsequent layers of fill. Loose or unstable soils shall be removed, where present, in order to provide a stable platform prior to placement of fill. Scarification and re-compaction will not be necessary at the bases of trenches.

Compaction Requirements: A representative of the geotechnical engineer should observe fill placement operations on a full-time basis. We recommend the following minimum compaction criteria be used on the project.

Table: Compaction Specifications

Area	Percentage of Proctor Maximum Dry Density	
	Standard (ASTM D698)	Modified (ASTM D1557)
Aggregate Base Course	-	95%
Utility Trenches, Exterior Flatwork, Fill placed for Site Grading, and Beneath Paved Areas	95%	90%
Landscape and Other Misc. Overlot Fill Areas	95%	90%
Compaction of fill materials should be achieved at a moisture content within +0 to +3% of the optimum moisture content for cohesive soils, and within -2 to +2 percent for granular soils.		

Grading During Inclement Weather: If grading occurs during the time of year with freezing temperatures, fill should not contain frost or be placed on frozen ground. A loose lift or blanket of soil should be placed on prepared subgrade at the end of day to protect against frost, and the presence of frost should be checked at the beginning of each day. Any frost should be removed prior to placement of new fill. During periods of precipitation, excessive wetting of building pad and pavement subgrades should be avoided. Measures should be implemented to keep surface runoff from ponding in subgrade areas, to include usage of diversion berms, creation of temporary low areas where water can be directed and removed by pumping, or other methods as appropriate.

Permanent Cut and Fill Slopes: Permanent unretained cuts in the soils and bedrock may be constructed at slopes of up to 3 horizontal to 1 vertical. The risk of slope instability will be significantly increased if seepage is encountered in cuts. If seepage is encountered, we should be retained to evaluate if the seepage will adversely affect the slope stability cut slopes. No formal stability analyses were performed to evaluate the slopes recommended above. Published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety. If a detailed stability analysis is required, we should be notified.

To provide a uniform base for fill placement, the ground surface underlying all fills should be carefully prepared as specified in this section (Subgrade Preparation, above). Fills should be benched into cuts or natural slopes exceeding 4H:1V. Vertical bench heights should be between 2 and 4 feet.

Good surface drainage should be provided around all permanent cuts and fills to direct surface runoff away from the slope faces. Fill slopes cut slopes and other stripped areas should be protected against erosion by revegetation or other methods.

Excavation Considerations: It is our opinion that the soils and bedrock can be excavated with conventional heavy-duty equipment. Specialized excavation methods such as pneumatic chiseling may be necessary for confined areas, or if well cemented bedrock is encountered.

All excavations should be made in accordance with OSHA, State, and local requirements. The contractor should follow appropriate safety precautions. The following guidelines are provided for planning purposes. Actual soil conditions should be verified at the time of excavation. If subsurface conditions that are different from those indicated in this report are encountered, the

OSHA soil type may vary, and the required cut slopes may need to be adjusted. The contractor's "competent person" should make decisions regarding excavation slopes.

Based on the subsurface conditions encountered in our borings, the soils will generally classify as Type C materials. The bedrock will likely classify as a Type B material. Per OSHA criteria, temporary unretained excavations should have slopes no steeper than those listed in the following table for each soil type.

Table: Maximum Temporary Cut Slopes

OSHA Soil Type	Maximum Temporary Cut Slope (H:V)
A	$\frac{3}{4}:1$
B	1:1
C	$1\frac{1}{2}:1$

A properly braced excavation or the use of an approved trench box should be used where the indicated unretained slopes cannot be accommodated. Flatter slopes will be required where groundwater seepage or fissuring is encountered, or where static or vibratory loads are present. OSHA regulations require that excavations greater than 20 feet in depth be designed by a professional engineer.

Groundwater will likely be a consideration during excavation in some areas, and a dewatering system may be necessary. A dewatering system consisting of trenches flowing into sumps where the water can be discharged using pumps will likely be adequate, but a more robust system such as well points may be necessary if high volumes of water are encountered.

It is assumed site dewatering would occur in advance of the excavation and be maintained the entire duration that the excavation is open. Surface drainage should be diverted away from all temporary cut slopes in order to reduce the potential for slope erosion and instability.

Subgrade Stabilization: Unstable subgrade material is not anticipated, but may be encountered at the base of the proposed fill in some areas. Unstable soils may be stabilized by scarifying/ripping the subgrade and allowing them to dry, or by over-excavation and replacement of the subgrade with suitable, imported, angular, well-graded materials if they are encountered. Other alternatives include the use of Type 2 biaxial geogrid reinforcement in combination with a

layer of Class 6 aggregate base course. It has been our experience that the use of a crushed concrete product meeting a Class 6 gradation can perform well when trying to achieve stabilization. Specific stabilization requirements should be evaluated at the time of construction.

Proof Rolling: Wherever possible, the foundation subgrade should be proof rolled with a heavily loaded pneumatic-tired vehicle with a gross vehicle weight of at least 50,000 pounds, a single axle weight of 18,000 pounds, and a tire pressure of 100 psi. Pavement design procedures assume a stable subgrade. Areas that deform under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade.

WATER SOLUBLE SULFATES

The concentration of water soluble sulfates measured in representative samples obtained from the exploratory borings was 0.02 percent or less. Water soluble sulfate concentrations of 0.10 percent or less represent a Class S0 severity of exposure to sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of Class S0 to Class S3 severity of exposure as presented in ACI 201. Based on the laboratory data and our experience, we recommend all concrete exposed to the on-site materials meet the cement requirements for Class S0 exposure as presented in ACI 201. Alternatively, the concrete could meet the Colorado Department of Transportation's (CDOT) cement requirements for Class S0 exposure as presented in Section 601.04 of the CDOT Standard Specifications for Road and Bridge Construction.

PAVEMENT DESIGN

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils, pavement section, and traffic loadings. The number and magnitude of wheel loads are major factors for pavement design.

Subgrade Materials: A resilient modulus of 3,562 psi, based on an estimated R-value of 10 was used for design of the flexible sections, and a corrected modulus of subgrade reaction of 23 pci was used for the design of rigid sections.

Design Traffic: For the purpose of our study, we have considered an 18-kip, 20 year ESAL value of 73,000 based on the assumption that traffic would largely consist of automobiles and light trucks, with occasional heavy trucks and service vehicles. If it is determined that actual traffic

volume is significantly different from the estimated values presented, we should be contacted to reevaluate the pavement thickness design presented in this report.

Pavement Sections: The following pavement section (HMA over ABC, and PCC over ABC) were determined using the AASHTO 1993 design method for flexible and rigid pavements.

Table: Flexible Pavement Section Thickness

Area	HMA ¹ over ABC ² (inches)	PCCP ³ over ABC ² (inches)
Site Pavements	5 over 6	6 over 4

1: HMA = Hot mix Asphalt

2: ABC = Aggregate base course

3: PCC = Portland cement concrete pavement

Pavement Materials: The asphalt pavement should consist of a bituminous material which meets the local jurisdictional requirements, and CDOT Specifications for Road and Bridge Construction. Aggregate base course should meet the requirements of a CDOT Class 6. A Superpave S or SX mix with a design gyration N value of 75, and a binder performance grade of 58-28 should be used.

A minimum lift thickness of 2-inches for SX and 3-inches for S mixes are recommended. Lift thickness should not exceed 3 inches unless pneumatic or vibratory rollers are used.

SURFACE DRAINAGE

The collection and diversion of surface drainage away from paved and constructed areas is extremely important to their satisfactory performance. Drainage design should provide for the removal of water from paved areas and prevent the wetting of the subgrade soils both during and after construction, and should follow recommendations provided by local, state and national entities. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying of the pavement subgrades should be avoided both during and after construction. It may be necessary to grade temporary drainage paths, and to construct berms to facilitate this during construction.

2. Good surface drainage should be provided within all ground surfaces and pavements, and around all cuts and fills to direct surface runoff away from these areas. Slopes and other stripped areas should be protected against erosion by paving, re-vegetation or other means.

DESIGN AND SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in this report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project and, if necessary, perform additional studies to accommodate any changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document that the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study.

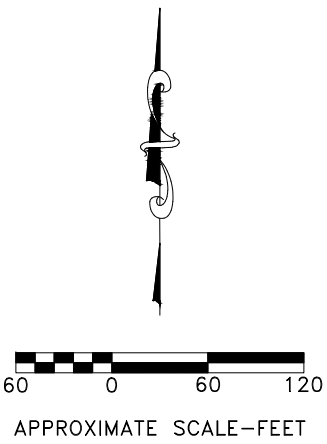
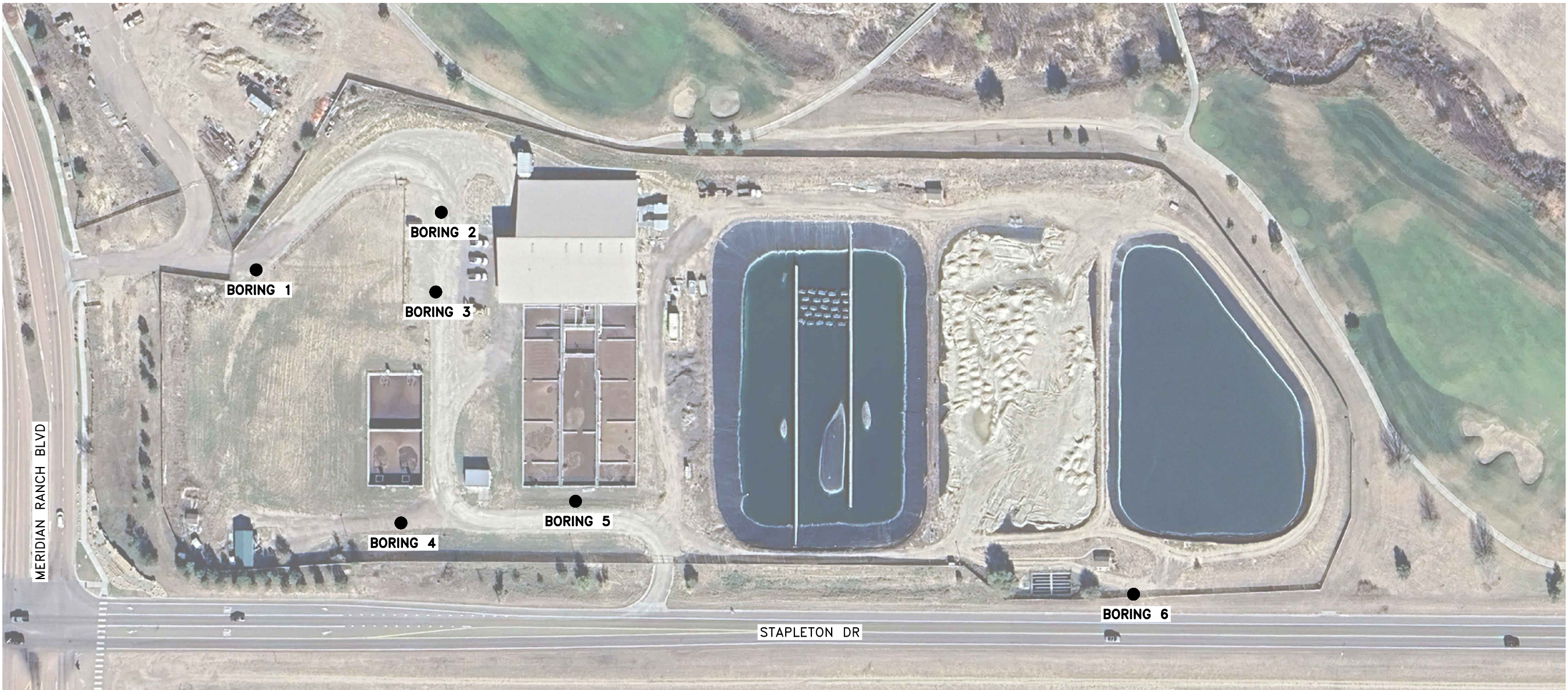
LIMITATIONS

This study has been conducted for exclusive use by the client for geotechnical related design and construction criteria for the project. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Fig. 1 or as described in the report, and the proposed type of construction. This report may not reflect subsurface variations that occur between the exploratory borings, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

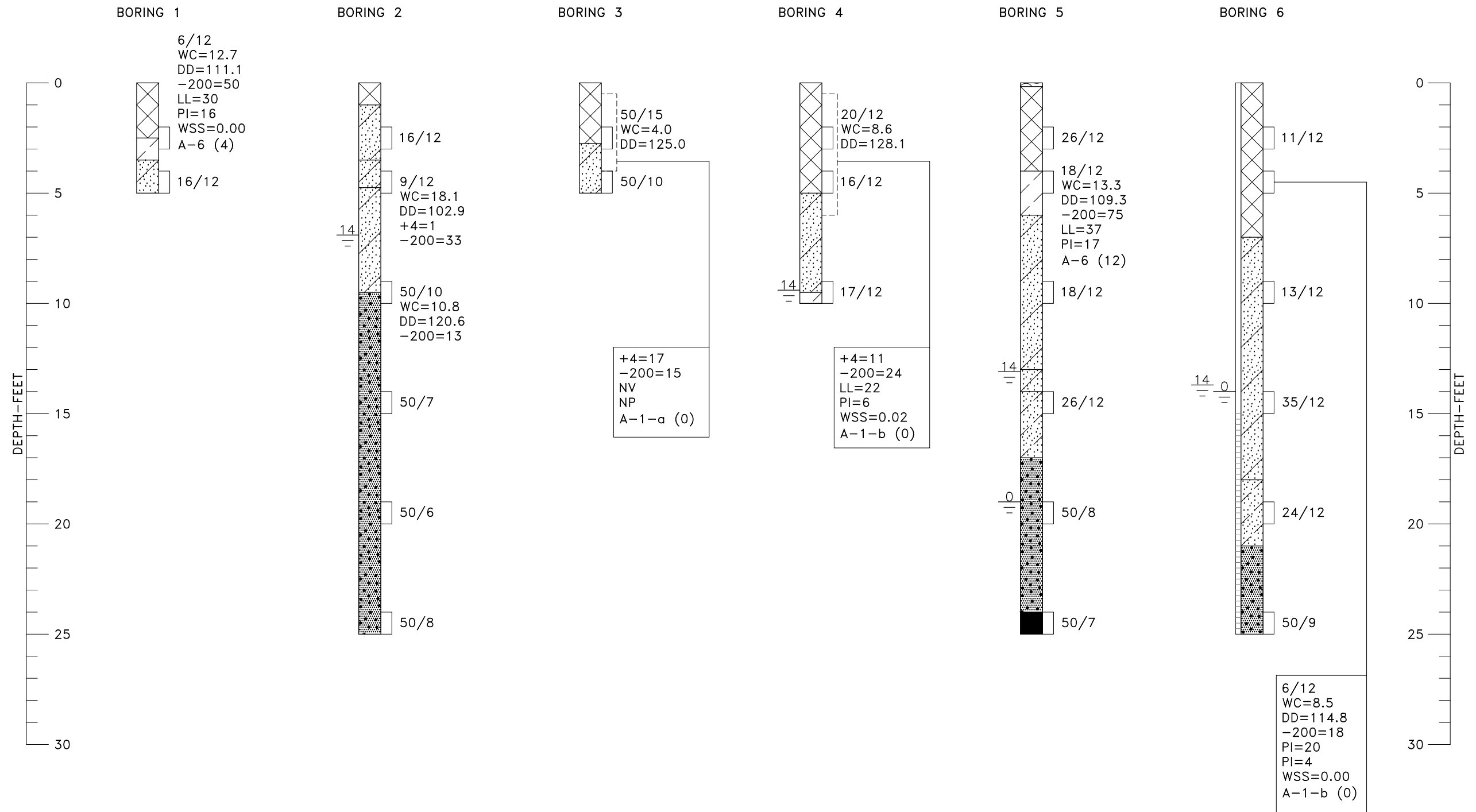
The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions, or the presence, prevention or possibility of mold or other biological contaminants (MOBC) developing in the future. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

AFK/sw

July 29, 2026 - 06:44am
C:\Users\mromero\AppData\Local\Temp\AcPublish_29808\262169-01.dwg



July 29, 2026 - 06:44am
V:\Projects\Den Current 2026- (ENG)\2026\26-2-169 WHMD RWRF\Drafting\262169-02 to 03.dwg



July 29, 2026 - 06:44am
V:\Projects\Den Current 2026- (ENG)\2026\26-2-169 WHMD RWRF\Drafting\262169-02 to 03.dwg

LEGEND



TOPSOIL.



FILL: CLAYEY SAND (SC), SILTY SAND (SM), SILTY CLAYEY SAND (SC-SM), WELL GRADED GRAVEL WITH SILT (GW-GM), FINE TO COARSE GRAINED WITH GRAVEL, DRY TO MOIST, MOTTLED BROWNS AND GRAYS.



SANDY LEAN CLAY (CL), FINE TO COARSE GRAINED, WITH OCCASIONAL GRAVEL, MEDIUM STIFF TO VERY STIFF, MOIST, DARK BROWN.



CLAYEY SAND (SC), FINE TO COARSE GRAINED, MEDIUM DENSE, MOIST TO WET, LIGHT GREY TO BROWN.



SILTY SAND (SM), FINE TO COARSE GRAINED, LOOSE, MOIST, LIGHT GRAY.



WELL GRADED SAND WITH SILT (SW-SM), WITH OCCASIONAL LENSES OF CLAY, FINE TO COARSE GRAINED, MEDIUM DENSE TO DENSE, MOIST TO WET, LIGHT BROWN TO GRAY.



SANDSTONE BEDROCK, POORLY CEMENTED, FINE TO COARSE GRAINED, HARD TO VERY HARD, MOIST TO VERY MOIST, LIGHT GRAY TO BROWN.



CLAYSTONE BEDROCK, FINE GRAINED, VERY HARD, MOIST, BLUE-GRAY.



DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.



DISTURBED BULK SAMPLE.



INDICATES PERFORATED PVC PIPE INSTALLED IN BORING TO DEPTH SHOWN.

6/12

DRIVE SAMPLE BLOW COUNT. INDICATES THAT 6 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

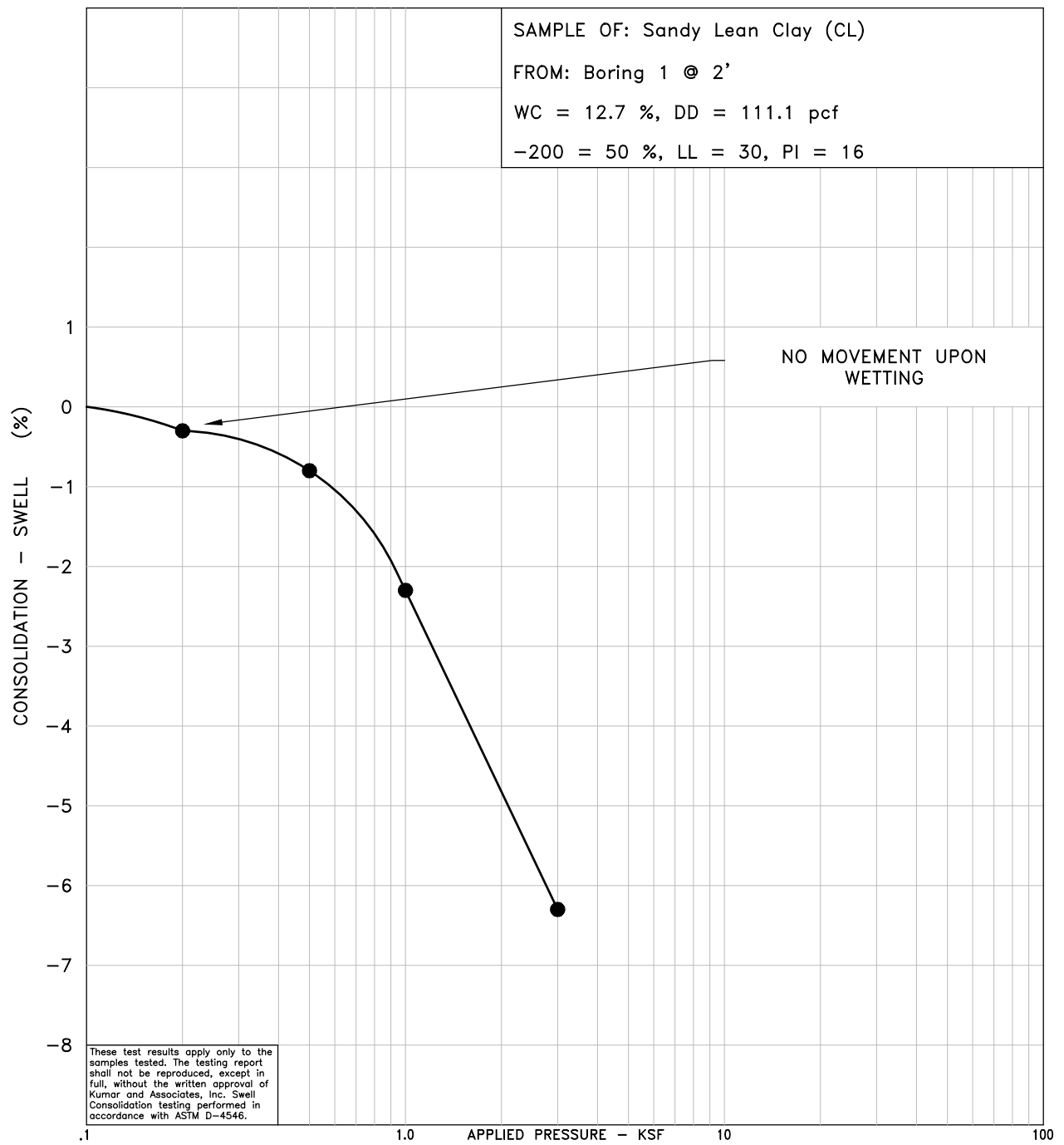


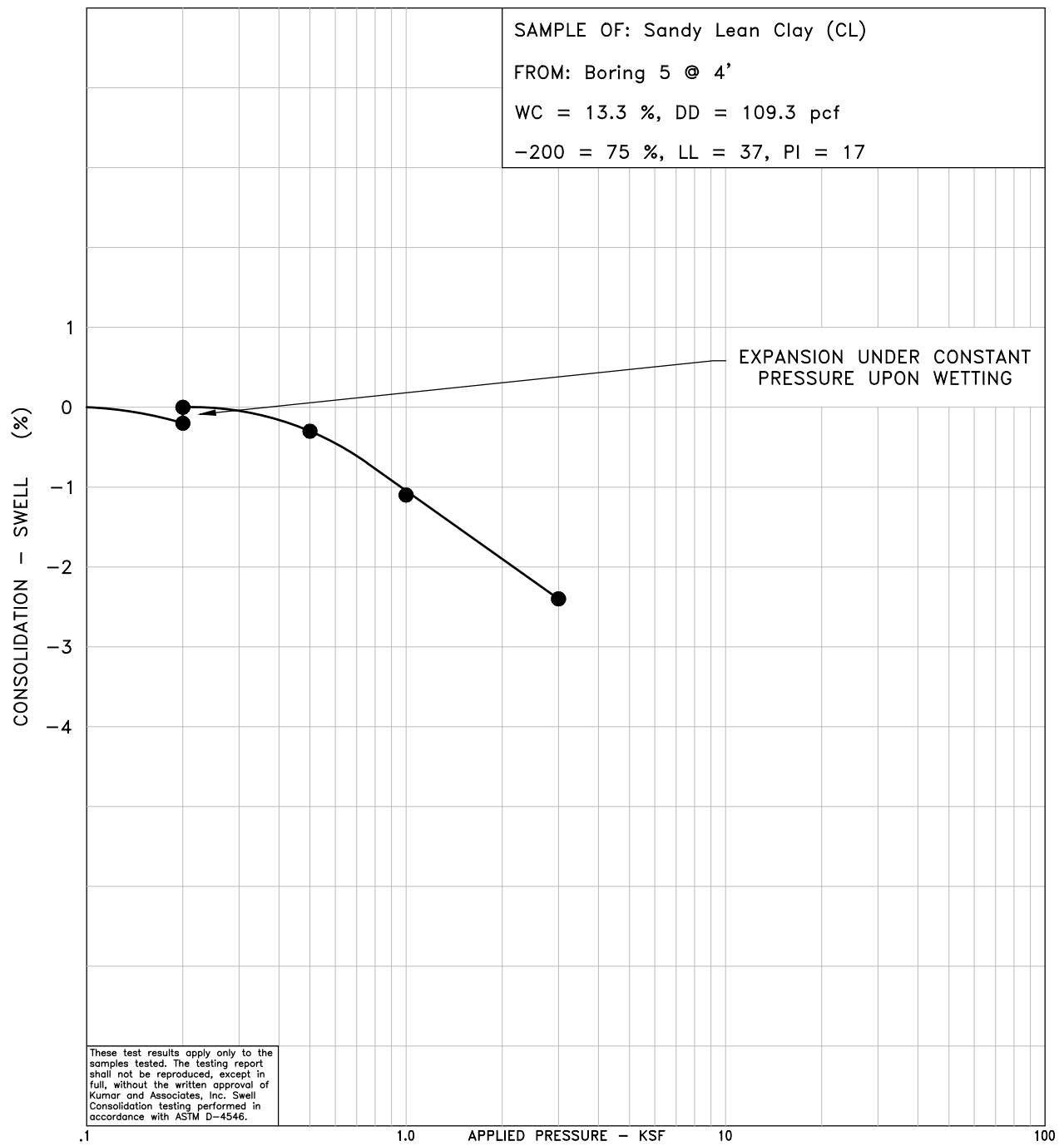
DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

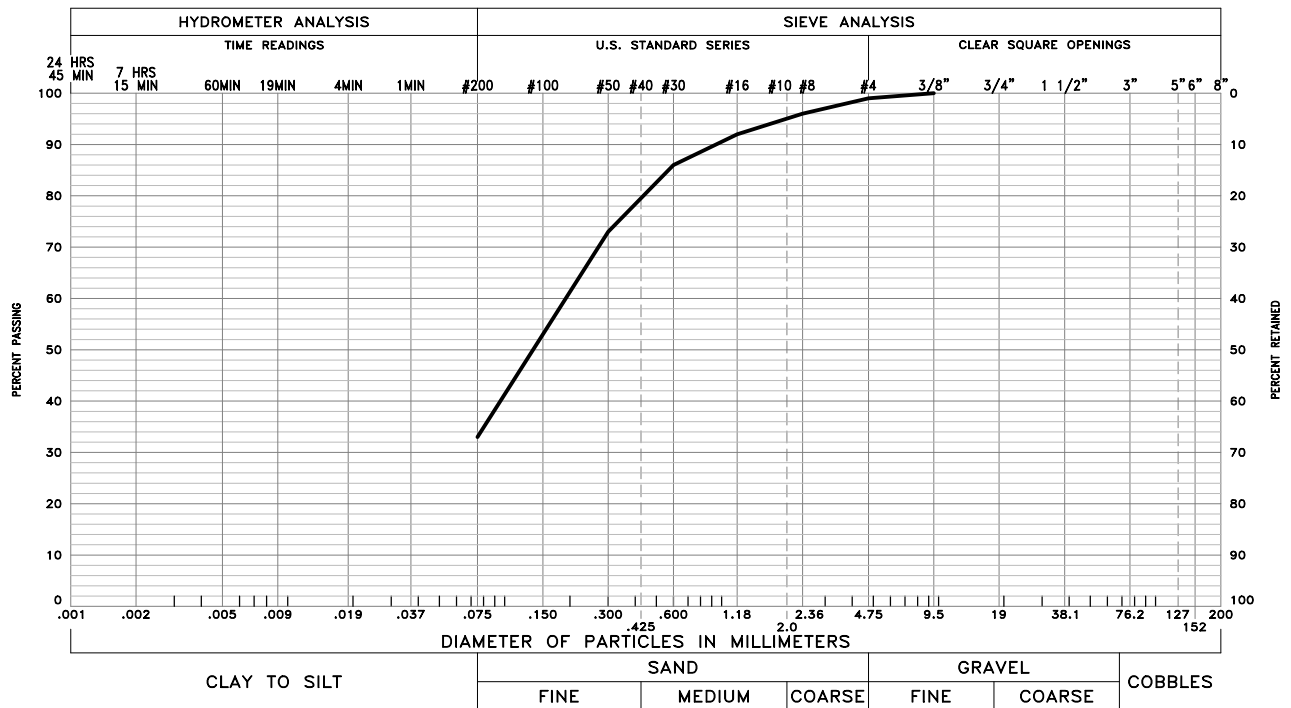
NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON JUNE 8, 2026 WITH A 4-INCH-DIAMETER CONTINUOUS-FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY HANDHELD GPS DEVICE.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.
4. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
5. GROUNDWATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
6. LABORATORY TEST RESULTS:
WC = WATER CONTENT (%) (ASTM D2216);
DD = DRY DENSITY (pcf) (ASTM D2216);
+4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D6913);
-200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
LL = LIQUID LIMIT (ASTM D4318);
PI = PLASTICITY INDEX (ASTM D4318);
NP = NON-PLASTIC (ASTM D4318);
WSS = WATER SOLUBLE SULFATES (%) (CP-L 2103).

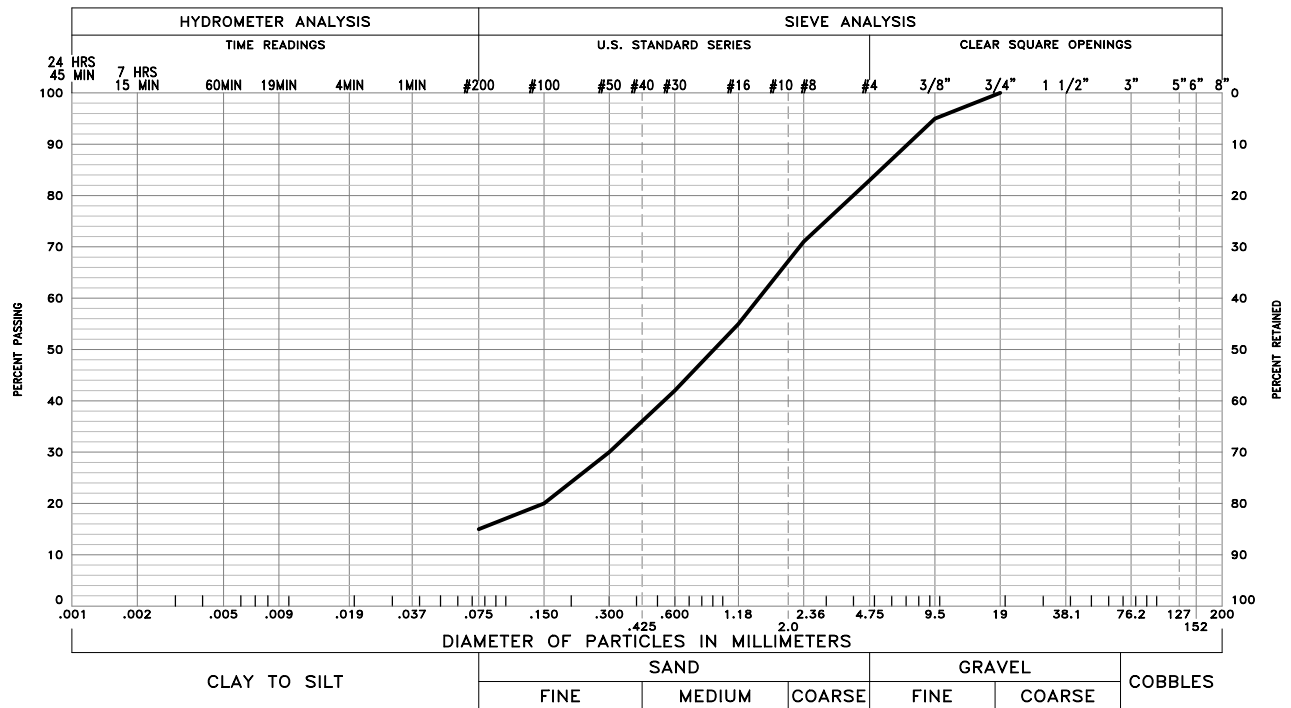
July 29, 2026 - 06:44am
V:\Projects\Den Current 2026- (ENG)\2026\26-2-169 WHMD RWRF\Drafting\262169-04 to 05.dwg





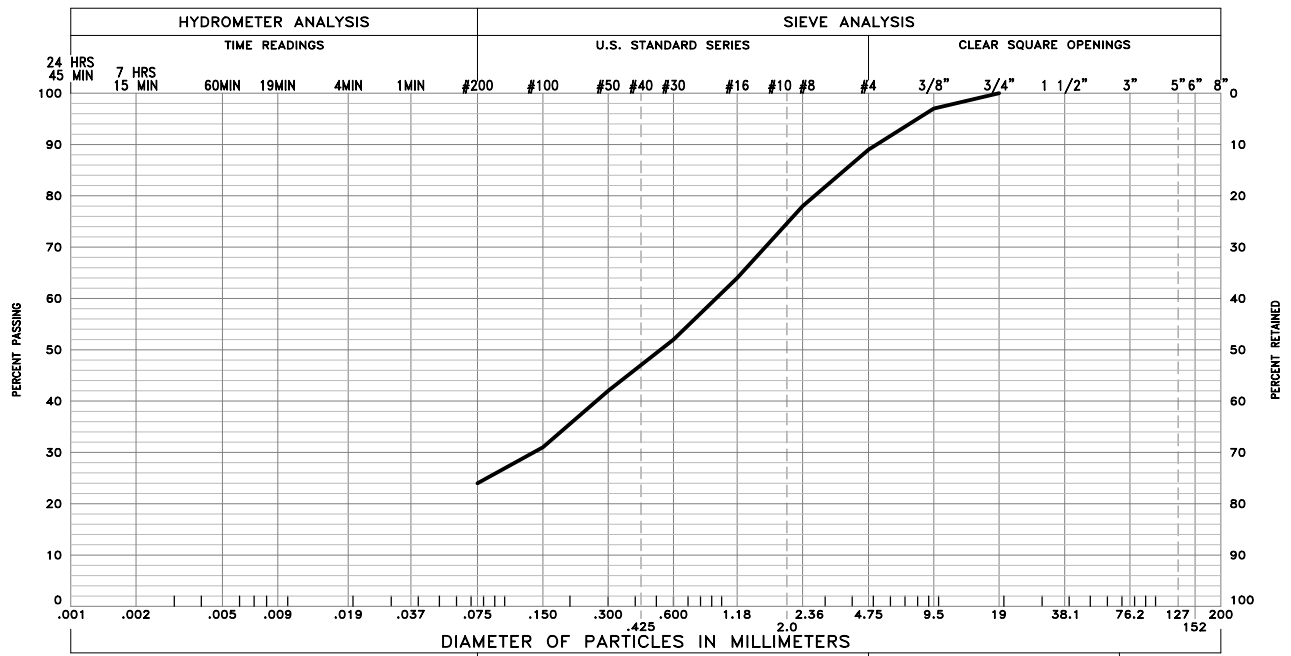


GRAVEL 1 % SAND 66 % SILT AND CLAY 33 %
 LIQUID LIMIT - PLASTICITY INDEX -
 SAMPLE OF: Silty Sand (SM) FROM: Boring 2 @ 4'



GRAVEL 17 % SAND 68 % SILT AND CLAY 15 %
 LIQUID LIMIT NV PLASTICITY INDEX NP
 SAMPLE OF: Fill: Silty Sand (SM) FROM: Boring 3 @ 0.5'-4'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



GRAVEL 11 % SAND 65 % SILT AND CLAY 24 %

LIQUID LIMIT 22 PLASTICITY INDEX 6

SAMPLE OF: Fill: Silty Clayey Sand (SC-SM) FROM: Boring 4 @ 0.5'-6'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.

Kumar and Associates, Inc.

TABLE I

Page 1 of 1

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 26-2-169

Project Name: WHMD RWRF Stormwater Improvements

Date Sampled: 6/8/2026

Date Received: 7/7/2026

[illegible]

APPENDIX D – HYDROLOGY



NOAA Atlas 14, Volume 8, Version 2
Location name: Peyton, Colorado, USA*
Latitude: 38.9709°, Longitude: -104.5991°
Elevation: 7053 ft**
* source: ESRI Maps
** source: USGS



POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffrey Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

[PF tabular](#) | [PF graphical](#) | [Maps & aerals](#)

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.238 (0.191-0.299)	0.290 (0.232-0.365)	0.380 (0.303-0.480)	0.459 (0.364-0.582)	0.575 (0.443-0.760)	0.670 (0.503-0.895)	0.769 (0.557-1.05)	0.874 (0.607-1.23)	1.02 (0.682-1.47)	1.14 (0.738-1.66)
10-min	0.349 (0.279-0.438)	0.425 (0.340-0.535)	0.557 (0.444-0.702)	0.673 (0.533-0.852)	0.842 (0.648-1.11)	0.980 (0.736-1.31)	1.13 (0.816-1.54)	1.28 (0.889-1.80)	1.50 (0.998-2.16)	1.66 (1.08-2.43)
15-min	0.425 (0.341-0.535)	0.518 (0.414-0.652)	0.679 (0.541-0.856)	0.820 (0.650-1.04)	1.03 (0.791-1.36)	1.20 (0.897-1.60)	1.37 (0.995-1.88)	1.56 (1.08-2.19)	1.82 (1.22-2.63)	2.03 (1.32-2.96)
30-min	0.609 (0.487-0.765)	0.741 (0.593-0.933)	0.970 (0.773-1.22)	1.17 (0.928-1.48)	1.46 (1.13-1.93)	1.70 (1.28-2.27)	1.95 (1.41-2.67)	2.22 (1.54-3.11)	2.59 (1.73-3.73)	2.88 (1.87-4.19)
60-min	0.780 (0.624-0.981)	0.935 (0.748-1.18)	1.21 (0.967-1.53)	1.46 (1.16-1.86)	1.84 (1.43-2.45)	2.16 (1.63-2.90)	2.50 (1.82-3.44)	2.87 (2.00-4.05)	3.40 (2.27-4.91)	3.82 (2.48-5.56)
2-hr	0.951 (0.767-1.19)	1.13 (0.910-1.41)	1.46 (1.17-1.82)	1.76 (1.40-2.21)	2.23 (1.74-2.95)	2.62 (1.99-3.50)	3.06 (2.24-4.18)	3.53 (2.48-4.95)	4.20 (2.84-6.05)	4.76 (3.11-6.88)
3-hr	1.04 (0.846-1.30)	1.22 (0.991-1.52)	1.57 (1.26-1.95)	1.89 (1.52-2.37)	2.41 (1.90-3.20)	2.86 (2.19-3.82)	3.36 (2.48-4.59)	3.91 (2.76-5.47)	4.70 (3.20-6.76)	5.36 (3.52-7.73)
6-hr	1.21 (0.990-1.49)	1.40 (1.15-1.73)	1.78 (1.45-2.20)	2.16 (1.74-2.67)	2.76 (2.20-3.64)	3.29 (2.54-4.37)	3.88 (2.90-5.28)	4.55 (3.25-6.34)	5.52 (3.79-7.89)	6.33 (4.20-9.07)
12-hr	1.40 (1.15-1.71)	1.63 (1.34-1.99)	2.06 (1.69-2.53)	2.49 (2.03-3.06)	3.17 (2.55-4.15)	3.77 (2.94-4.97)	4.44 (3.34-5.98)	5.18 (3.73-7.16)	6.26 (4.33-8.88)	7.16 (4.79-10.2)
24-hr	1.62 (1.34-1.96)	1.90 (1.57-2.30)	2.41 (1.99-2.93)	2.90 (2.38-3.53)	3.65 (2.95-4.71)	4.31 (3.37-5.60)	5.02 (3.80-6.69)	5.80 (4.21-7.94)	6.93 (4.83-9.74)	7.86 (5.30-11.1)
2-day	1.88 (1.57-2.25)	2.22 (1.85-2.66)	2.82 (2.35-3.39)	3.37 (2.79-4.07)	4.20 (3.40-5.34)	4.90 (3.86-6.29)	5.65 (4.30-7.44)	6.46 (4.72-8.75)	7.61 (5.35-10.6)	8.55 (5.82-12.0)
3-day	2.06 (1.73-2.46)	2.43 (2.04-2.90)	3.08 (2.58-3.69)	3.67 (3.05-4.41)	4.55 (3.70-5.74)	5.29 (4.19-6.75)	6.08 (4.65-7.96)	6.93 (5.08-9.33)	8.13 (5.73-11.3)	9.10 (6.23-12.7)
4-day	2.22 (1.87-2.64)	2.60 (2.19-3.09)	3.28 (2.75-3.91)	3.89 (3.25-4.66)	4.81 (3.92-6.04)	5.57 (4.43-7.09)	6.39 (4.90-8.34)	7.27 (5.35-9.76)	8.52 (6.03-11.8)	9.52 (6.54-13.3)
7-day	2.62 (2.23-3.10)	3.03 (2.57-3.58)	3.75 (3.17-4.44)	4.40 (3.70-5.23)	5.37 (4.41-6.70)	6.18 (4.95-7.81)	7.05 (5.45-9.15)	7.99 (5.92-10.7)	9.31 (6.64-12.8)	10.4 (7.19-14.4)
10-day	2.98 (2.54-3.50)	3.42 (2.92-4.02)	4.20 (3.56-4.95)	4.89 (4.13-5.79)	5.92 (4.88-7.34)	6.78 (5.44-8.52)	7.69 (5.96-9.92)	8.66 (6.45-11.5)	10.0 (7.19-13.7)	11.1 (7.75-15.4)
20-day	3.99 (3.43-4.64)	4.59 (3.95-5.35)	5.61 (4.81-6.56)	6.49 (5.52-7.62)	7.73 (6.39-9.44)	8.73 (7.04-10.8)	9.75 (7.61-12.4)	10.8 (8.11-14.2)	12.3 (8.86-16.6)	13.4 (9.43-18.4)
30-day	4.80 (4.15-5.56)	5.54 (4.79-6.42)	6.76 (5.82-7.86)	7.78 (6.66-9.09)	9.19 (7.61-11.1)	10.3 (8.32-12.6)	11.4 (8.91-14.4)	12.5 (9.40-16.3)	14.0 (10.1-18.8)	15.1 (10.7-20.7)
45-day	5.80 (5.04-6.68)	6.70 (5.81-7.72)	8.13 (7.03-9.40)	9.30 (8.00-10.8)	10.9 (9.03-13.0)	12.1 (9.80-14.7)	13.2 (10.4-16.6)	14.4 (10.9-18.6)	15.9 (11.6-21.2)	17.0 (12.1-23.2)
60-day	6.64 (5.79-7.62)	7.64 (6.65-8.77)	9.23 (8.01-10.6)	10.5 (9.06-12.2)	12.2 (10.1-14.5)	13.4 (10.9-16.3)	14.7 (11.5-18.3)	15.8 (12.0-20.3)	17.3 (12.6-23.0)	18.4 (13.1-25.0)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

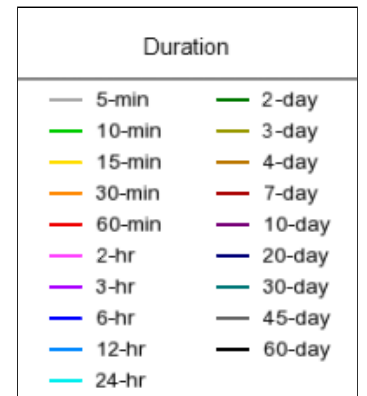
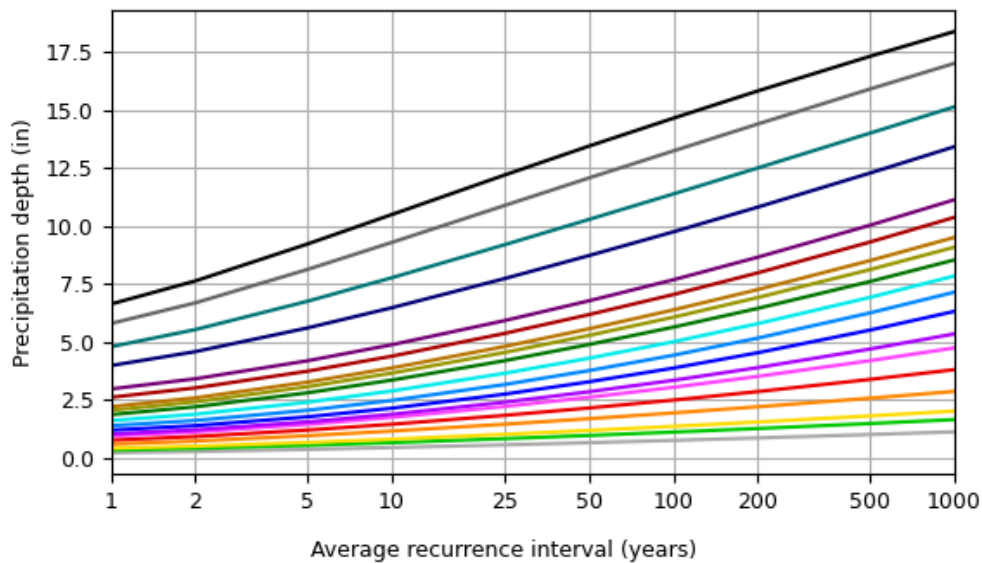
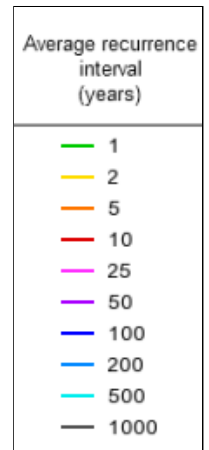
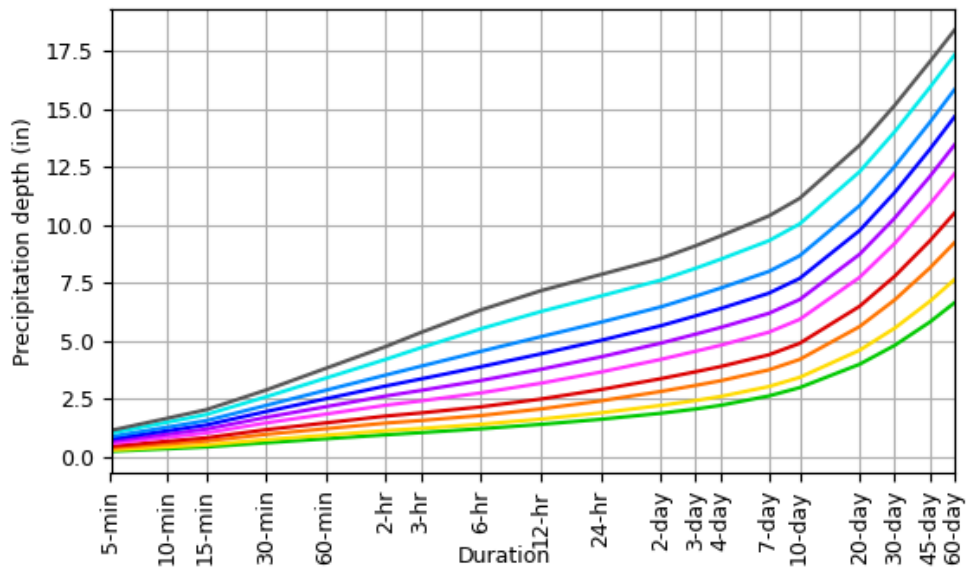
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

PF graphical

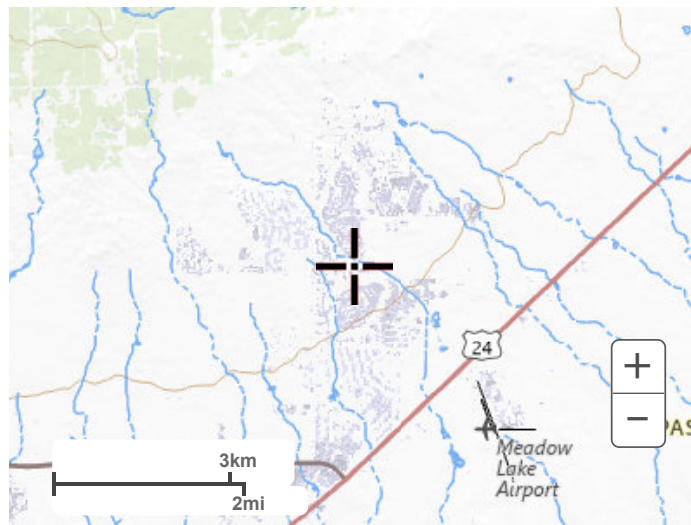
PDS-based depth-duration-frequency (DDF) curves
Latitude: 38.9709°, Longitude: -104.5991°



[Back to Top](#)

Maps & aerials

Small scale terrain



Large scale terrain



Large scale map



Large scale aerial



[Back to Top](#)

[US Department of Commerce](#)
[National Oceanic and Atmospheric Administration](#)
[National Weather Service](#)
[National Water Center](#)
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

[Disclaimer](#)



STANDARD FORM SF-1 (EXISITNG CONDITIONS)
RUNOFF COEFFICIENTS - IMPERVIOUS CALCULATION

PROJECT NAME: WHMD RWRF Stormwater Improvements
PROJECT NUMBER: 296082000
CALCULATED BY: PLH
CHECKED BY: MEO

HYDROLOGIC SOIL GROUP: A

Impervious values and runoff coefficients are taken from the Colorado Springs Drainage Criteria Manual (Vol. 1) Table 6-6	LAND USE (HSG A/B):	PAVEMENT	ROOF	GRAVEL	LANDSCAPE									
	2-YEAR COEFF.	0.89	0.71	0.57	0.02									
	5-YEAR COEFF.	0.90	0.73	0.59	0.08									
	10-YEAR COEFF.	0.92	0.75	0.63	0.15									
	100-YEAR COEFF.	0.96	0.81	0.70	0.35									
	IMPERVIOUS %	100%	90%	80%	0%									
DESIGN BASIN	DESIGN POINT	PAVEMENT AREA (SF)	ROOF AREA (SF)	GRAVEL AREA (SF)	LANDSCAPE AREA (SF)	TOTAL AREA (SF)	TOTAL AREA (AC)	C(2)	C(5)	C(10)	C(100)	Imp %	HSG	
Basins														
EX-1	EX-1				1,355	1,355	0.03	0.02	0.08	0.15	0.35	0%	A	
EX-2	EX-2				9,852	9,852	0.23	0.02	0.08	0.15	0.35	0%	A	
EX-3	EX-3				1,183	1,183	0.03	0.02	0.08	0.15	0.35	0%	A	
EX-4	EX-4				32,282	32,282	0.74	0.02	0.08	0.15	0.35	0%	A	
EX-5	EX-5			2,307	34,290	36,597	0.84	0.02	0.11	0.18	0.37	5%	A	
EX-6	EX-6			17,689	36,076	53,764	1.23	0.02	0.25	0.31	0.47	26%	A	
EX-7	EX-7	625		10,294	15,564	26,482	0.61	0.04	0.30	0.35	0.50	33%	A	
EX-8	EX-8		15,427			15,427	0.35	0.71	0.73	0.75	0.81	90%	A	
EX-9	EX-9	23,425				23,425	0.54	0.89	0.90	0.92	0.96	100%	A	
EX-10	EX-10	7,167	380	17,155	35,131	59,833	1.37	0.13	0.33	0.38	0.53	35%	A	
EX-11	EX-11	7,159				7,159	0.16	0.89	0.90	0.92	0.96	100%	A	
EX-12	EX-12	755	558	441	17,933	19,687	0.45	0.07	0.14	0.21	0.39	8%	A	
EX-13	EX-13				3,002	3,002	0.07	0.02	0.08	0.15	0.35	0%	A	
EX-14	EX-14	4,718	145	1,491	27,395	33,750	0.77	0.14	0.22	0.28	0.45	18%	A	
EX-15	EX-15	2,430		53,591	43,218	99,239	2.28	0.04	0.38	0.43	0.55	46%	A	
EX-16	EX-16	648		61,851		62,499	1.43	0.03	0.59	0.63	0.70	80%	A	
EX-17	EX-17			9,799	66,181	75,979	1.74	0.02	0.15	0.21	0.40	10%	A	
EX-18	EX-18	615	144	3,092	15,363	19,213	0.44	0.05	0.19	0.26	0.43	17%	A	
EX-19	EX-19	651		1,878	24,610	27,139	0.62	0.04	0.13	0.20	0.39	8%	A	
OF-1	OF-1				11,667	11,667	0.27	0.02	0.08	0.15	0.35	0%	A	
OF-2	OF-2				2,352	2,352	0.05	0.02	0.08	0.15	0.35	0%	A	
OF-3	OF-3				23,451	23,451	0.54	0.02	0.08	0.15	0.35	0%	A	
OF-4	OF-4				4,841	4,841	0.11	0.02	0.08	0.15	0.35	0%	A	
OF-5	OF-5				2,595	2,595	0.06	0.02	0.08	0.15	0.35	0%	A	
OF-6	OF-6				5,176	5,176	0.12	0.02	0.08	0.15	0.35	0%	A	
OVERALL SUBTOTAL		48,192	16,654	179,588	413,516	657,949	15.10	0.25	0.30	0.35	0.50	31.44%	A	
OVERALL ONSITE SUBTOTAL		7%	3%	27%	63%	100%	100%							
OVERALL ONSITE SUBTOTAL		48,192	16,654	179,588	363,434	607,868	13.95	0.27	0.31	0.37	0.51	34.03%	A	
OVERALL ONSITE SUBTOTAL		8%	3%	30%	60%	100%	100%							



STANDARD FORM SF-2 (EXISTING CONDITIONS)
Time of Concentration

PROJECT NAME: WHMD RWRF Stormwater Improvements
PROJECT NUMBER: 296008000
CALCULATED BY: PLH
CHECKED BY: MEO

SUB-BASIN DATA			INITIAL TIME (T _i)			TRAVEL TIME (T _t)					T _c CHECK (URBANIZED BASINS)					FINAL T _c
DESIGN BASIN (1)	AREA SF (2)	C5 (3)	LENGTH Ft (4)	SLOPE % (5)	T _i Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	C _v (9)	VEL fps (11)	T _t Min. (12)	COMP. t _c (13)	TOTAL LENGTH (14)	TOTAL SLOPE (15)	TOTAL IMP. (16)	T _c Min. (17)	Min.
All Basins																
EX-1	1,355	0.08	25	6.7%	4.9	23	10.2%	10.0	3.2	0.1	5.1	47	8.4%	0%	26.3	5.1
EX-2	9,852	0.08	19	7.1%	4.3	103	6.8%	10.0	2.6	0.7	4.9	122	6.9%	0%	26.9	5.0
EX-3	1,183	0.08	16	9.3%	3.6	51	7.9%	10.0	2.8	0.3	3.9	67	8.2%	0%	26.4	5.0
EX-4	32,282	0.08	62	13.5%	6.2	594	0.6%	10.0	0.8	12.4	18.6	656	1.9%	0%	34.9	18.6
EX-5	36,597	0.11	77	3.3%	10.7	247	2.6%	10.0	1.6	2.6	13.2	324	2.8%	5%	28.5	13.2
EX-6	53,764	0.25	57	5.9%	6.5	325	2.4%	10.0	1.6	3.5	10.0	382	3.0%	26%	24.4	10.0
EX-7	26,482	0.30	80	7.0%	6.9	249	1.2%	10.0	1.1	3.8	10.6	329	2.6%	33%	22.8	10.6
EX-8	15,427	0.73	87	0.0%	0.0	79	1.0%	20.0	2.0	0.7	0.7	166	0.5%	90%	12.6	5.0
EX-9	23,425	0.90	66	0.0%	0.0	151	1.0%	20.0	2.0	1.3	1.3	217	0.7%	100%	10.9	5.0
EX-10	59,833	0.33	78	9.6%	5.9	534	1.2%	10.0	1.1	8.2	14.1	613	2.3%	35%	24.8	14.1
EX-11	7,159	0.90	54	0.0%	0.0	74	1.0%	20.0	2.0	0.6	0.6	128	0.6%	100%	10.2	5.0
EX-12	19,687	0.14	98	8.2%	8.6	407	0.7%	10.0	0.9	7.9	16.5	504	2.2%	8%	30.2	16.5
EX-13	3,002	0.08	14	3.5%	4.6	46	7.6%	10.0	2.8	0.3	4.9	60	6.6%	0%	26.4	5.0
EX-14	33,750	0.22	21	1.7%	6.2	678	0.6%	10.0	0.7	15.1	21.3	699	0.6%	18%	36.1	21.3
EX-15	99,239	0.38	80	12.9%	5.1	318	0.2%	10.0	0.4	12.2	17.2	398	2.7%	46%	20.8	17.2
EX-16	62,499	0.59	108	7.5%	4.9	213	0.7%	10.0	0.8	4.3	9.2	321	3.0%	80%	13.9	9.2
EX-17	75,979	0.15	39	0.8%	11.8	334	0.3%	10.0	0.6	10.0	21.8	373	0.4%	10%	34.2	21.8
EX-18	19,213	0.19	105	6.9%	8.9	228	1.0%	10.0	1.0	3.8	12.8	333	2.9%	17%	26.0	12.8
EX-19	27,139	0.13	65	6.2%	7.8	635	2.2%	10.0	1.5	7.1	14.9	699	2.6%	8%	31.8	14.9
OF-1	11,667	0.08	23	8.1%	4.4	163	3.8%	10.0	2.0	1.4	5.8	185	4.3%	0%	27.6	5.8
OF-2	2,352	0.08	18	9.1%	3.8	47	10.7%	10.0	3.3	0.2	4.1	65	10.3%	0%	26.4	5.0
OF-3	23,451	0.08	52	0.6%	16.4	278	1.8%	10.0	1.3	3.4	19.8	330	1.6%	0%	30.8	19.8
OF-4	4,841	0.08	27	8.7%	4.7	158	0.6%	10.0	0.8	3.3	8.0	185	1.8%	0%	28.6	8.0
OF-5	2,595	0.08	76	2.9%	11.4	102	3.5%	10.0	1.9	0.9	12.3	178	3.2%	0%	27.8	12.3
OF-6	5,176	0.08	97	0.9%	19.4	573	1.8%	10.0	1.4	7.0	26.4	670	1.7%	0%	35.5	26.4

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

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

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

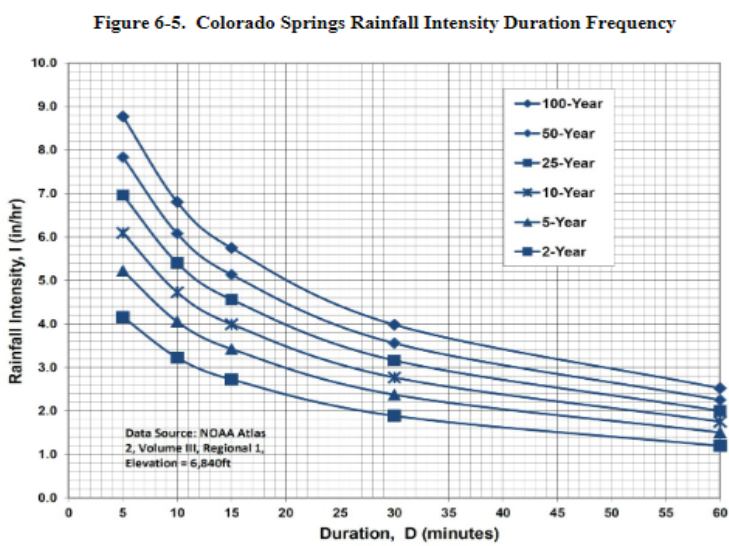
Kimley»Horn

STANDARD FORM SF-3 (EXISTING CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 5 YEAR EVENT

PROJECT NAME: WHMD RWRF Stormwater Improvements
PROJECT NUMBER: 296008000
CALCULATED BY: PLH
CHECKED BY: MEO

P₁ (1-Hour Rainfall) = 1.21

STORM LINE	DESIGN POINT	DIRECT RUNOFF								TOTAL RUNOFF				REMARKS
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF	t _c (min)	C*A(ac)	I (in/hr)	Q (cfs)	t _c (max)	S(C*A) (ac)	I (in/hr)	Q (cfs)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)	
All Basins														
		EX-1	EX-1	0.03	0.08	5.1	0.00	5.15	0.01					
		EX-2	EX-2	0.23	0.08	5.0	0.02	5.17	0.09					
		EX-3	EX-3	0.03	0.08	5.0	0.00	5.17	0.01					
		EX-4	EX-4	0.74	0.08	18.6	0.06	3.20	0.19					
		EX-5	EX-5	0.84	0.11	13.2	0.09	3.71	0.35					
		EX-6	EX-6	1.23	0.25	10.0	0.31	4.13	1.26					
		EX-7	EX-7	0.61	0.30	10.6	0.18	4.04	0.73					
		EX-8	EX-8	0.35	0.73	5.0	0.26	5.17	1.34					
		EX-9	EX-9	0.54	0.90	5.0	0.48	5.17	2.50					
		EX-10	EX-10	1.37	0.33	14.1	0.45	3.61	1.63					
		EX-11	EX-11	0.16	0.90	5.0	0.15	5.17	0.76					
		EX-12	EX-12	0.45	0.14	16.5	0.06	3.38	0.22					
		EX-13	EX-13	0.07	0.08	5.0	0.01	5.17	0.03					
		EX-14	EX-14	0.77	0.22	21.3	0.17	2.99	0.51					
		EX-15	EX-15	2.28	0.38	17.2	0.86	3.31	2.83					
		EX-16	EX-16	1.43	0.59	9.2	0.85	4.25	3.62					
		EX-17	EX-17	1.74	0.15	21.8	0.25	2.96	0.75					
		EX-18	EX-18	0.44	0.19	12.8	0.09	3.76	0.32					
		EX-19	EX-19	0.62	0.13	14.9	0.08	3.53	0.30					
		OF-1	OF-1	0.27	0.08	5.8	0.02	4.94	0.11					
		OF-2	OF-2	0.05	0.08	5.0	0.00	5.17	0.02					
		OF-3	OF-3	0.54	0.08	19.8	0.04	3.10	0.13					
		OF-4	OF-4	0.11	0.08	8.0	0.01	4.46	0.04					
		OF-5	OF-5	0.06	0.08	12.3	0.00	3.82	0.02					
		OF-6	OF-6	0.12	0.08	26.4	0.01	2.67	0.03					



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_5 = -1.50 \ln(D) + 7.583$

STANDARD FORM SF-3 (EXISTING CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 100 YEAR EVENT

PROJECT NAME: WHMD RWRP Stormwater Improvements

PROJECT NUMBER: 296008000

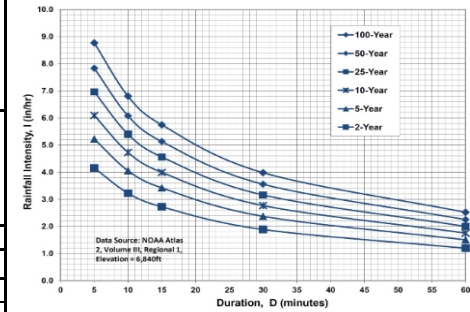
CALCULATED BY: PLH

CHECKED BY: MEO

P₁ (1-Hour Rainfall) = 2.5

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF	t _c (min)	C*A(ac)	I (in/hr)	Q (cfs)	t _c (max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
	EX-1	EX-1	0.03	0.35	5.1	0.01	8.65	0.09					
	EX-2	EX-2	0.23	0.35	5.0	0.08	8.68	0.69					
	EX-3	EX-3	0.03	0.35	5.0	0.01	8.68	0.08					
	EX-4	EX-4	0.74	0.35	18.6	0.26	5.37	1.39					
	EX-5	EX-5	0.84	0.37	13.2	0.31	6.23	1.95					
	EX-6	EX-6	1.23	0.47	10.0	0.57	6.94	3.98					
	EX-7	EX-7	0.61	0.50	10.6	0.30	6.78	2.06					
	EX-8	EX-8	0.35	0.81	5.0	0.29	8.68	2.49					
	EX-9	EX-9	0.54	0.96	5.0	0.52	8.68	4.48					
	EX-10	EX-10	1.37	0.53	14.1	0.72	6.06	4.38					
	EX-11	EX-11	0.16	0.96	5.0	0.16	8.68	1.37					
	EX-12	EX-12	0.45	0.39	16.5	0.18	5.67	1.01					
	EX-13	EX-13	0.07	0.35	5.0	0.02	8.68	0.21					
	EX-14	EX-14	0.77	0.45	21.3	0.35	5.03	1.76					
	EX-15	EX-15	2.28	0.55	17.2	1.26	5.56	7.02					
	EX-16	EX-16	1.43	0.70	9.2	1.01	7.14	7.20					
	EX-17	EX-17	1.74	0.40	21.8	0.69	4.96	3.42					
	EX-18	EX-18	0.44	0.43	12.8	0.19	6.32	1.20					
	EX-19	EX-19	0.62	0.39	14.9	0.24	5.93	1.44					
	OF-1	OF-1	0.27	0.35	5.8	0.09	8.30	0.78					
	OF-2	OF-2	0.05	0.35	5.0	0.02	8.68	0.16					
	OF-3	OF-3	0.54	0.35	19.8	0.19	5.21	0.98					
	OF-4	OF-4	0.11	0.35	8.0	0.04	7.50	0.29					
	OF-5	OF-5	0.06	0.35	12.3	0.02	6.41	0.13					
	OF-6	OF-6	0.12	0.35	26.4	0.04	4.48	0.19					

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$$I_{100} = -2.52 \ln(D) + 12.735$$

$$I_{50} = -2.25 \ln(D) + 11.375$$

$$I_{25} = -2.00 \ln(D) + 10.111$$

$$I_{10} = -1.75 \ln(D) + 8.847$$

$$I_5 = -1.50 \ln(D) + 7.583$$

$$I_2 = -1.19 \ln(D) + 6.035$$

Note: Values calculated by equations may not precisely duplicate values read from figure.



EXISTING CONDITIONS

WHMD RWRF

Stormwater

DATE: 2/25/2026

Improvements

PROJECT NUMBER: 296008000

CALCULATED BY: PLH

CHECKED BY: MEO

EXISTING RATIONAL CALCULATIONS SUMMARY

DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
EX-1	EX-1	0.03	0.01	0.09
EX-2	EX-2	0.23	0.09	0.69
EX-3	EX-3	0.03	0.01	0.08
EX-4	EX-4	0.74	0.19	1.39
EX-5	EX-5	0.84	0.35	1.95
EX-6	EX-6	1.23	1.26	3.98
EX-7	EX-7	0.61	0.73	2.06
EX-8	EX-8	0.35	1.34	2.49
EX-9	EX-9	0.54	2.50	4.48
EX-10	EX-10	1.37	1.63	4.38
EX-11	EX-11	0.16	0.76	1.37
EX-12	EX-12	0.45	0.22	1.01
EX-13	EX-13	0.07	0.03	0.21
EX-14	EX-14	0.77	0.51	1.76
EX-15	EX-15	2.28	2.83	7.02
EX-16	EX-16	1.43	3.62	7.20
EX-17	EX-17	1.74	0.75	3.42
EX-18	EX-18	0.44	0.32	1.20
EX-19	EX-19	0.62	0.30	1.44
OF-1	OF-1	0.27	0.11	0.78
OF-2	OF-2	0.05	0.02	0.16
OF-3	OF-3	0.54	0.13	0.98
OF-4	OF-4	0.11	0.04	0.29
OF-5	OF-5	0.06	0.02	0.13
OF-6	OF-6	0.12	0.03	0.19



STANDARD FORM SF-1 (PROPOSED CONDITIONS)
RUNOFF COEFFICIENTS - IMPERVIOUS CALCULATION

PROJECT NAME: WHMD RWRF Stormwater Improvements
PROJECT NUMBER: 196013004
CALCULATED BY: MEO
CHECKED BY: KRK

HYDROLOGIC SOIL GROUP: A

Impervious values and runoff coefficients are taken from the Colorado Springs Drainage Criteria Manual (Vol. 1) - Table 6.6	LAND USE (HSG A/B):	ROOF	PAVEMENT	GRAVEL	LAWN									
	2-YEAR COEFF.	0.71	0.89	0.57	0.02									
	5-YEAR COEFF.	0.73	0.90	0.59	0.08									
	10-YEAR COEFF.	0.75	0.92	0.63	0.15									
	100-YEAR COEFF.	0.81	0.96	0.70	0.35									
	IMPERVIOUS %	90%	100%	80%	0%									
DESIGN BASIN	DESIGN POINT	ROOF AREA (SF)	PAVEMENT AREA (SF)	GRAVEL AREA (SF)	LAWN AREA (SF)	TOTAL AREA (SF)	TOTAL AREA (AC)	C(2)	C(5)	C(10)	C(100)	Imp %	HSG	
Basins														
P-1	P-1		24,851	1,246	12,310	38,407	0.88	0.47	0.63	0.66	0.76	67%	A	
P-2	P-2				5,537	5,537	0.13	0.02	0.08	0.15	0.35	0%	A	
P-3	P-3				15,755	15,755	0.36	0.02	0.08	0.15	0.35	0%	A	
P-4	P-4	4,932	10,777	10,421	20,925	47,055	1.08	0.27	0.45	0.50	0.62	50%	A	
P-5	P-5			1,477	32,415	33,892	0.78	0.02	0.10	0.17	0.37	3%	A	
P-6	P-6	707			6,018	6,725	0.15	0.11	0.15	0.21	0.40	9%	A	
P-7	P-7	1,480		9,437	12,126	23,043	0.53	0.08	0.33	0.39	0.52	39%	A	
P-8	P-8			385	1,269	1,654	0.04	0.02	0.20	0.26	0.43	19%	A	
OS-1	OS-1	340			2,993	3,333	0.08	0.11	0.15	0.21	0.40	9%	A	
OS-2	OS-2	15,423				15,423	0.35	0.89	0.73	0.75	0.81	90%	A	
OS-3	OS-3		199	6,025	27,527	33,750	0.77	0.02	0.18	0.24	0.42	15%	A	
OS-4	OS-4		2,430	53,591	43,218	99,239	2.28	0.04	0.38	0.43	0.55	46%	A	
OS-5	OS-5		648	61,851		62,499	1.43	0.03	0.59	0.63	0.70	80%	A	
OS-6	OS-6			9,799	66,181	75,979	1.74	0.02	0.15	0.21	0.40	10%	A	
OS-7	OS-7	144	615	3,092	15,363	19,213	0.44	0.05	0.19	0.26	0.43	17%	A	
OS-8	OS-8		651	1,878	24,610	27,139	0.62	0.04	0.13	0.20	0.39	8%	A	
OS-9	OS-9	559	705	468	17,955	19,687	0.45	0.07	0.14	0.21	0.39	8%	A	
OS-10	OS-10				32,282	32,282	0.74	0.02	0.08	0.15	0.35	0%	A	
OS-11	OS-11				3,002	3,002	0.07	0.02	0.08	0.15	0.35	0%	A	
OS-12	OS-12				1,355	1,355	0.03	0.02	0.08	0.15	0.35	0%	A	
OS-13	OS-13				11,034	11,034	0.25	0.02	0.08	0.15	0.35	0%	A	
OS-14	OS-14		7,159			7,159	0.16	0.71	0.90	0.92	0.96	100%	A	
OS-15	OS-15		24,707			24,707	0.57	0.71	0.90	0.92	0.96	100%	A	
OF-1	OF-1				2,595	2,595	0.06	0.02	0.08	0.15	0.35	0%	A	
OF-2	OF-2				5,176	5,176	0.12	0.02	0.08	0.15	0.35	0%	A	
OF-3	OF-3				11,667	11,667	0.27	0.02	0.08	0.15	0.35	0%	A	
OF-4	OF-4				5,259	5,259	0.12	0.02	0.08	0.15	0.35	0%	A	
OF-5	OF-5				20,543	20,543	0.47	0.02	0.08	0.15	0.35	0%	A	
OF-6	OF-6				4,841	4,841	0.11	0.02	0.08	0.15	0.35	0%	A	
OVERALL SUBTOTAL		23,586	72,741	159,669	401,957	657,953	15.10	0.27	0.32	0.37	0.52	33.70%	A	
OVERALL ONSITE SUBTOTAL		4%	11%	24%	61%	100%	100%							
OVERALL ONSITE SUBTOTAL		23,586	72,741	159,669	351,876	607,872	13.95	0.30	0.34	0.39	0.53	36.47%	A	
OVERALL ONSITE SUBTOTAL		4%	12%	26%	58%	100%	100%							



STANDARD FORM SF-2 (PROPOSED CONDITIONS)
Time of Concentration

PROJECT NAME: WHMD RWRF Stormwater Improvements
PROJECT NUMBER: 296008000
CALCULATED BY: MEO
CHECKED BY: KRK

SUB-BASIN DATA			INITIAL TIME (T _i)			TRAVEL TIME (T _t)					T _c CHECK (URBANIZED BASINS)					FINAL T _c
DESIGN BASIN (1)	AREA SF (2)	C5 (3)	LENGTH Ft (4)	SLOPE % (5)	T _i Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	C _v (9)	VEL fps (11)	T _t Min. (12)	COMP. t _c (13)	TOTAL LENGTH (14)	TOTAL SLOPE (15)	TOTAL IMP. (16)	T _c Min. (17)	Min.
All Basins																
P-1	38,407	0.63	40	3.0%	3.8	220	3.0%	20.0	3.5	1.1	4.9	260	3.0%	67%	15.9	5.0
P-2	5,537	0.08	30	0.7%	11.5	60	2.5%	7.0	1.1	0.9	12.4	90	1.9%	0%	27.2	12.4
P-3	15,755	0.08	30	2.2%	7.9	130	5.0%	7.0	1.6	1.4	9.3	160	4.5%	0%	27.4	9.3
P-4	47,055	0.45	33	1.5%	6.0	80	2.3%	20.0	3.0	0.4	6.5	113	2.0%	50%	18.3	6.5
P-5	33,892	0.10	60	2.6%	10.3	250	2.1%	7.0	1.0	4.2	14.4	310	2.2%	3%	29.1	14.4
P-6	6,725	0.15	20	0.6%	9.3	100	1.0%	7.0	0.7	2.4	11.6	120	0.9%	9%	26.4	11.6
P-7	23,043	0.33	25	10.0%	3.3	135	1.0%	7.0	0.7	3.2	6.5	160	2.4%	39%	20.6	6.5
P-8	1,654	0.20	5	7.0%	1.9	10	1.0%	7.0	0.7	0.2	2.2	15	3.0%	19%	23.0	5.0
OS-1	3,333	0.15	8	9.0%	2.4	100	1.0%	7.0	0.7	2.4	4.8	108	1.6%	9%	25.8	5.0
OS-2	15,423	0.73	50	1.0%	4.8	100	1.0%	20.0	2.0	0.8	5.6	150	1.0%	90%	11.9	5.6
OS-3	33,750	0.18	70	11.0%	6.4	470	0.5%	7.0	0.5	15.8	22.2	540	1.9%	15%	29.4	22.2
OS-4	99,239	0.38	90	12.0%	5.5	285	0.2%	7.0	0.3	15.2	20.7	375	3.0%	46%	20.6	20.6
OS-5	62,499	0.59	80	9.0%	4.0	260	2.5%	7.0	1.1	3.9	7.9	340	4.0%	80%	13.8	7.9
OS-6	75,979	0.15	30	2.0%	7.6	331	0.2%	7.0	0.3	17.6	25.2	361	0.3%	10%	34.0	25.2
OS-7	19,213	0.19	56	14.0%	5.2	45	6.1%	7.0	1.7	0.4	5.6	101	10.5%	17%	23.6	5.6
OS-8	27,139	0.13	78	2.9%	11.0	580	2.5%	7.0	1.1	8.8	19.8	658	2.5%	8%	31.5	19.8
OS-9	19,687	0.14	65	6.0%	7.8	340	1.1%	7.0	0.7	7.7	15.5	405	1.9%	8%	29.5	15.5
OS-10	32,282	0.08	100	6.7%	9.9	280	0.6%	7.0	0.6	8.4	18.3	380	2.2%	0%	30.7	18.3
OS-11	3,002	0.08	25	7.0%	4.9	33	6.2%	7.0	1.7	0.3	5.2	58	6.6%	0%	26.4	5.2
OS-12	1,355	0.08	10	8.0%	3.0	25	8.8%	7.0	2.1	0.2	3.2	35	8.6%	0%	26.2	5.0
OS-13	11,034	0.08	60	13.0%	6.2	75	0.5%	7.0	0.5	2.5	8.7	135	6.1%	0%	27.0	8.7
OS-14	7,159	0.90	20	1.0%	1.6	50	1.0%	20.0	2.0	0.4	2.1	70	1.0%	100%	9.5	5.0
OS-15	24,707	0.90	50	1.0%	2.6	200	1.0%	20.0	2.0	1.7	4.3	250	1.0%	100%	10.8	5.0
OF-1	2,595	0.08	61	3.0%	10.1	62	5.2%	7.0	1.6	0.6	10.8	123	4.1%	0%	27.1	10.8
OF-2	5,176	0.08	105	1.4%	17.1	440	2.1%	7.0	1.0	7.3	24.4	545	1.9%	0%	33.3	24.4
OF-3	11,667	0.08	55	3.5%	9.2	113	1.1%	7.0	0.7	2.6	11.7	168	1.9%	0%	28.3	11.7
OF-4	5,259	0.08	30	9.0%	4.9	22	11.0%	7.0	2.3	0.2	5.1	52	9.8%	0%	26.3	5.1
OF-5	20,543	0.08	55	2.9%	9.7	222	2.7%	7.0	1.2	3.2	12.9	277	2.8%	0%	29.1	12.9
OF-6	4,841	0.08	50	5.6%	7.4	30	0.5%	7.0	0.5	1.0	8.5	80	3.7%	0%	26.8	8.5

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

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

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

STANDARD FORM SF-3 (PROPOSED CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 5 YEAR EVENT

PROJECT NAME: WHMD RWRP Stormwater Improvements

PROJECT NUMBER: 296008000

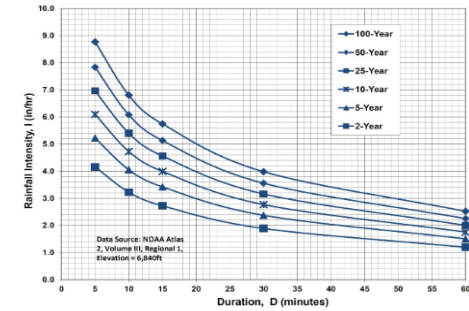
CALCULATED BY: MEO

CHECKED BY: KRK

P₁ (1-Hour Rainfall) = **1.21**

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF	t _c (min)	C*A(ac)	I (in/hr)	Q (cfs)	t _c (max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
	P-1	P-1	0.88	0.63	5.0	0.55	5.17	2.86					
	P-2	P-2	0.13	0.08	12.4	0.01	3.80	0.04					
	P-3	P-3	0.36	0.08	9.3	0.03	4.24	0.12					
	P-4	P-4	1.08	0.45	6.5	0.48	4.78	2.32					
	P-5	P-5	0.78	0.10	14.4	0.08	3.58	0.28					
	P-6	P-6	0.15	0.15	11.6	0.02	3.90	0.09					
	P-7	P-7	0.53	0.33	6.5	0.17	4.78	0.84					
	P-8	P-8	0.04	0.20	5.0	0.01	5.17	0.04					
	OS-1	OS-1	0.08	0.15	5.0	0.01	5.17	0.06					
	OS-2	OS-2	0.35	0.73	5.6	0.26	4.99	1.29					
	OS-3	OS-3	0.77	0.18	22.2	0.14	2.93	0.40					
	OS-4	OS-4	2.28	0.38	20.6	0.86	3.05	2.61					
	OS-5	OS-5	1.43	0.59	7.9	0.85	4.48	3.81					
	OS-6	OS-6	1.74	0.15	25.2	0.25	2.74	0.70					
	OS-7	OS-7	0.44	0.19	5.6	0.09	5.00	0.43					
	OS-8	OS-8	0.62	0.13	19.8	0.08	3.11	0.26					
	OS-9	OS-9	0.45	0.14	15.5	0.06	3.47	0.22					
	OS-10	OS-10	0.74	0.08	18.3	0.06	3.22	0.19					
	OS-11	OS-11	0.07	0.08	5.2	0.01	5.11	0.03					
	OS-12	OS-12	0.03	0.08	5.0	0.00	5.17	0.01					
	OS-13	OS-13	0.25	0.08	8.7	0.02	4.34	0.09					
	OS-14	OS-14	0.16	0.90	5.0	0.15	5.17	0.76					
	OS-15	OS-15	0.57	0.90	5.0	0.51	5.17	2.64					
	OF-1	OF-1	0.06	0.08	10.8	0.00	4.02	0.02					
	OF-2	OF-2	0.12	0.08	24.4	0.01	2.79	0.03					
	OF-3	OF-3	0.27	0.08	11.7	0.02	3.89	0.08					
	OF-4	OF-4	0.12	0.08	5.1	0.01	5.14	0.05					
	OF-5	OF-5	0.47	0.08	12.9	0.04	3.75	0.14					
	OF-6	OF-6	0.11	0.08	8.5	0.01	4.38	0.04					

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$$I_{100} = -2.52 \ln(D) + 12.735$$

$$I_{50} = -2.25 \ln(D) + 11.375$$

$$I_{25} = -2.00 \ln(D) + 10.111$$

$$I_{10} = -1.75 \ln(D) + 8.847$$

$$I_5 = -1.50 \ln(D) + 7.583$$

$$I_2 = -1.19 \ln(D) + 6.035$$

STANDARD FORM SF-3 (PROPOSED CONDITIONS)
STORM DRAINAGE DESIGN - RATIONAL METHOD 100 YEAR EVENT

PROJECT NAME: WHMD RWRP Stormwater Improvements

PROJECT NUMBER: 296008000

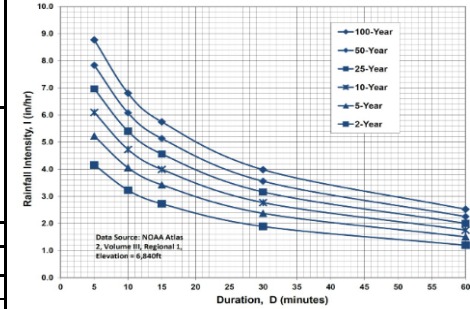
CALCULATED BY: MEO

CHECKED BY: KRK

P₁ (1-Hour Rainfall) = 2.5

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				REMARKS
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF	t _c (min)	C*A(ac)	I (in/hr)	Q (cfs)	t _c (max)	S(C*A) (ac)	I (in/hr)	Q (cfs)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(22)
All Basins													
		P-1	P-1	0.88	0.76	5.0	0.67	8.68	5.79				
		P-2	P-2	0.13	0.35	12.4	0.04	6.38	0.28				
		P-3	P-3	0.36	0.35	9.3	0.13	7.13	0.90				
		P-4	P-4	1.08	0.62	6.5	0.66	8.02	5.33				
		P-5	P-5	0.78	0.37	14.4	0.28	6.01	1.71				
		P-6	P-6	0.15	0.40	11.6	0.06	6.55	0.40				
		P-7	P-7	0.53	0.52	6.5	0.28	8.02	2.22				
		P-8	P-8	0.04	0.43	5.0	0.02	8.68	0.14				
		OS-1	OS-1	0.08	0.40	5.0	0.03	8.68	0.26				
		OS-2	OS-2	0.35	0.81	5.6	0.29	8.38	2.40				
		OS-3	OS-3	0.77	0.42	22.2	0.32	4.92	1.59				
		OS-4	OS-4	2.28	0.55	20.6	1.26	5.11	6.45				
		OS-5	OS-5	1.43	0.70	7.9	1.01	7.52	7.58				
		OS-6	OS-6	1.74	0.40	25.2	0.69	4.60	3.17				
		OS-7	OS-7	0.44	0.43	5.6	0.19	8.40	1.59				
		OS-8	OS-8	0.62	0.39	19.8	0.24	5.22	1.26				
		OS-9	OS-9	0.45	0.39	15.5	0.18	5.83	1.04				
		OS-10	OS-10	0.74	0.35	18.3	0.26	5.41	1.40				
		OS-11	OS-11	0.07	0.35	5.2	0.02	8.58	0.21				
		OS-12	OS-12	0.03	0.35	5.0	0.01	8.68	0.09				
		OS-13	OS-13	0.25	0.35	8.7	0.09	7.29	0.65				
		OS-14	OS-14	0.16	0.96	5.0	0.16	8.68	1.37				
		OS-15	OS-15	0.57	0.96	5.0	0.54	8.68	4.73				
		OF-1	OF-1	0.06	0.35	10.8	0.02	6.74	0.14				
		OF-2	OF-2	0.12	0.35	24.4	0.04	4.68	0.19				
		OF-3	OF-3	0.27	0.35	11.7	0.09	6.53	0.61				
		OF-4	OF-4	0.12	0.35	5.1	0.04	8.64	0.37				
		OF-5	OF-5	0.47	0.35	12.9	0.17	6.30	1.04				
		OF-6	OF-6	0.11	0.35	8.5	0.04	7.35	0.29				

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$$I_{100} = -2.52 \ln(D) + 12.735$$

$$I_{50} = -2.25 \ln(D) + 11.375$$

$$I_{25} = -2.00 \ln(D) + 10.111$$

$$I_{10} = -1.75 \ln(D) + 8.847$$

$$I_5 = -1.50 \ln(D) + 7.583$$

$$I_2 = -1.19 \ln(D) + 6.035$$

Note: Values calculated by equations may not precisely duplicate values read from figure.



PROPOSED CONDITIONS

WHMD RWRF Stormwater Improvements

DATE: 2/25/2026

PROJECT NUMBER: 296008000

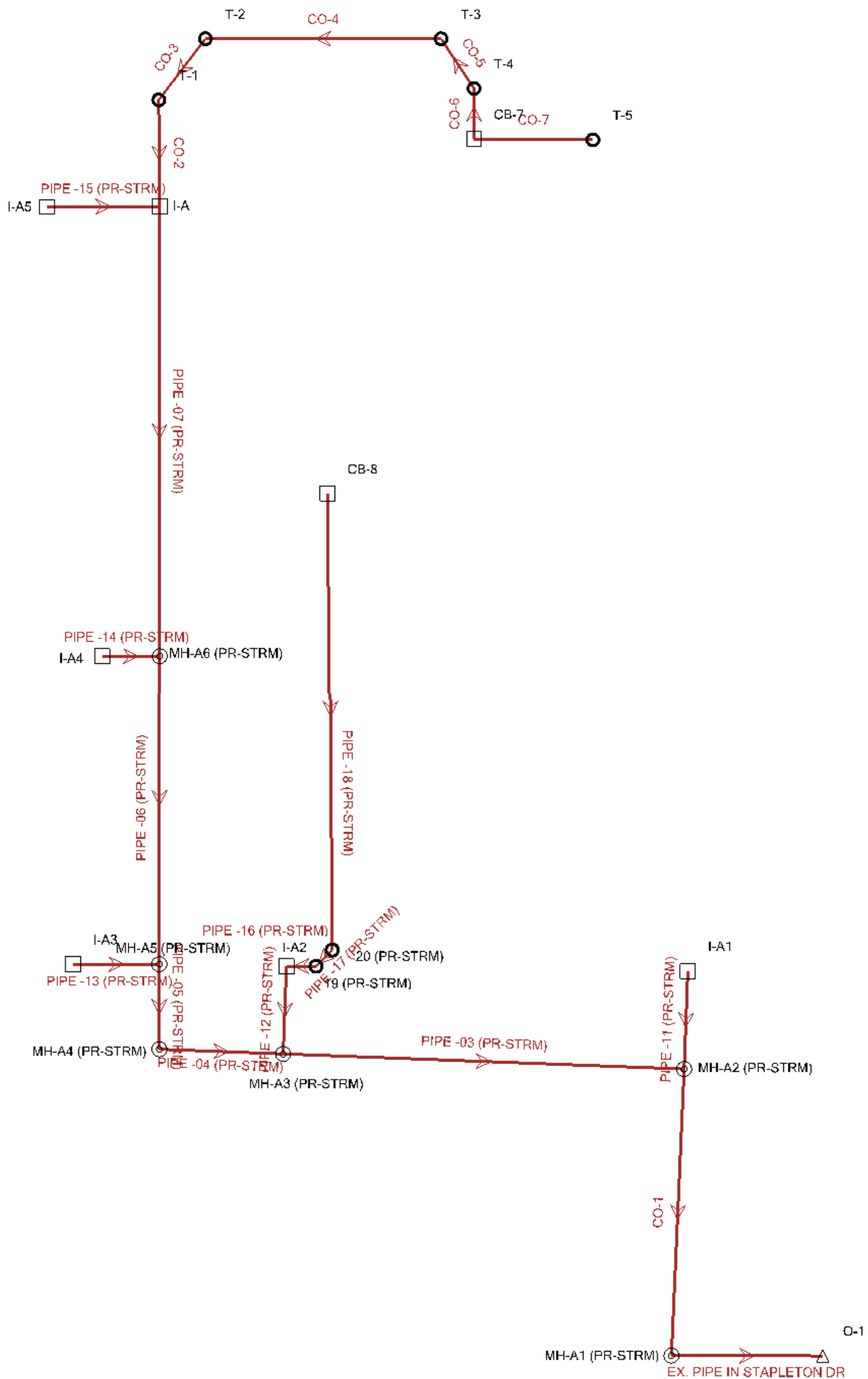
CALCULATED BY: MEO

CHECKED BY: KRK

PROPOSED RATIONAL CALCULATIONS SUMMARY				
DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
P-1	P-1	0.88	2.86	5.79
P-2	P-2	0.13	0.04	0.28
P-3	P-3	0.36	0.12	0.90
P-4	P-4	1.08	2.32	5.33
P-5	P-5	0.78	0.28	1.71
P-6	P-6	0.15	0.09	0.40
P-7	P-7	0.53	0.84	2.22
P-8	P-8	0.04	0.04	0.14
OS-1	OS-1	0.08	0.06	0.26
OS-2	OS-2	0.35	1.29	2.40
OS-3	OS-3	0.77	0.40	1.59
OS-4	OS-4	2.28	2.61	6.45
OS-5	OS-5	1.43	3.81	7.58
OS-6	OS-6	1.74	0.70	3.17
OS-7	OS-7	0.44	0.43	1.59
OS-8	OS-8	0.62	0.26	1.26
OS-9	OS-9	0.45	0.22	1.04
OS-10	OS-10	0.74	0.19	1.40
OS-11	OS-11	0.07	0.03	0.21
OS-12	OS-12	0.03	0.01	0.09
OS-13	OS-13	0.25	0.09	0.65
OS-14	OS-14	0.16	0.76	1.37
OS-15	OS-15	0.57	2.64	4.73
OF-1	OF-1	0.06	0.02	0.14
OF-2	OF-2	0.12	0.03	0.19
OF-3	OF-3	0.27	0.08	0.61
OF-4	OF-4	0.12	0.05	0.37
OF-5	OF-5	0.47	0.14	1.04
OF-6	OF-6	0.11	0.04	0.29

APPENDIX E – HYDRAULICS

WHMD RWRF Stormwater Improvements StormCAD Map



5-YEAR (80% FULL TAILWATER)
Conduit Table - Time: 0.00 hours

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
PIPE -03 (PR-STRM)	MH-A2 (PR-STRM)	7,044.61	MH-A3 (PR-STRM)	7,045.09	160.1	-0.003	0.013	7.05	4.05	22.48	7,046.05	7,045.49
PIPE -11 (PR-STRM)	MH-A2 (PR-STRM)	7,045.61	I-A1	7,045.80	39.1	-0.005	0.013	0.84	2.79	7.44	7,046.14	7,045.95
PIPE -04 (PR-STRM)	MH-A3 (PR-STRM)	7,045.19	MH-A4 (PR-STRM)	7,045.35	49.4	-0.003	0.013	7.01	4.18	23.51	7,046.36	7,046.31
PIPE -12 (PR-STRM)	MH-A3 (PR-STRM)	7,046.19	I-A2	7,046.37	35.0	-0.005	0.013	0.04	1.13	7.55	7,046.45	7,046.31
PIPE -05 (PR-STRM)	MH-A4 (PR-STRM)	7,045.64	MH-A5 (PR-STRM)	7,045.74	34.0	-0.003	0.013	7.01	4.05	22.48	7,046.69	7,046.58
PIPE -06 (PR-STRM)	MH-A5 (PR-STRM)	7,046.40	MH-A6 (PR-STRM)	7,046.80	132.7	-0.003	0.013	6.73	3.82	22.35	7,047.57	7,047.13
PIPE -13 (PR-STRM)	MH-A5 (PR-STRM)	7,046.24	I-A3	7,046.41	34.4	-0.005	0.013	0.28	1.94	15.99	7,046.95	7,046.95
PIPE -15 (PR-STRM)	I-A	7,047.34	I-A5	7,047.57	45.5	-0.005	0.013	0.12	1.46	7.19	7,048.39	7,048.39
PIPE -07 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A	7,047.34	181.1	-0.003	0.013	4.41	3.61	5.72	7,048.13	7,047.80
PIPE -14 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A4	7,046.92	23.2	-0.005	0.013	2.32	3.55	7.16	7,047.81	7,047.80
PIPE -16 (PR-STRM)	I-A2	7,047.09	19 (PR-STRM)	7,047.15	11.8	-0.005	0.010	0.04	1.42	3.27	7,047.23	7,047.16
PIPE -18 (PR-STRM)	20 (PR-STRM)	7,047.19	CB-8	7,048.12	186.2	-0.005	0.010	0.04	1.42	3.28	7,048.20	7,047.28
PIPE -17 (PR-STRM)	19 (PR-STRM)	7,047.15	20 (PR-STRM)	7,047.19	9.2	-0.005	0.010	0.04	1.42	3.28	7,047.27	7,047.24
CO-1	MH-A2 (PR-STRM)	7,044.11	MH-A1 (PR-STRM)	7,043.77	111.5	0.003	0.013	7.89	4.12	36.51	7,045.20	7,045.15
CO-2	I-A	7,047.39	T-1	7,047.56	29.0	-0.006	0.010	1.35	4.21	3.54	7,048.40	7,048.39
CO-3	T-1	7,047.56	T-2	7,047.70	23.6	-0.006	0.010	1.35	4.21	3.54	7,048.42	7,048.42
CO-4	T-2	7,047.70	T-3	7,048.06	62.1	-0.006	0.010	1.35	4.21	3.55	7,048.55	7,048.45
CO-5	T-3	7,048.06	T-4	7,048.13	12.6	-0.006	0.010	1.35	4.20	3.53	7,048.62	7,048.63
CO-6	T-4	7,048.13	CB-7	7,048.23	15.6	-0.006	0.010	1.35	4.22	3.56	7,048.72	7,048.70
CO-7	CB-7	7,048.53	T-5	7,049.00	95.4	-0.005	0.010	0.00	0.00	3.27	7,049.00	7,048.97
EX. PIPE IN STAPLETON DR	MH-A1 (PR-STRM)	7,042.77	O-1	7,041.94	29.8	0.028	0.013	7.89	8.78	240.09	7,045.13	7,045.14

5-YEAR (80% FULL TAILWATER)

Catch Basin Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Additional Subsurface) (cfs)	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
I-A3	7,050.17	7,050.17	7,046.41	0.28	7,046.95	0.050
I-A1	7,049.54	7,049.54	7,045.80	0.84	7,046.15	0.050
I-A2	7,052.04	7,052.04	7,046.37	0.00	7,046.47	1.020
I-A4	7,050.16	7,050.16	7,046.92	2.32	7,047.81	0.000
I-A	7,050.44	7,050.44	7,047.34	2.94	7,048.39	1.320
I-A5	7,051.44	7,051.44	7,047.57	0.12	7,048.39	0.050
CB-7	7,050.80	7,050.80	7,048.23	1.35	7,048.97	1.320
CB-8	7,051.48	7,051.48	7,048.12	0.04	7,048.20	0.000

5-YEAR (80% FULL TAILWATER)

Manhole Table - Time: 0.00 hours

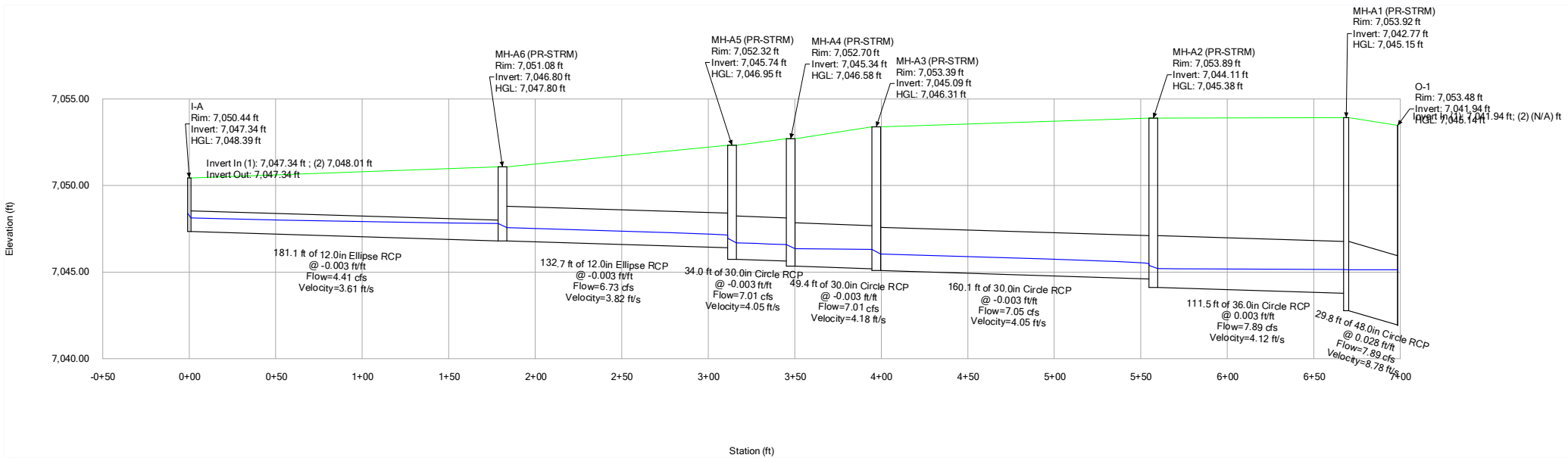
Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert Out) (ft)	Flow (Total Out) (cfs)	Hydraulic Grade Line (Out) (ft)	Headloss Method	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
MH-A2 (PR-STRM)	7,053.89	7,053.89	7,044.11	7.89	7,045.20	Standard	7,045.38	1.020
MH-A3 (PR-STRM)	7,053.39	7,053.39	7,045.09	7.05	7,046.05	Standard	7,046.31	1.020
MH-A4 (PR-STRM)	7,052.70	7,052.70	7,045.35	7.01	7,046.36	Standard	7,046.58	1.020
MH-A5 (PR-STRM)	7,052.32	7,052.32	7,045.74	7.01	7,046.69	Standard	7,046.95	1.020
MH-A6 (PR-STRM)	7,051.08	7,051.08	7,046.80	6.73	7,047.57	Standard	7,047.80	1.020
MH-A1 (PR-STRM)	7,053.92	7,053.92	7,042.77	7.89	7,045.13	Standard	7,045.15	1.020

5-YEAR (80% FULL TAILWATER)

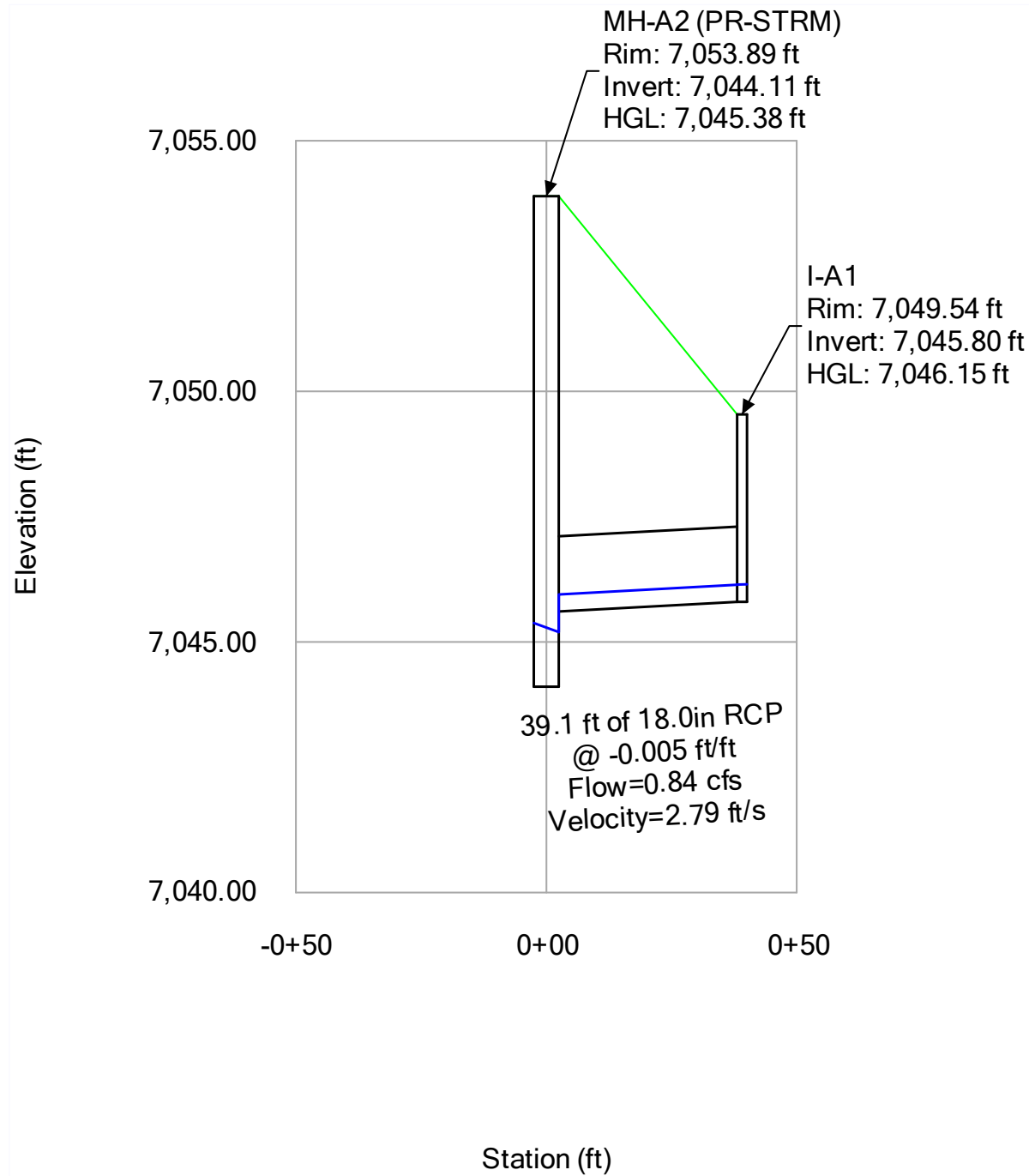
Outfall Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Set Rim to Ground Elevation?	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
O-1	7,053.48	True	7,041.94	User Defined Tailwater	7,045.14	7.89

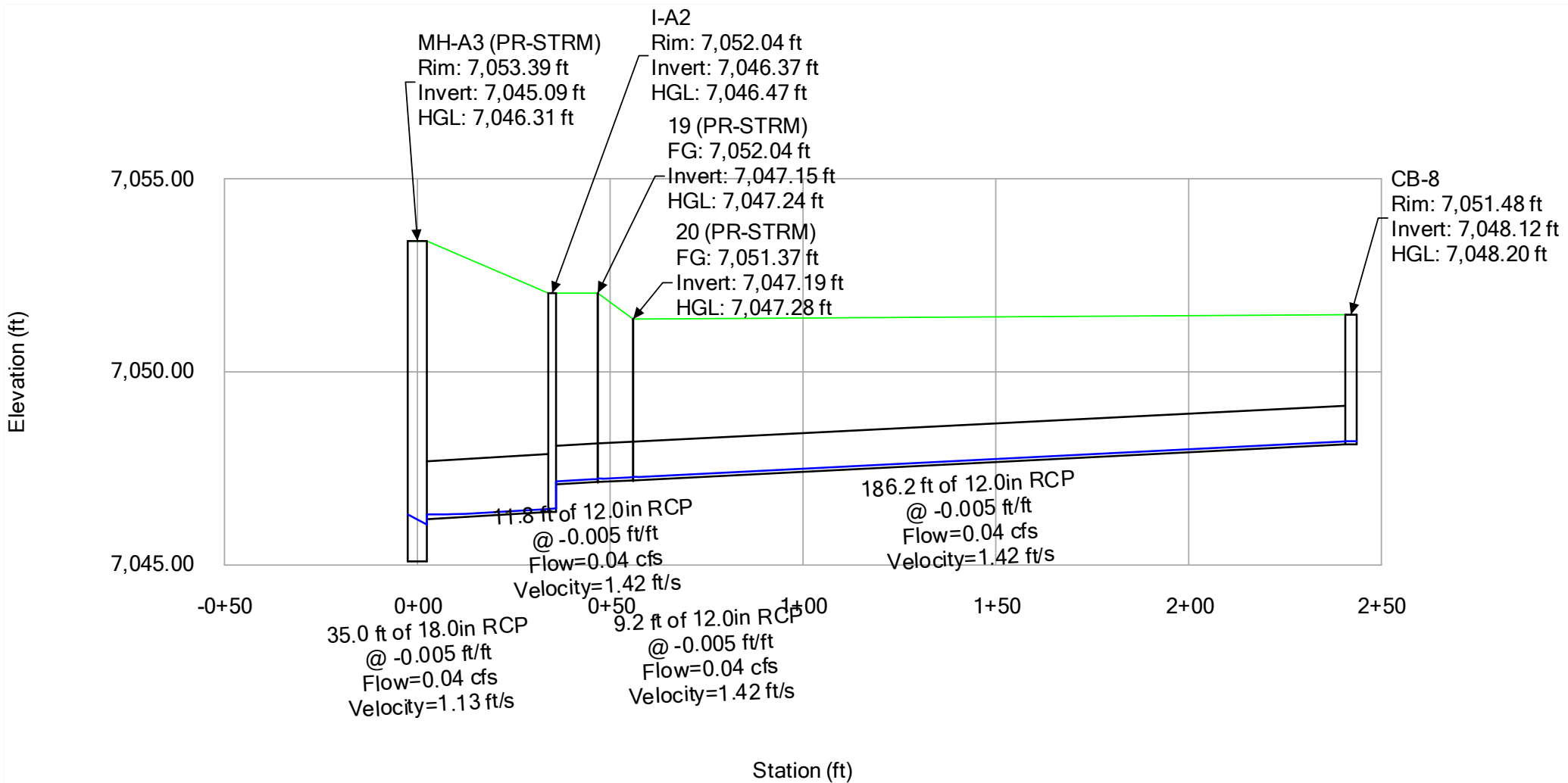
5-YEAR - STRM-A



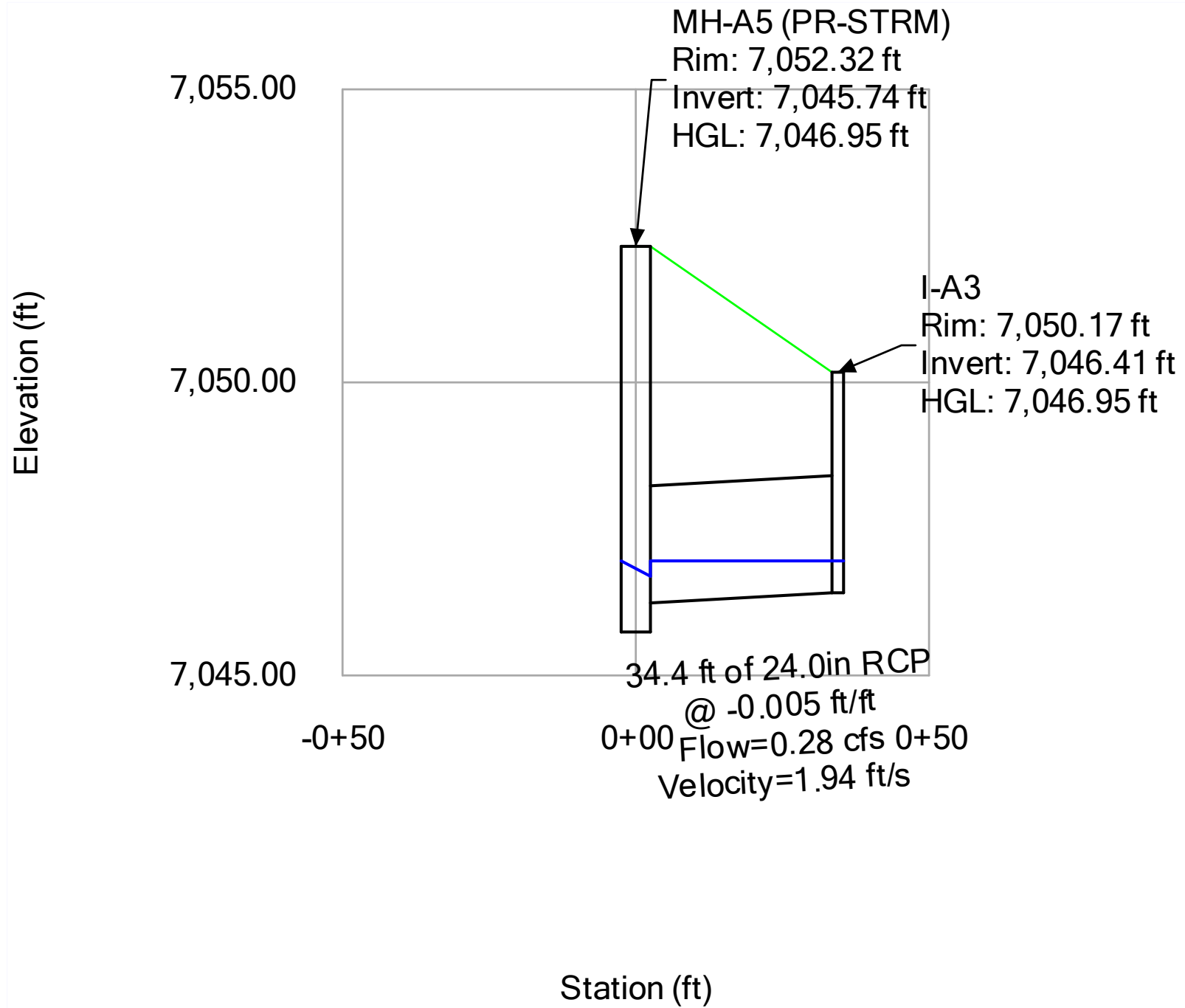
5-YEAR - STRM-A1



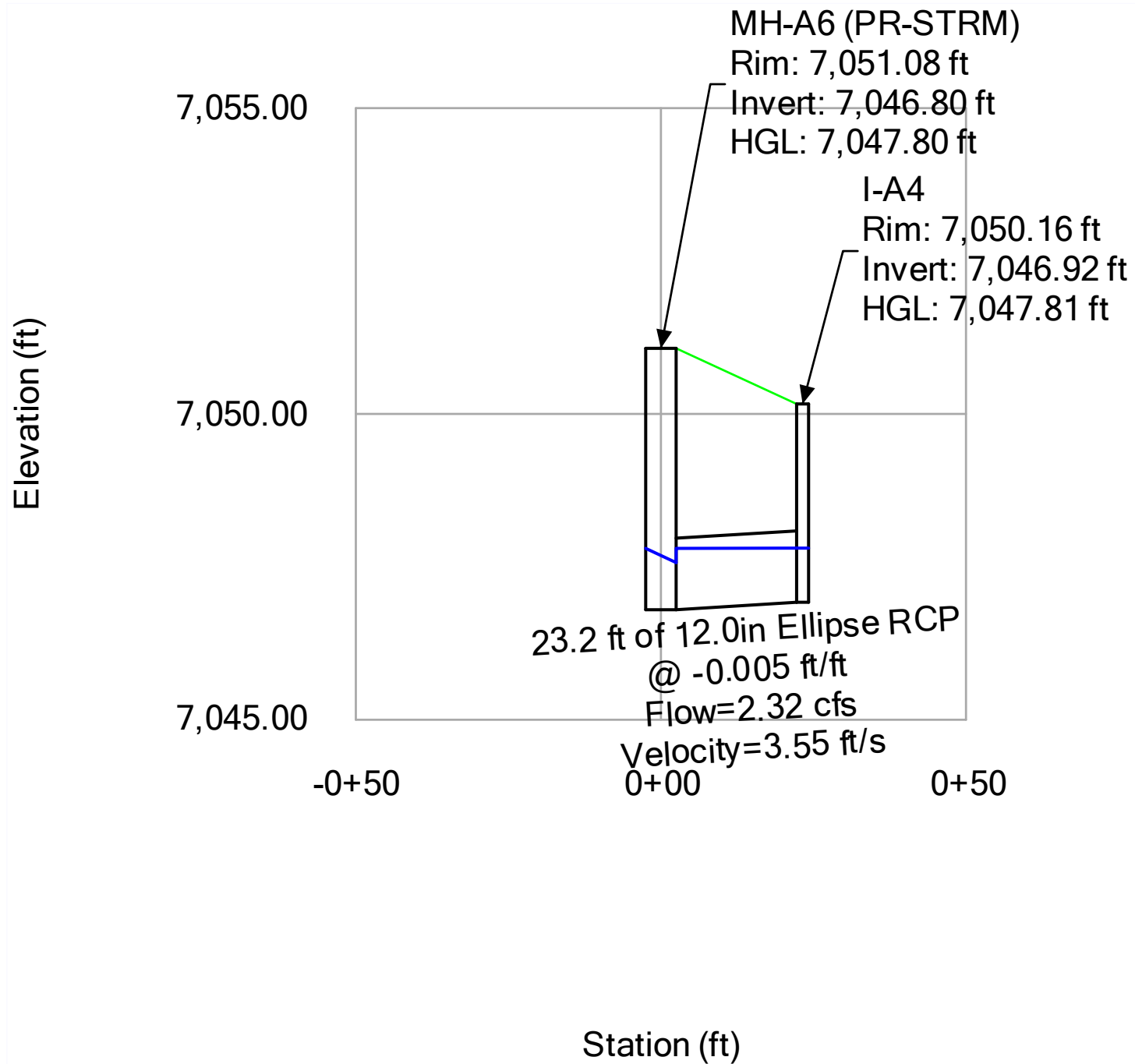
5-YEAR - STRM-A2



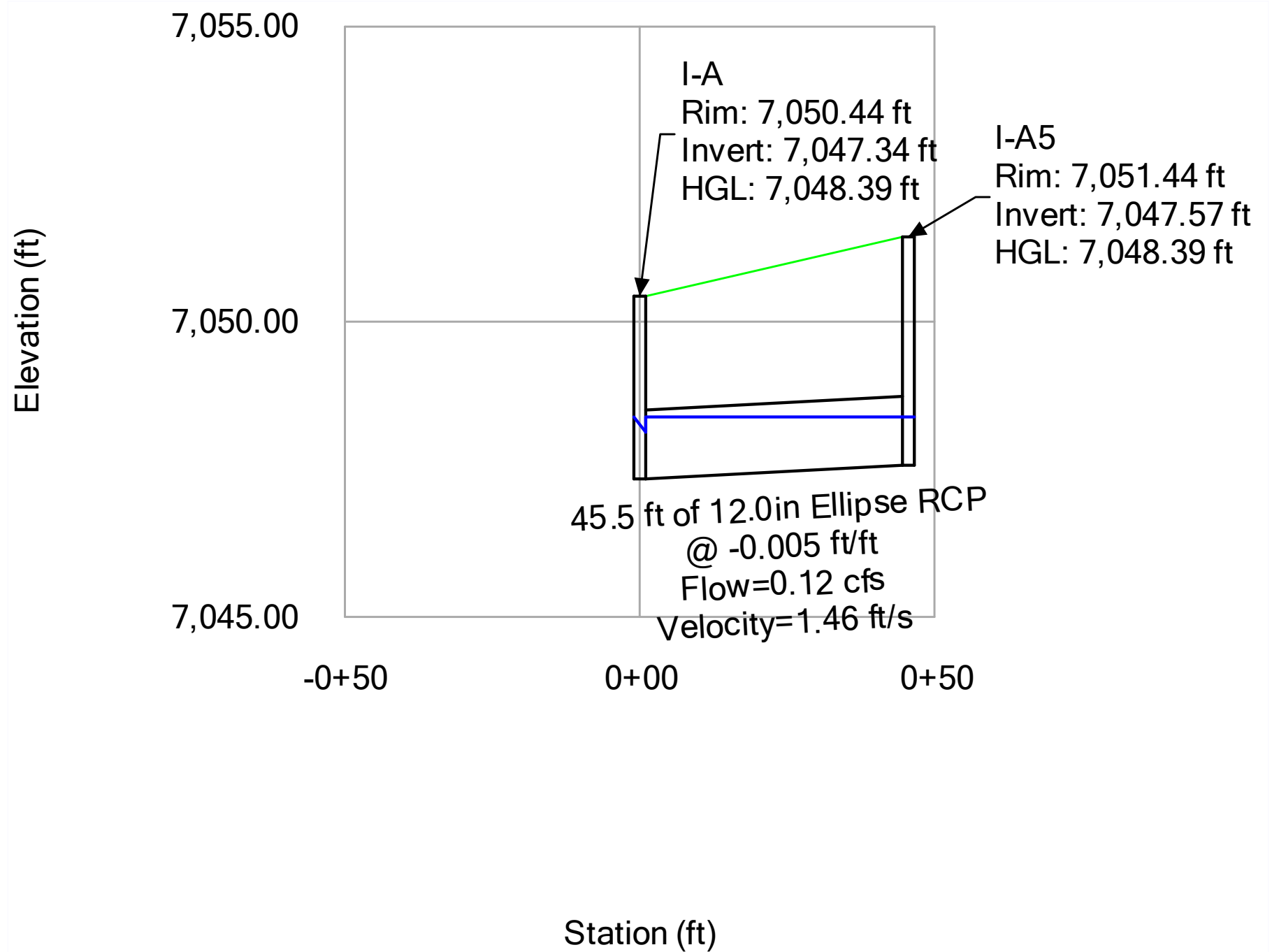
5-YEAR - STRM-A3



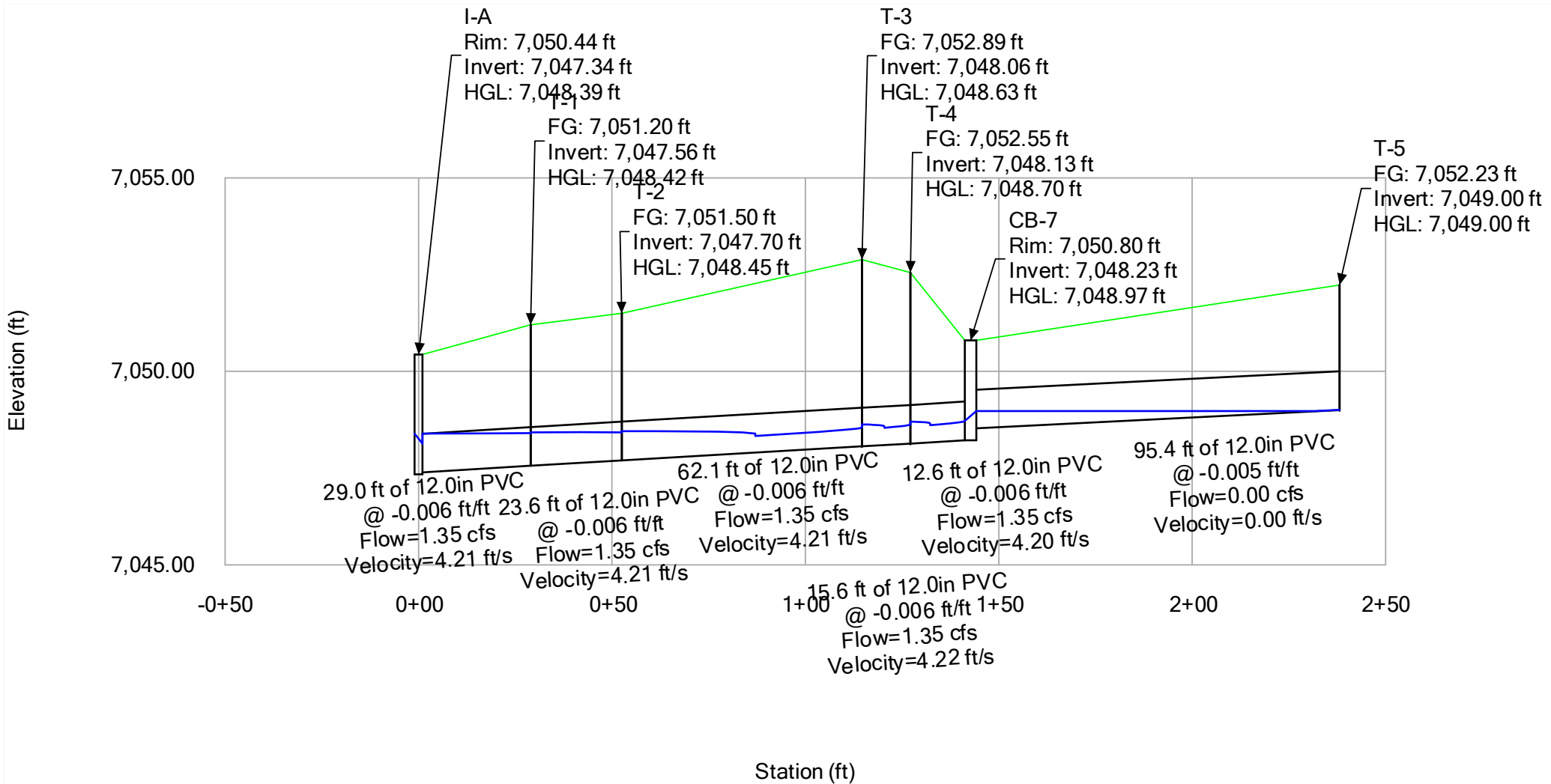
5-YEAR - STRM-A4



5-YEAR - STRM-A5



5-YEAR - STRM-B



100-YEAR (100% FULL TAILWATER)**Conduit Table - Time: 0.00 hours**

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
PIPE -03 (PR-STRM)	MH-A2 (PR-STRM)	7,044.61	MH-A3 (PR-STRM)	7,045.09	160.1	-0.003	0.013	18.61	5.12	22.48	7,046.83	7,046.37
PIPE -11 (PR-STRM)	MH-A2 (PR-STRM)	7,045.61	I-A1	7,045.80	39.1	-0.005	0.013	2.22	3.67	7.44	7,046.37	7,046.37
PIPE -04 (PR-STRM)	MH-A3 (PR-STRM)	7,045.19	MH-A4 (PR-STRM)	7,045.35	49.4	-0.003	0.013	18.07	5.28	23.51	7,047.32	7,047.24
PIPE -12 (PR-STRM)	MH-A3 (PR-STRM)	7,046.19	I-A2	7,046.37	35.0	-0.005	0.013	0.54	2.48	7.55	7,047.24	7,047.24
PIPE -05 (PR-STRM)	MH-A4 (PR-STRM)	7,045.64	MH-A5 (PR-STRM)	7,045.74	34.0	-0.003	0.013	18.07	5.09	22.48	7,047.68	7,047.62
PIPE -06 (PR-STRM)	MH-A5 (PR-STRM)	7,046.40	MH-A6 (PR-STRM)	7,046.80	132.7	-0.003	0.013	16.36	5.01	22.35	7,048.16	7,047.99
PIPE -13 (PR-STRM)	MH-A5 (PR-STRM)	7,046.24	I-A3	7,046.41	34.4	-0.005	0.013	1.71	3.32	15.99	7,047.99	7,047.99
PIPE -15 (PR-STRM)	I-A	7,047.34	I-A5	7,047.57	45.5	-0.005	0.013	0.90	0.51	7.19	7,050.44	7,050.44
PIPE -07 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A	7,047.34	181.1	-0.003	0.013	11.03	6.16	5.72	7,050.55	7,048.49
PIPE -14 (PR-STRM)	MH-A6 (PR-STRM)	7,046.80	I-A4	7,046.92	23.2	-0.005	0.013	5.33	3.03	7.16	7,048.55	7,048.49
PIPE -16 (PR-STRM)	I-A2	7,047.09	19 (PR-STRM)	7,047.15	11.8	-0.005	0.010	0.14	2.07	3.27	7,047.30	7,047.24
PIPE -18 (PR-STRM)	20 (PR-STRM)	7,047.19	CB-8	7,048.12	186.2	-0.005	0.010	0.14	2.07	3.28	7,048.28	7,047.37
PIPE -17 (PR-STRM)	19 (PR-STRM)	7,047.15	20 (PR-STRM)	7,047.19	9.2	-0.005	0.010	0.14	2.08	3.28	7,047.35	7,047.32
CO-1	MH-A2 (PR-STRM)	7,044.11	MH-A1 (PR-STRM)	7,043.77	111.5	0.003	0.013	20.83	5.33	36.51	7,046.09	7,045.99
CO-2	I-A	7,047.39	T-1	7,047.56	29.0	-0.006	0.010	2.67	3.40	3.54	7,050.53	7,050.44
CO-3	T-1	7,047.56	T-2	7,047.70	23.6	-0.006	0.010	2.67	3.40	3.54	7,050.68	7,050.60
CO-4	T-2	7,047.70	T-3	7,048.06	62.1	-0.006	0.010	2.67	3.40	3.55	7,050.96	7,050.75
CO-5	T-3	7,048.06	T-4	7,048.13	12.6	-0.006	0.010	2.67	3.40	3.53	7,051.07	7,051.03
CO-6	T-4	7,048.13	CB-7	7,048.23	15.6	-0.006	0.010	2.67	3.40	3.56	7,051.20	7,051.15
CO-7	CB-7	7,048.53	T-5	7,049.00	95.4	-0.005	0.010	0.00	0.00	3.27	7,050.80	7,050.80
EX. PIPE IN STAPLETON DR	MH-A1 (PR-STRM)	7,042.77	O-1	7,041.94	29.8	0.028	0.013	20.83	11.72	240.09	7,045.93	7,045.94

100-YEAR (100% FULL TAILWATER)

Catch Basin Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Additional Subsurface) (cfs)	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
I-A3	7,050.17	7,050.17	7,046.41	1.71	7,047.99	0.050
I-A1	7,049.54	7,049.54	7,045.80	2.22	7,046.38	0.050
I-A2	7,052.04	7,052.04	7,046.37	0.40	7,047.24	1.020
I-A4	7,050.16	7,050.16	7,046.92	5.33	7,048.55	0.000
I-A	7,050.44	7,050.44	7,047.34	7.46	7,051.21	1.320
I-A5	7,051.44	7,051.44	7,047.57	0.90	7,050.44	0.050
CB-7	7,050.80	7,050.80	7,048.23	2.67	7,051.04	1.320
CB-8	7,051.48	7,051.48	7,048.12	0.14	7,048.28	0.000

100-YEAR (100% FULL TAILWATER)

Manhole Table - Time: 0.00 hours

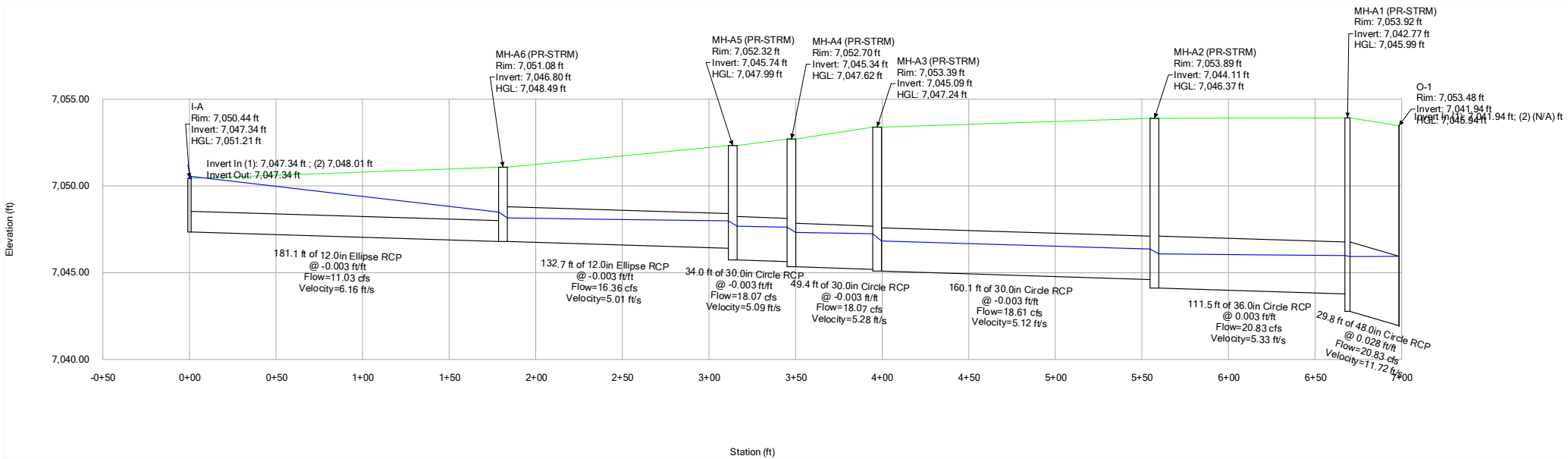
Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert Out) (ft)	Flow (Total Out) (cfs)	Hydraulic Grade Line (Out) (ft)	Headloss Method	Hydraulic Grade Line (In) (ft)	Headloss Coefficient (Standard)
MH-A2 (PR-STRM)	7,053.89	7,053.89	7,044.11	20.83	7,046.09	Standard	7,046.37	1.020
MH-A3 (PR-STRM)	7,053.39	7,053.39	7,045.09	18.61	7,046.83	Standard	7,047.24	1.020
MH-A4 (PR-STRM)	7,052.70	7,052.70	7,045.35	18.07	7,047.32	Standard	7,047.62	1.020
MH-A5 (PR-STRM)	7,052.32	7,052.32	7,045.74	18.07	7,047.68	Standard	7,047.99	1.020
MH-A6 (PR-STRM)	7,051.08	7,051.08	7,046.80	16.36	7,048.16	Standard	7,048.49	1.020
MH-A1 (PR-STRM)	7,053.92	7,053.92	7,042.77	20.83	7,045.93	Standard	7,045.99	1.020

100-YEAR (100% FULL TAILWATER)

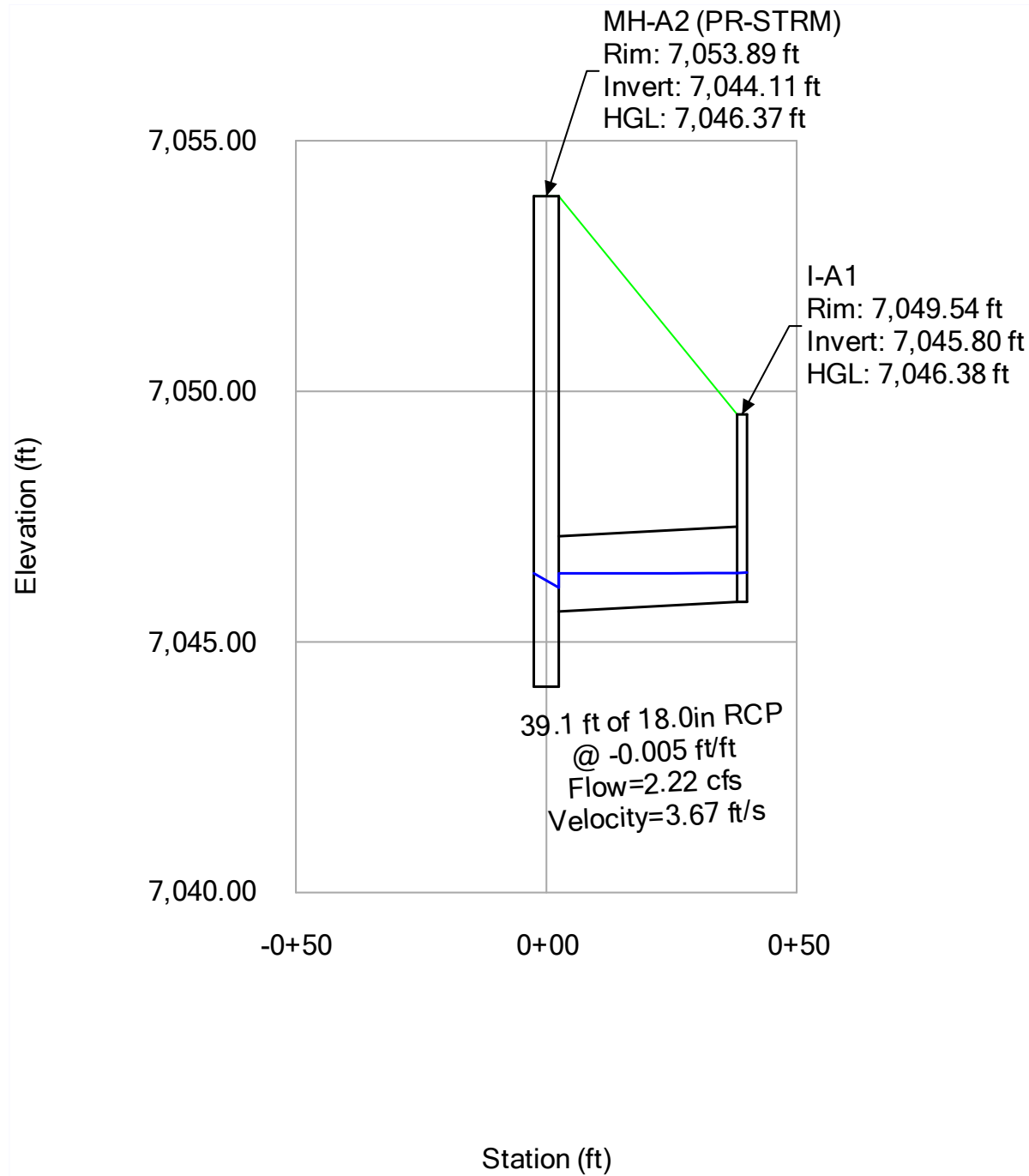
Outfall Table - Time: 0.00 hours

Label	Elevation (Ground) (ft)	Set Rim to Ground Elevation?	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
O-1	7,053.48	True	7,041.94	User Defined Tailwater	7,045.94	20.83

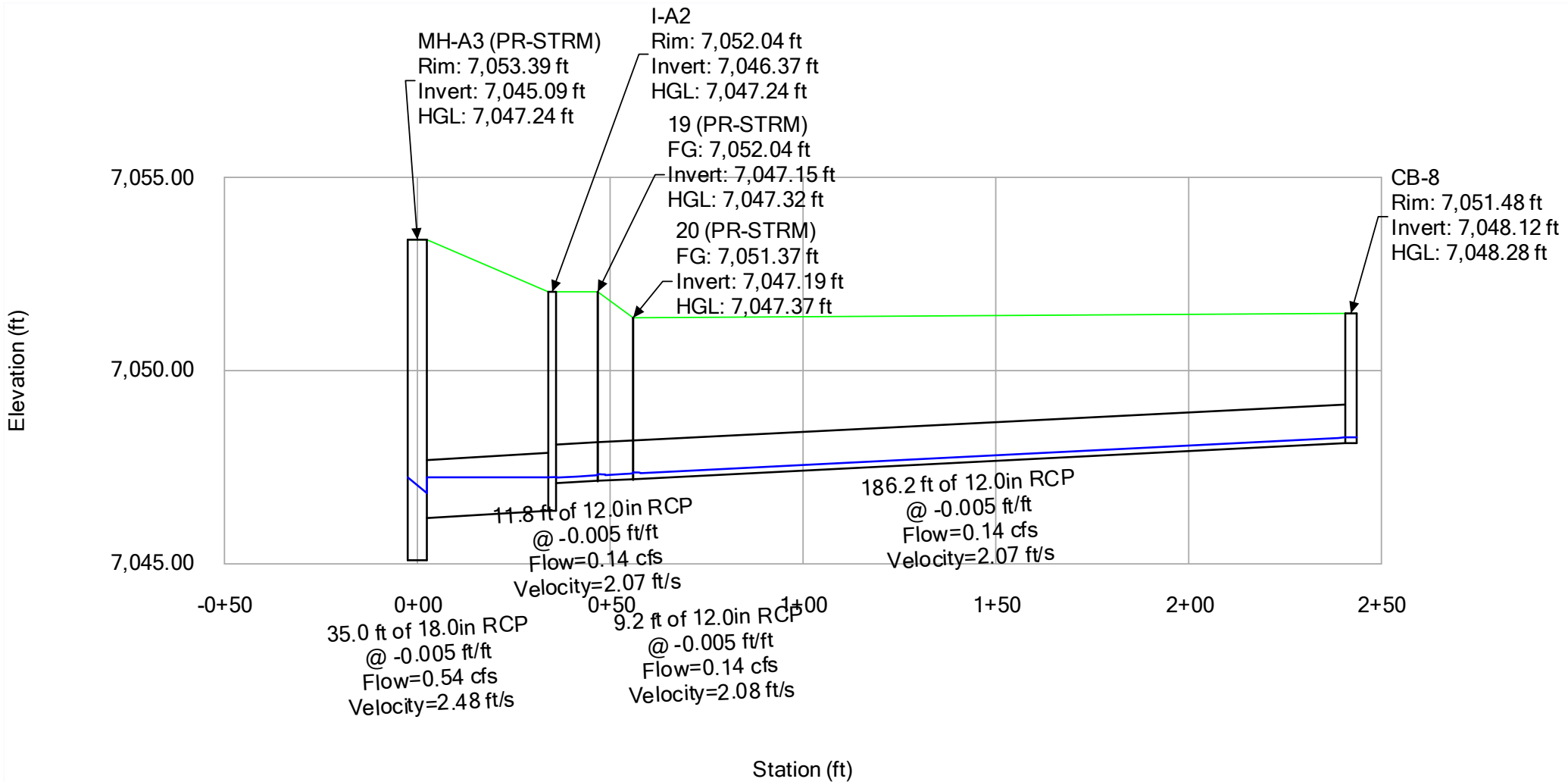
100-YEAR - STRM-A



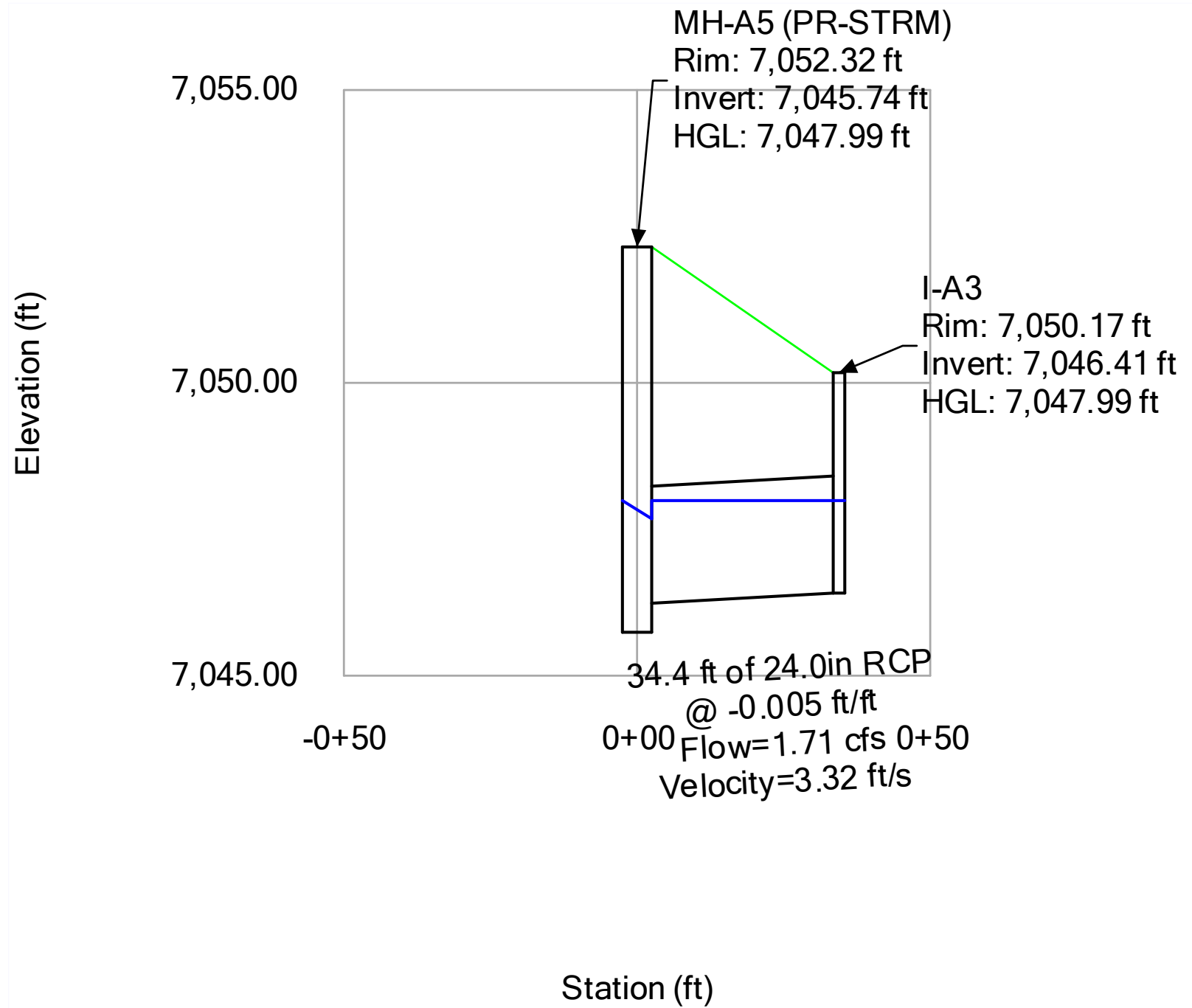
100-YEAR - STRM-A1



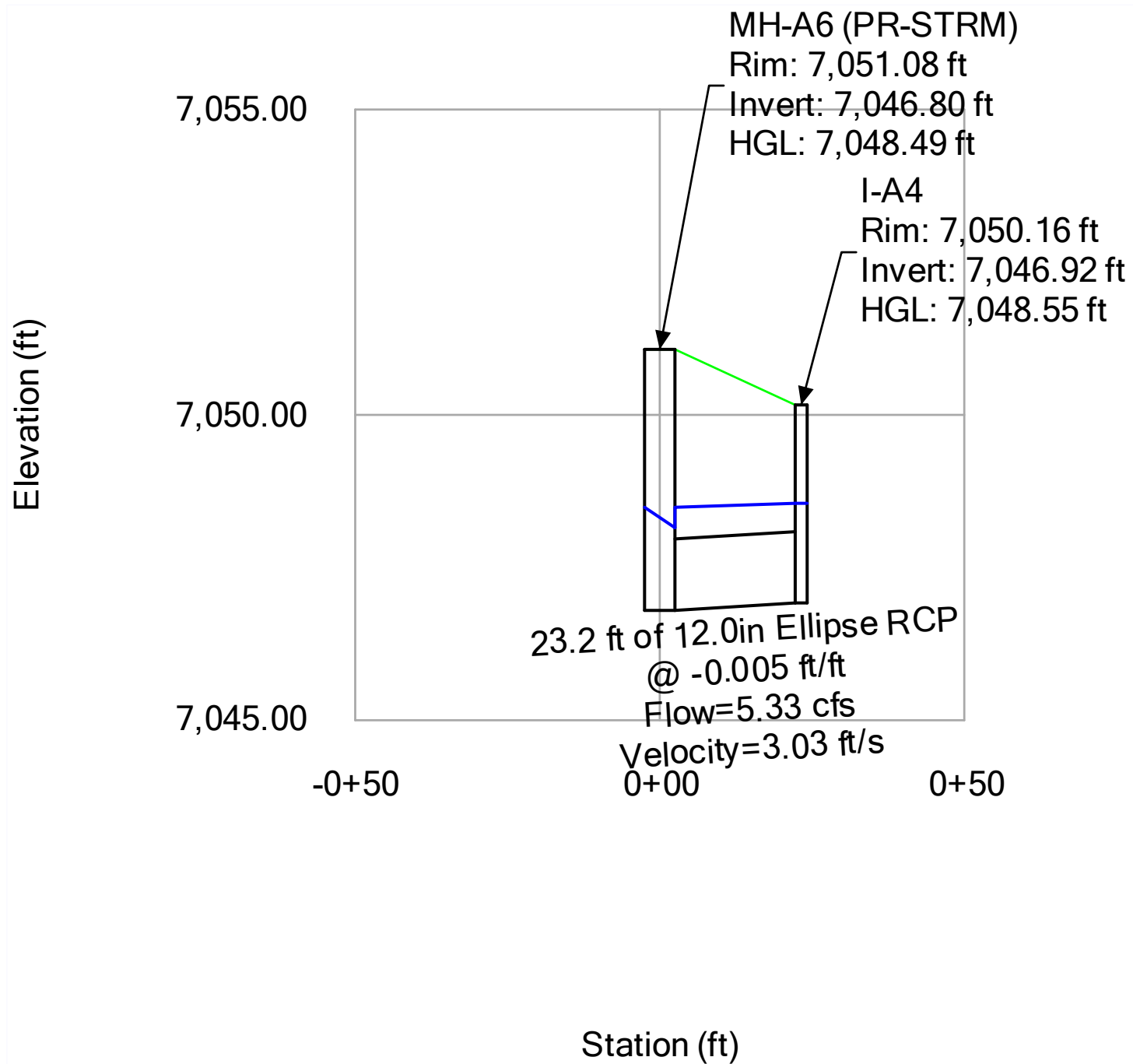
100-YEAR - STRM-A2



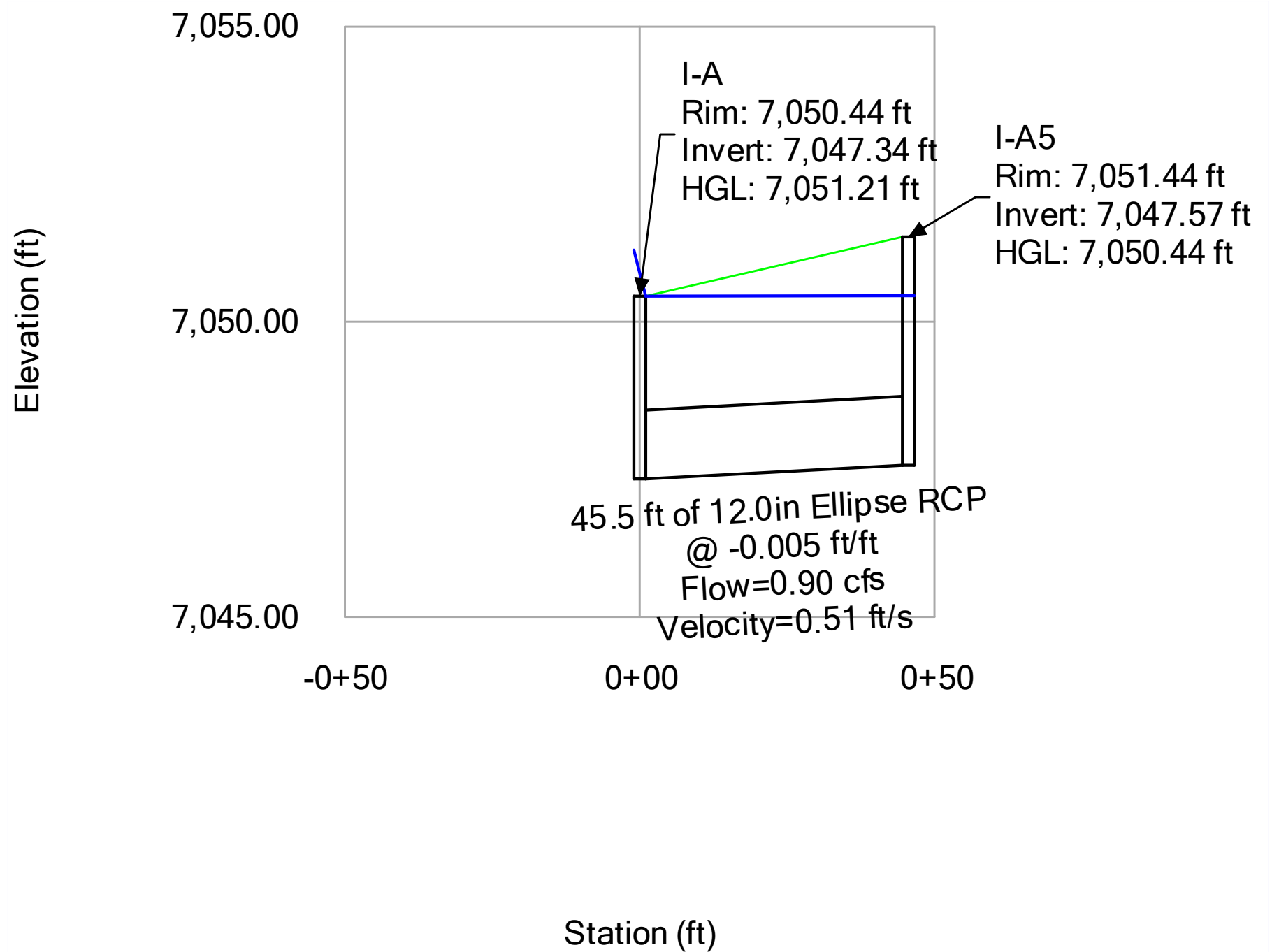
100-YEAR - STRM-A3



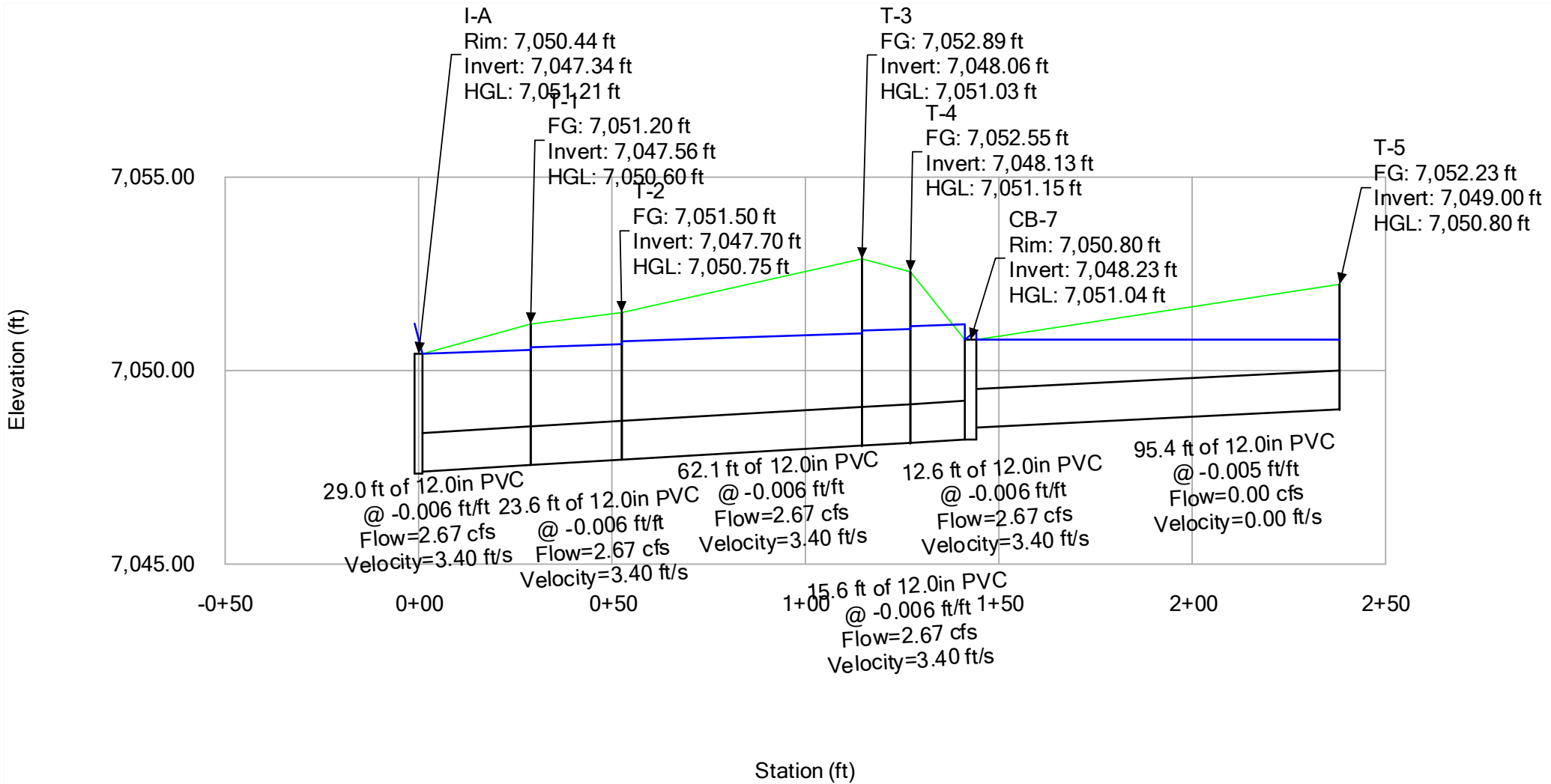
100-YEAR - STRM-A4



100-YEAR - STRM-A5

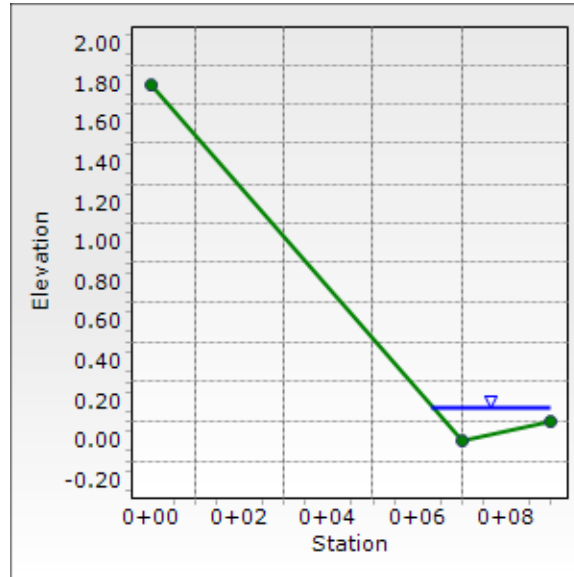


100-YEAR - STRM-B



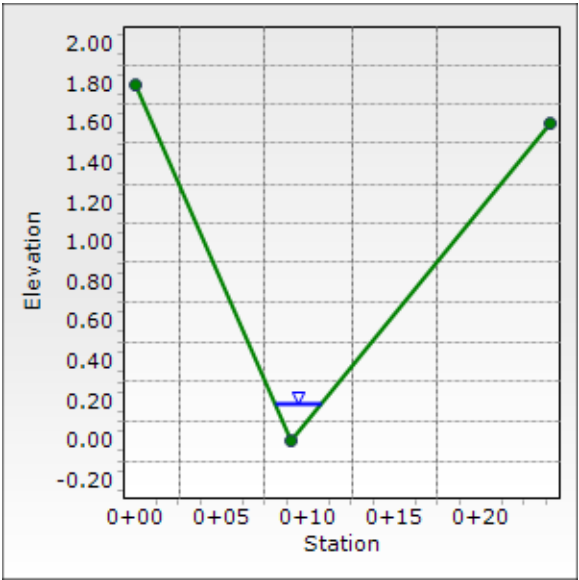
Cross Section for SWALE A - P3

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	2.0 in
Discharge	0.31 cfs



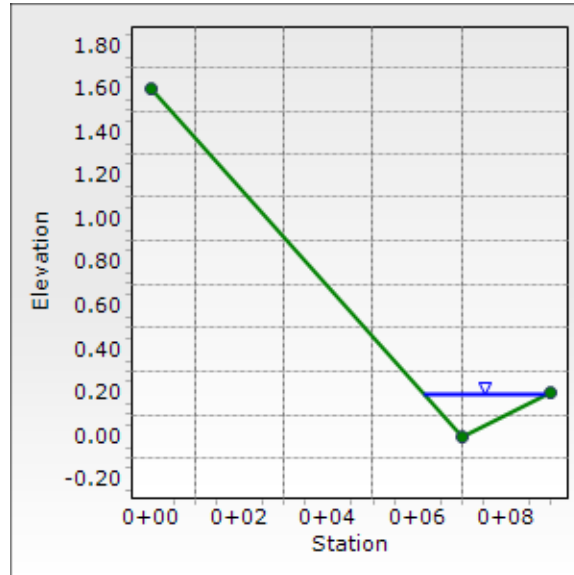
Cross Section for SWALE B - OS1

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	2.2 in
Discharge	0.25 cfs



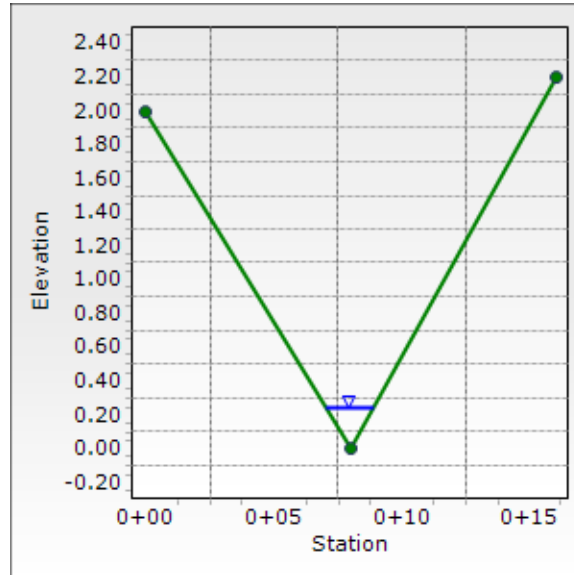
Cross Section for SWALE C - P4

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.2 in
Discharge	0.31 cfs



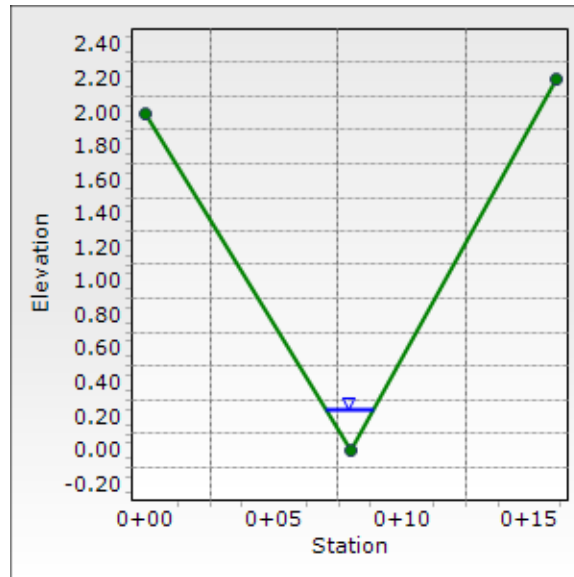
Cross Section for SWALE D - P4

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.9 in
Discharge	0.31 cfs



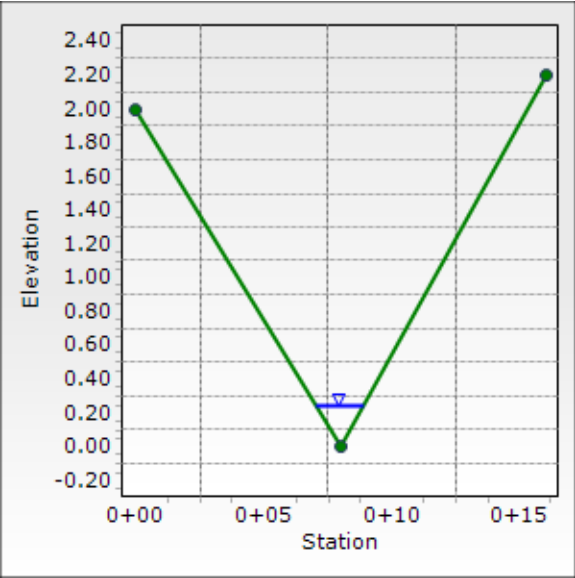
Cross Section for SWALE E - P5

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.9 in
Discharge	0.31 cfs



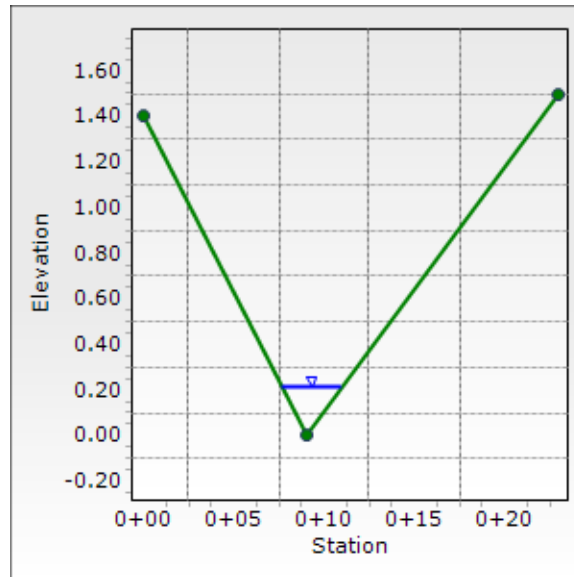
Cross Section for SWALE F - P7

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.015 ft/ft
Normal Depth	2.9 in
Discharge	0.31 cfs



Cross Section for SWALE G - P6

Project Description	
Friction Method	Manning
	Formula
Solve For	Normal Depth
Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	2.6 in
Discharge	0.40 cfs



INLET MANAGEMENT

Worksheet Protected

INLET NAME	I-A	I-A1	I-A2
Site Type (Urban or Rural)	RURAL	RURAL	RURAL
Inlet Application (Street or Area)	AREA	AREA	AREA
Hydraulic Condition	Swale	Swale	Swale
Inlet Type	CDOT Type C (Depressed)	CDOT Type C	CDOT Type C

USER-DEFINED INPUT**User-Defined Design Flows**

Minor Q_{Known} (cfs)	2.9	0.8	0.1
Major Q_{Known} (cfs)	5.8	2.2	0.4

Bypass (Carry-Over) Flow from Upstream Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	2.9	0.8	0.1
Major Total Design Peak Flow, Q (cfs)	5.8	2.2	0.4
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0

INLET MANAGEMENT

Worksheet Protected

INLET NAME	I-A3	I-A4	I-A5
Site Type (Urban or Rural)	RURAL	RURAL	RURAL
Inlet Application (Street or Area)	AREA	AREA	AREA
Hydraulic Condition	Swale	Swale	Swale
Inlet Type	CDOT Type C	CDOT Type D (In Series)	CDOT Type C

USER-DEFINED INPUT**User-Defined Design Flows**

Minor Q_{known} (cfs)	0.3	2.3	0.1
Major Q_{known} (cfs)	1.7	5.3	0.9

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

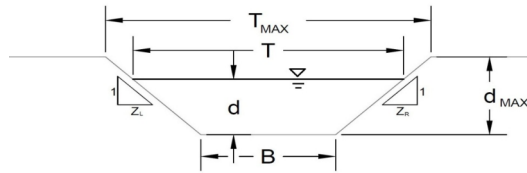
Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.3	2.3	0.1
Major Total Design Peak Flow, Q (cfs)	1.7	5.3	0.9
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0

AREA INLET IN A SWALE

I-A



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

n =	0.013	
S_0 =	0.0150	ft/ft
B =	0.00	ft
Z1 =	50.00	ft/ft
Z2 =	50.00	ft/ft

Choose One:

- ☒ Non-Cohesive
☐ Cohesive
☐ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T_{MAX} =	65.00	65.00	ft
d_{MAX} =	1.50	1.50	ft

Maximum Channel Capacity Based On Allowable Top Width

Maximum Allowable Top Width

Water Depth

Flow Area

Wetted Perimeter

Hydraulic Radius

Manning's n

Flow Velocity

Velocity-Depth Product

Hydraulic Depth

Froude Number

Maximum Flow Based on Allowable Water Depth

	Minor Storm	Major Storm	
T_{MAX} =	65.00	65.00	ft
d =	0.65	0.65	ft
A =	21.13	21.13	sq ft
P =	65.01	65.01	ft
R =	0.32	0.32	ft
n =	0.013	0.013	
V =	6.63	6.63	fps
VR =	2.16	2.16	ft ² /s
D =	0.33	0.33	ft
Fr =	2.05	2.05	
Q_T =	140.2	140.2	cfs

Maximum Channel Capacity Based On Allowable Water Depth

Maximum Allowable Water Depth

Top Width

Flow Area

Wetted Perimeter

Hydraulic Radius

Manning's n

Flow Velocity

Velocity-Depth Product

Hydraulic Depth

Froude Number

Maximum Flow Based On Allowable Water Depth

	Minor Storm	Major Storm	
d_{MAX} =	1.50	1.50	ft
T =	150.00	150.00	ft
A =	112.50	112.50	sq ft
P =	150.03	150.03	ft
R =	0.75	0.75	ft
n =	0.013	0.013	
V =	11.59	11.59	fps
VR =	8.69	8.69	ft ² /s
D =	0.75	0.75	ft
Fr =	2.36	2.36	
Q_d =	1,303.4	1,303.4	cfs

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Top Width Criterion

MAJOR STORM Allowable Capacity is based on Top Width Criterion

	Minor Storm	Major Storm	
Q_{allow} =	140.2	140.2	cfs
d_{allow} =	0.65	0.65	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

Top Width

Flow Area

Wetted Perimeter

Hydraulic Radius

Manning's n

Flow Velocity

Velocity-Depth Product

Hydraulic Depth

Froude Number

	Minor Storm	Major Storm	
Q_o =	2.9	5.8	cfs
d =	0.15	0.20	ft
T =	15.08	19.62	ft
A =	1.14	1.93	sq ft
P =	15.09	19.63	ft
R =	0.08	0.10	ft
n =	0.013	0.013	
V =	2.51	2.99	fps
VR =	0.19	0.29	ft ² /s
D =	0.08	0.10	ft
Fr =	1.61	1.68	

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A

Inlet Design Information (Input)

Type of Inlet

CDOT Type C (Depressed)

Inlet Type =

CDOT Type C (Depressed)

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

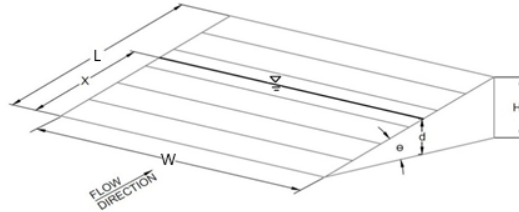
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient

 $\theta =$ 0.00 degrees

W = 3.00 ft

L = 3.00 ft

A_{RATIO} = 0.70H_B = 0.00 ftC_f = 0.50C_g = 0.84C_o = 0.56C_w = 1.81

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

	MINOR	MAJOR
d =	1.15	1.20

Grate Capacity as a Weir

Submerged Side Weir Length

Inclined Side Weir Flow

Base Weir Flow

Interception Without Clogging

Interception With Clogging

	MINOR	MAJOR	
X =	3.00	3.00	ft
Q _{ws} =	11.7	12.4	cfs
Q _{wb} =	16.7	17.7	cfs
Q _{wi} =	40.1	42.5	cfs
Q _{wa} =	20.1	21.3	cfs

Grate Capacity as an Orifice

Interception Without Clogging

Interception With Clogging

	MINOR	MAJOR	
Q _{oi} =	30.5	31.1	cfs
Q _{oa} =	15.3	15.6	cfs

Total Inlet Interception Capacity (assumes clogged condition)

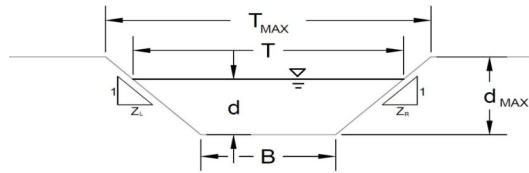
Bypassed Flow

Capture Percentage = Q_a/Q_o

	MINOR	MAJOR	
Q _a =	15.3	15.6	cfs
Q _b =	0.0	0.0	cfs
C% =	100	100	%

AREA INLET IN A SWALE

I-A1



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

A
n = see details below
$S_0 = 0.0100$ ft/ft
B = 0.00 ft
Z1 = 4.00 ft/ft
Z2 = 4.00 ft/ft

Choose One:

- ☐ Non-Cohesive
☐ Cohesive
☐ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
$T_{MAX} =$	23.00	23.00	ft
$d_{MAX} =$	2.00	2.00	ft

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Depth Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	6.3	6.3	cfs
$d_{allow} =$	2.00	2.00	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

	Minor Storm	Major Storm	
$Q_o =$	0.8	2.2	cfs
d =	0.85	1.29	ft

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A1

Inlet Design Information (Input)

Type of Inlet

CDOT Type C

Inlet Type =

CDOT Type C

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

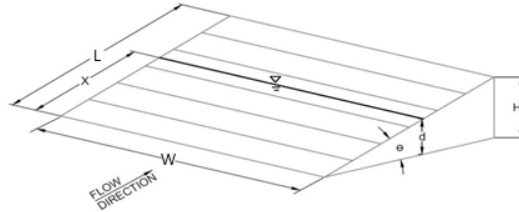
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient

 $\theta =$ 0.00 degrees

W = 3.00 ft

L = 3.00 ft

 $A_{\text{RATIO}} =$ 0.70 $H_b =$ 0.00 ft $C_f =$ 0.50 $C_d =$ 0.96 $C_o =$ 0.64 $C_w =$ 2.05

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

Total Inlet Interception Capacity (assumes clogged condition)

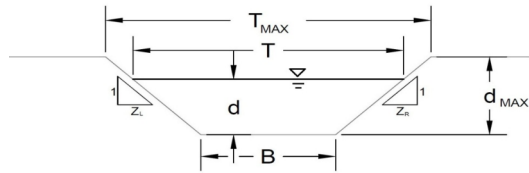
Bypassed Flow

Capture Percentage = Q_a/Q_o

	MINOR	MAJOR	
d =	0.85	1.29	
$Q_a =$	14.5	18.3	cfs
$Q_b =$	0.0	0.0	cfs
C% =	100	100	%

AREA INLET IN A SWALE

I-A2



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

A
n = see details below
$S_0 = 0.0150$ ft/ft
B = 0.00 ft
Z1 = 4.00 ft/ft
Z2 = 4.00 ft/ft

Choose One:

- ☐ Non-Cohesive
☐ Cohesive
☐ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
$T_{MAX} =$	20.00	20.00	ft
$d_{MAX} =$	1.50	1.50	ft

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Depth Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	3.7	3.7	cfs
$d_{allow} =$	1.50	1.50	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

$Q_o =$	0.1	0.4	cfs
$d =$	0.34	0.59	ft

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A2

Inlet Design Information (Input)

Type of Inlet

CDOT Type C

Inlet Type =

CDOT Type C

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

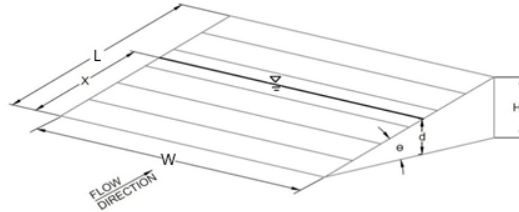
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient

 $\theta =$ 0.00 degrees

W = 3.00 ft

L = 3.00 ft

 $A_{\text{RATIO}} =$ 0.70 $H_b =$ 0.00 ft $C_f =$ 0.50 $C_d =$ 0.96 $C_o =$ 0.64 $C_w =$ 2.05

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

Total Inlet Interception Capacity (assumes clogged condition)

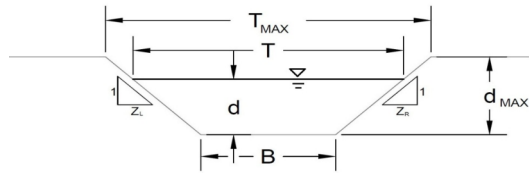
Bypassed Flow

Capture Percentage = Q_a/Q_o

	MINOR	MAJOR	
d =	0.34	0.59	
$Q_a =$	3.6	8.4	cfs
$Q_b =$	0.0	0.0	cfs
C% =	100	100	%

AREA INLET IN A SWALE

I-A3



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

A

n = see details below

 S_0 = 0.0100 ft/ft

B = 0.00 ft

 Z_1 = 4.00 ft/ft Z_2 = 4.00 ft/ft

Choose One:

☐ Non-Cohesive☐ Cohesive☐ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T_{MAX} =	16.00	16.00	ft
d_{MAX} =	2.25	2.25	ft

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Top Width Criterion

MAJOR STORM Allowable Capacity is based on Top Width Criterion

	Minor Storm	Major Storm	
Q_{allow} =	6.3	6.3	cfs
d_{allow} =	2.00	2.00	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

	Minor Storm	Major Storm	
Q_o =	0.3	1.7	cfs
d =	0.56	1.15	ft

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A3

Inlet Design Information (Input)

Type of Inlet

CDOT Type C

Inlet Type =

CDOT Type C

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

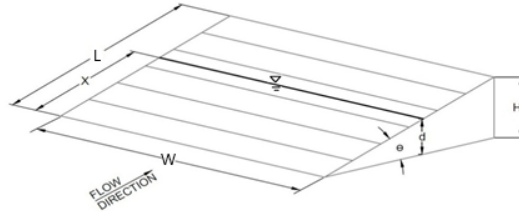
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient

 $\theta =$ 0.00 degrees

W = 3.00 ft

L = 3.00 ft

 $A_{\text{RATIO}} =$ 0.70 $H_b =$ 0.00 ft $C_f =$ 0.50 $C_d =$ 0.96 $C_o =$ 0.64 $C_w =$ 2.05

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

Total Inlet Interception Capacity (assumes clogged condition)

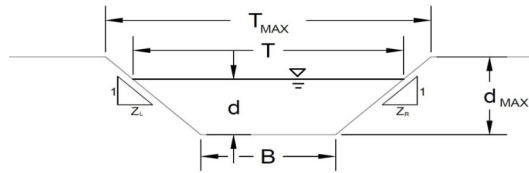
Bypassed Flow

Capture Percentage = Q_a/Q_o

	MINOR	MAJOR	
d =	0.56	1.15	
$Q_a =$	7.7	17.3	cfs
$Q_b =$	0.0	0.0	cfs
C% =	100	100	%

AREA INLET IN A SWALE

I-A4



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

A
n = see details below
S_0 = 0.0150 ft/ft
B = 0.00 ft
Z1 = 4.00 ft/ft
Z2 = 4.00 ft/ft

Choose One:

- ☐ Non-Cohesive
☐ Cohesive
☐ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T_{MAX} =	18.00	18.00	ft
d_{MAX} =	2.00	2.00	ft

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Depth Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q_{allow} =	7.8	7.8	cfs
d_{allow} =	2.00	2.00	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

	Minor Storm	Major Storm	
Q_o =	2.3	5.3	cfs
d =	1.22	1.73	ft

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A4

Inlet Design Information (Input)

Type of Inlet

CDOT Type D (In Series)

Inlet Type =

CDOT Type D (In Series)

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

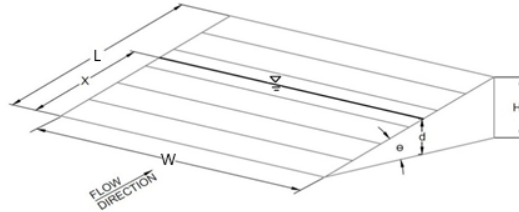
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient



θ = 0.00 degrees

W = 3.00 ft

L = 6.00 ft

A_{RATIO} = 0.70H_B = 0.00 ftC_f = 0.38C_g = 0.78C_o = 0.52C_w = 1.67

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

Total Inlet Interception Capacity (assumes clogged condition)

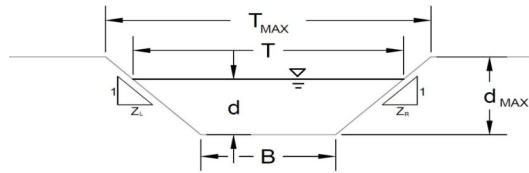
Bypassed Flow

Capture Percentage = Q_a/Q_o

	MINOR	MAJOR	
d =	1.22	1.73	
Q _a =	36.3	43.3	cfs
Q _b =	0.0	0.0	cfs
C% =	100	100	%

AREA INLET IN A SWALE

I-A5



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

A

n = see details below

 S_0 = 0.0150 ft/ft

B = 0.00 ft

 Z_1 = 4.00 ft/ft Z_2 = 20.00 ft/ft

Choose One:

☒ Non-Cohesive☐ Cohesive☐ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T_{MAX} =	2.00	2.00	ft
d_{MAX} =	0.20	0.20	ft

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Top Width Criterion

MAJOR STORM Allowable Capacity is based on Top Width Criterion

	Minor Storm	Major Storm	
Q_{allow} =	0.0	0.0	cfs
d_{allow} =	0.08	0.08	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

	Minor Storm	Major Storm	
Q_o =	0.1	0.9	cfs
d =	0.25	0.53	ft

Warning 05

WARNING: MINOR STORM max. allowable capacity is less than the design flow given on sheet 'Inlet Management'

WARNING: MAJOR STORM max. allowable capacity is less than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

I-A5

Inlet Design Information (Input)

Type of Inlet

CDOT Type C

Inlet Type =

CDOT Type C

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

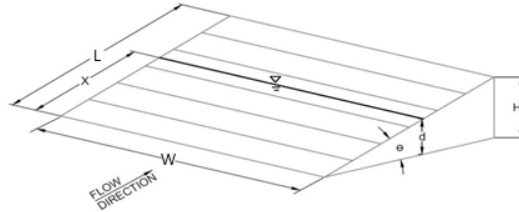
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient

 $\theta =$ 0.00 degrees $W =$ 3.00 ft $L =$ 3.00 ft $A_{\text{RATIO}} =$ 0.70 $H_b =$ 0.00 ft $C_f =$ 0.50 $C_d =$ 0.96 $C_o =$ 0.64 $C_w =$ 2.05

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

Total Inlet Interception Capacity (assumes clogged condition)

Bypassed Flow

Capture Percentage = Q_a/Q_o

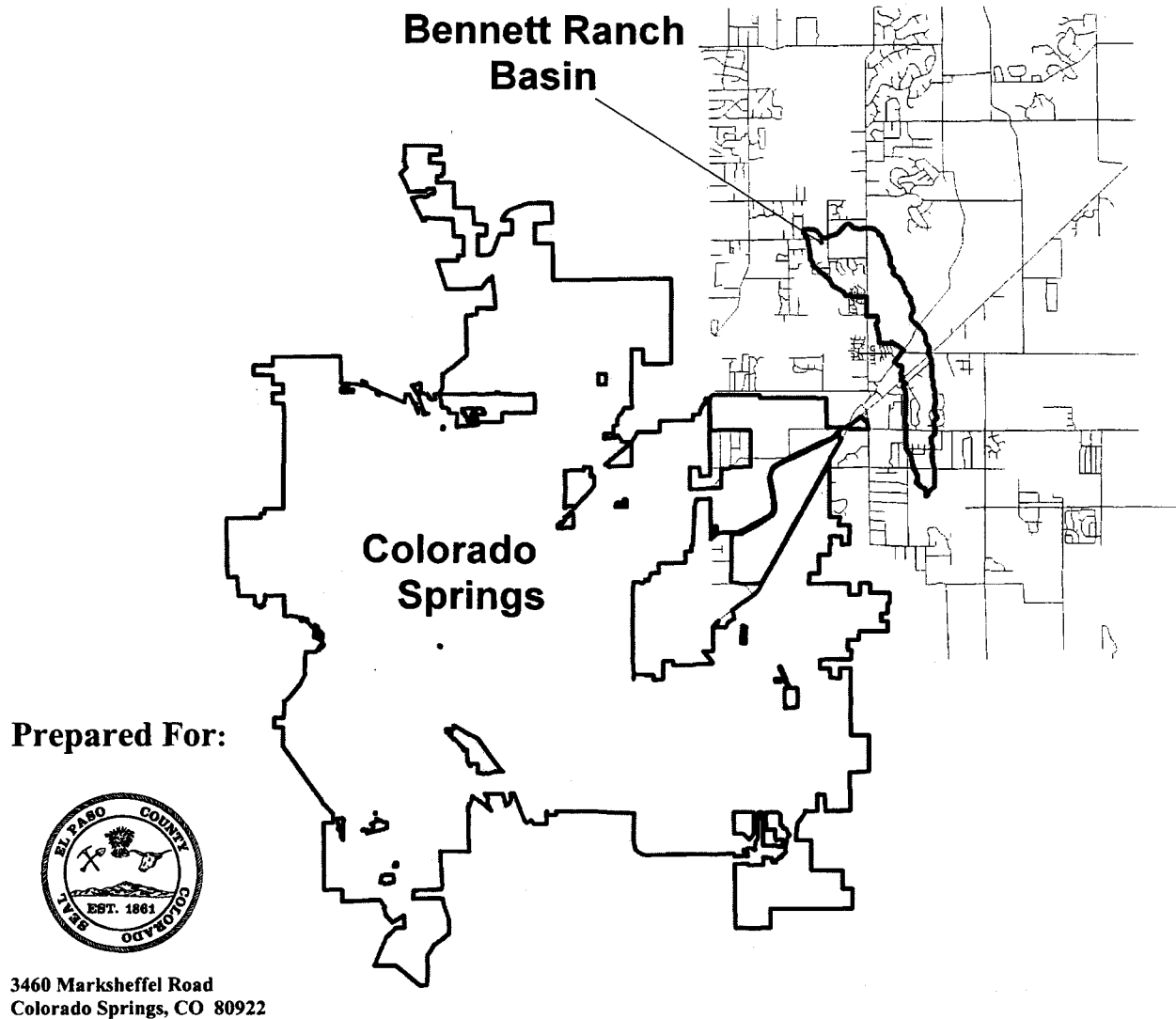
	MINOR	MAJOR	
$d =$	0.25	0.53	
$Q_a =$	2.3	7.0	cfs
$Q_b =$	0.0	0.0	cfs
$C\% =$	100	100	%

Warning 05: Depth (d) exceeds max allowable depth (d_{max}).Warning 06: Top Width (T) exceeds max allowable top width (T_{max}).

APPENDIX F – BENNETT RANCH DBPS

Bennett Ranch Pilot Project Drainage Basin Planning Study

November, 2001



Prepared By:



Table of Contents

EXECUTIVE SUMMARY	1
CONTRACT AUTHORIZATION	1
AGENCY JURISDICTIONS	1
SCOPE AND PURPOSE	1
EXISTING CONDITIONS	2
HYDROLOGY	2
FLOODPLAINS	2
APPROACH AND ALTERNATIVES	2
RECOMMENDED ALTERNATIVE AND PHASING	3
<i>High Priority Improvements</i>	3
<i>Medium Priority Improvements</i>	3
<i>Low Priority Improvements</i>	4
1. SCOPE AND PURPOSE	5
ISSUES REQUIRING FURTHER CONSIDERATION	6
2. WATERSHED CHARACTERISTICS	8
INTRODUCTION	8
EXISTING DRAINAGE PATTERNS AND PROBLEMS	8
<i>Northern Reaches</i>	8
<i>Middle Reaches</i>	8
<i>Southern Reaches</i>	9
<i>Land Use</i>	9
SOILS	10
3. HYDROLOGIC MODELING AND PEAK FLOWS	19
INTRODUCTION	19
MODEL PARAMETERS	19
<i>Basin Parameters</i>	19
<i>Routing Parameters</i>	19
<i>Rainfall Parameters</i>	20
MODEL RESULTS	21
MODEL VERIFICATION	23
<i>URS Meridian Subdivision Model</i>	23
<i>URS HWY 24 Report</i>	23
<i>Muller Study</i>	23
4. PRUDENT LINE	28
DEFINITION	28
APPLICABILITY	28
5. IDENTIFICATION OF DEFICIENCIES	32
DEFINITION OF SYSTEM DEFICIENCIES	32
EVALUATED REACHES	33
IDENTIFICATION OF SYSTEM DEFICIENCIES	33

6. DEVELOPMENT AND EVALUATION OF ALTERNATIVES	39
SCREENING OF ALTERNATIVES	39
<i>Snowbrush to Eastonville Road.....</i>	<i>39</i>
<i>Eastonville Road to Drake Pond.....</i>	<i>39</i>
<i>Drake Pond to the Watershed Outfall.....</i>	<i>40</i>
DEVELOPMENT OF ALTERNATIVES	42
<i>Alternative 1</i>	<i>42</i>
<i>Alternative 2</i>	<i>43</i>
EVALUATION OF ALTERNATIVES	44
7. RECOMMENDED ALTERNATIVE	48
RECOMMENDED ALTERNATIVE HYDROLOGY	48
DRAINAGE BASIN AND BRIDGE FEES.....	48
RECOMMENDED PHASING OF IMPROVEMENTS	51
EASEMENTS AND MAINTENANCE.....	52
MISCELLANEOUS ITEMS	52
APPENDIX A	56
AGENCY COORDINATION.....	56

List of Tables

Table 1-1 - Major Differences in Study Scopes.....	5
Table 3-1 - Model Input Parameters	20
Table 3-2 - HEC-1 Model Results: Peak Flows at Major Crossings	22
Table 4-1 - El Paso County DCM Prudent Line Applicability Criteria.....	29
Table 5-1 - Criteria for Prudent Line Channel Reaches	32
Table 5-2 - Criteria for Traditional-Improvement Channel Segments	32
Table 5-3 - Criteria for Structures.....	33
Table 5-4 - Evaluation of Existing Channel Segments.....	36
Table 5-5 - Evaluation of Existing Channel Segments.....	37
Table 5-6 - Evaluation of Existing Culverts and Bridges	38
Table 6-1 - Alternative Screening Matrix	41
Table 6-2 - Alternative Development Design Criteria.....	42
Table 6-3 - Alternative 1	43
Table 6-4 - Alternative 2	44
Table 6-5 - Comparison of Alternatives	47
Table 7-1 – Improvement Cost Inclusion in Fee Calculations	49
Table 7-2 – Existing and Added Future Developed Impervious Area.....	50
Table 7-3 - Recommended Alternative Improvements.....	54

Table of Figures and Photographs

Figure 2-1 Project Location	11
Figure 2-2 Existing Drainage.....	12
Photograph 2-1:.....	13
Photograph 2-2:.....	13
Photograph 2-3:.....	14
Photograph 2-4:.....	14
Photograph 2-5:.....	15
Photograph 2-6:.....	15
Figure 2-3 Existing Land Use	16
Figure 2-4 Future Land Use.....	17
Figure 2-5 Soils.....	18
Figure 3-1 Model Subcatchments	24
Figure 3-2 Model Connectivity.....	25
Figure 3-3 Peak Flows	26
Figure 3-4 Peak Flows	27
Figure 4-1 Prudent Line Reaches.....	30
Figure 4-2 Prudent Line Reaches.....	31
Figure 5-1 System Deficiencies	35
Figure 6-1 Alternative 1	45
Figure 6-2 Alternative 2.....	46
Figure 7-1 - CAD Figures Containing a Total of Five Sheets	55

Figure 2-1
Project Location

Bennett Ranch
Regional Detention
Pond Approximate
Location

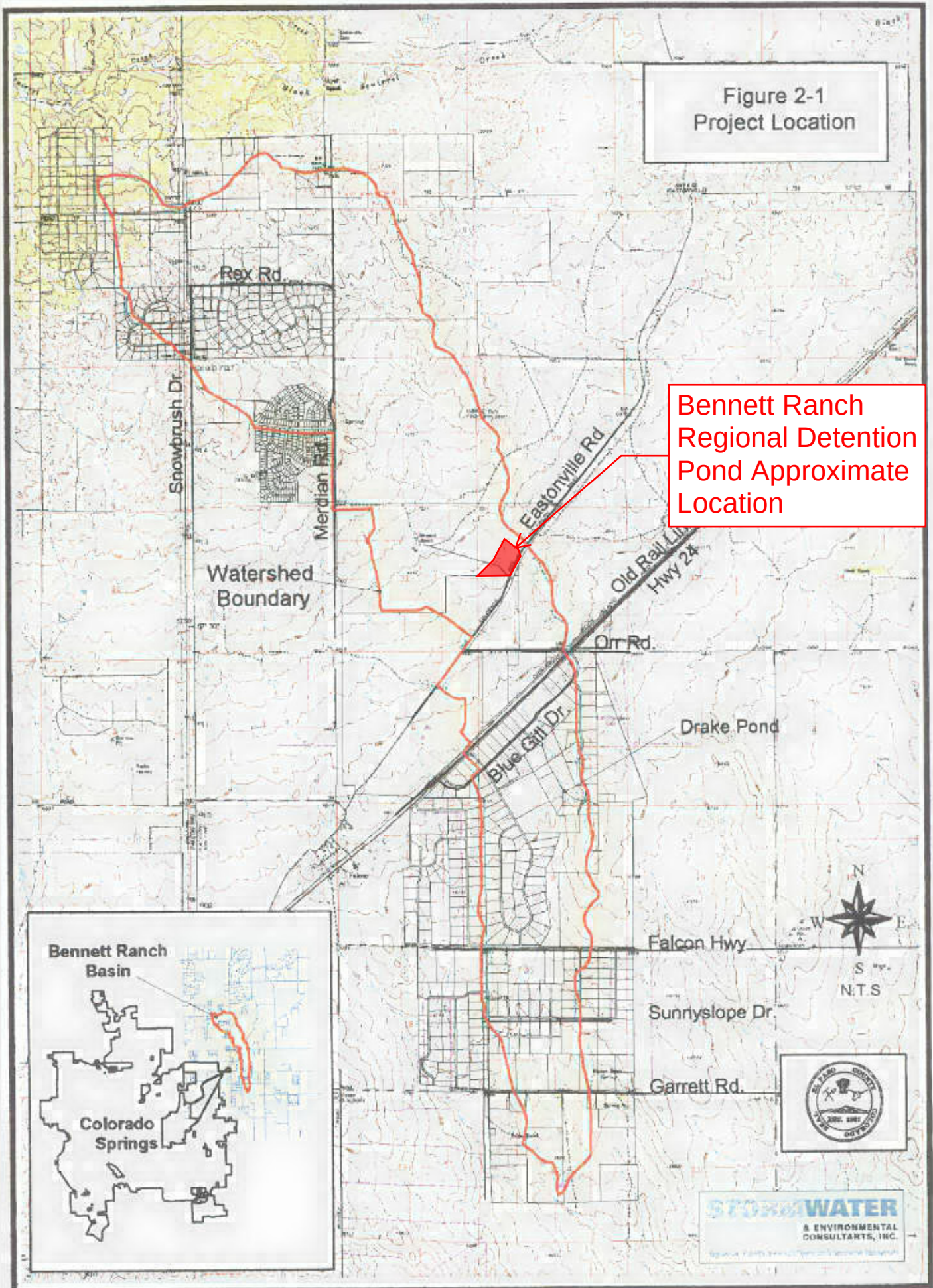
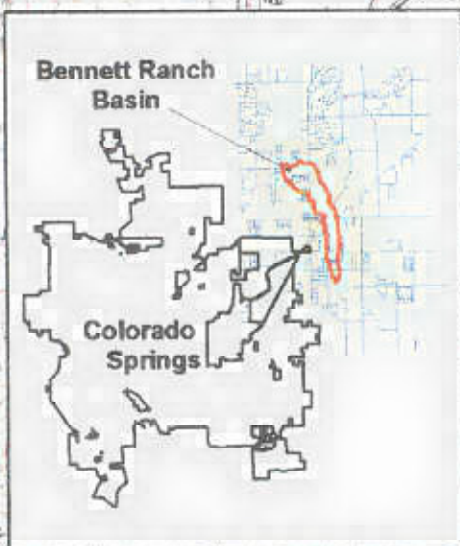


Figure 2-4
Future Land Use

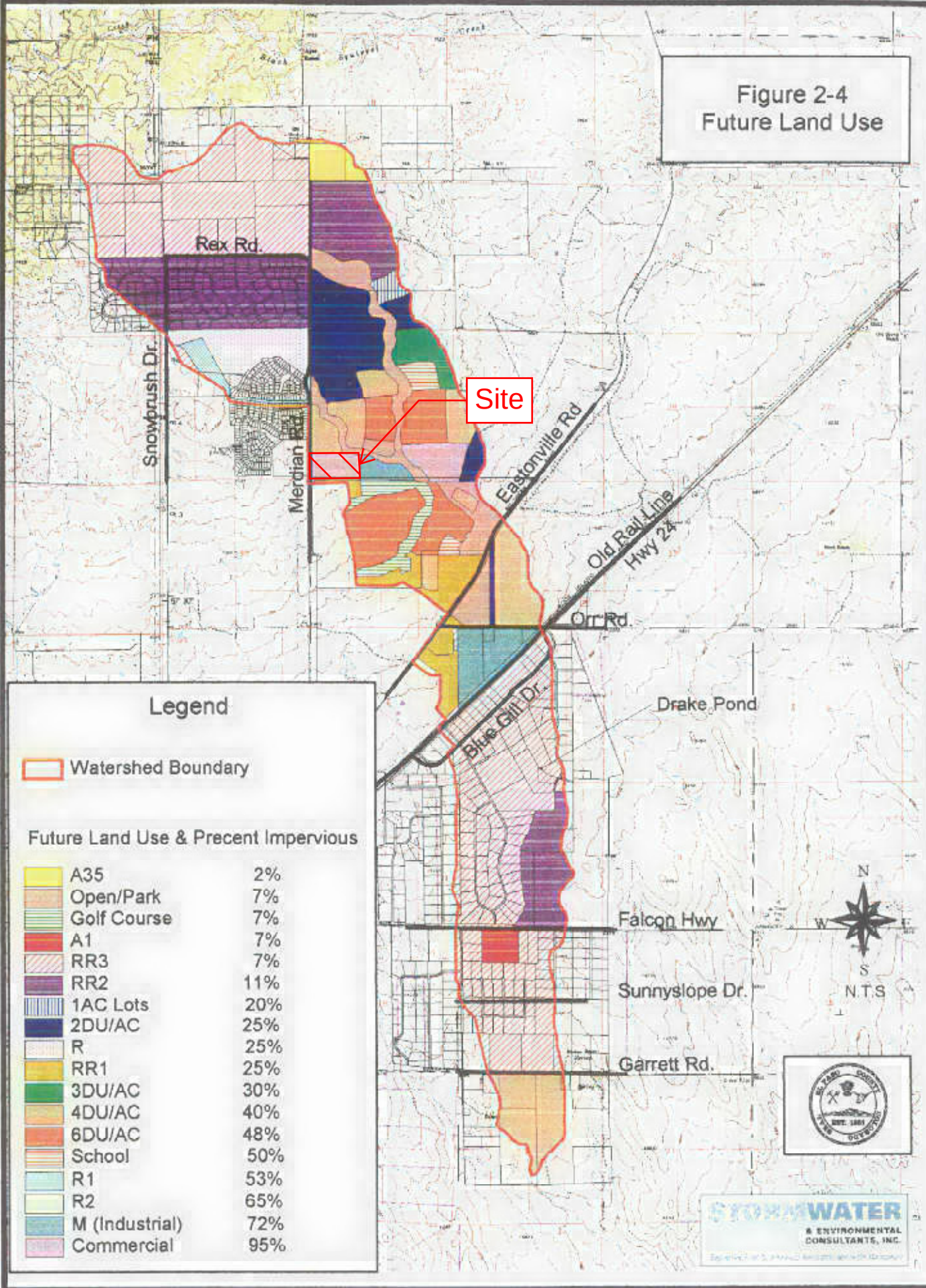
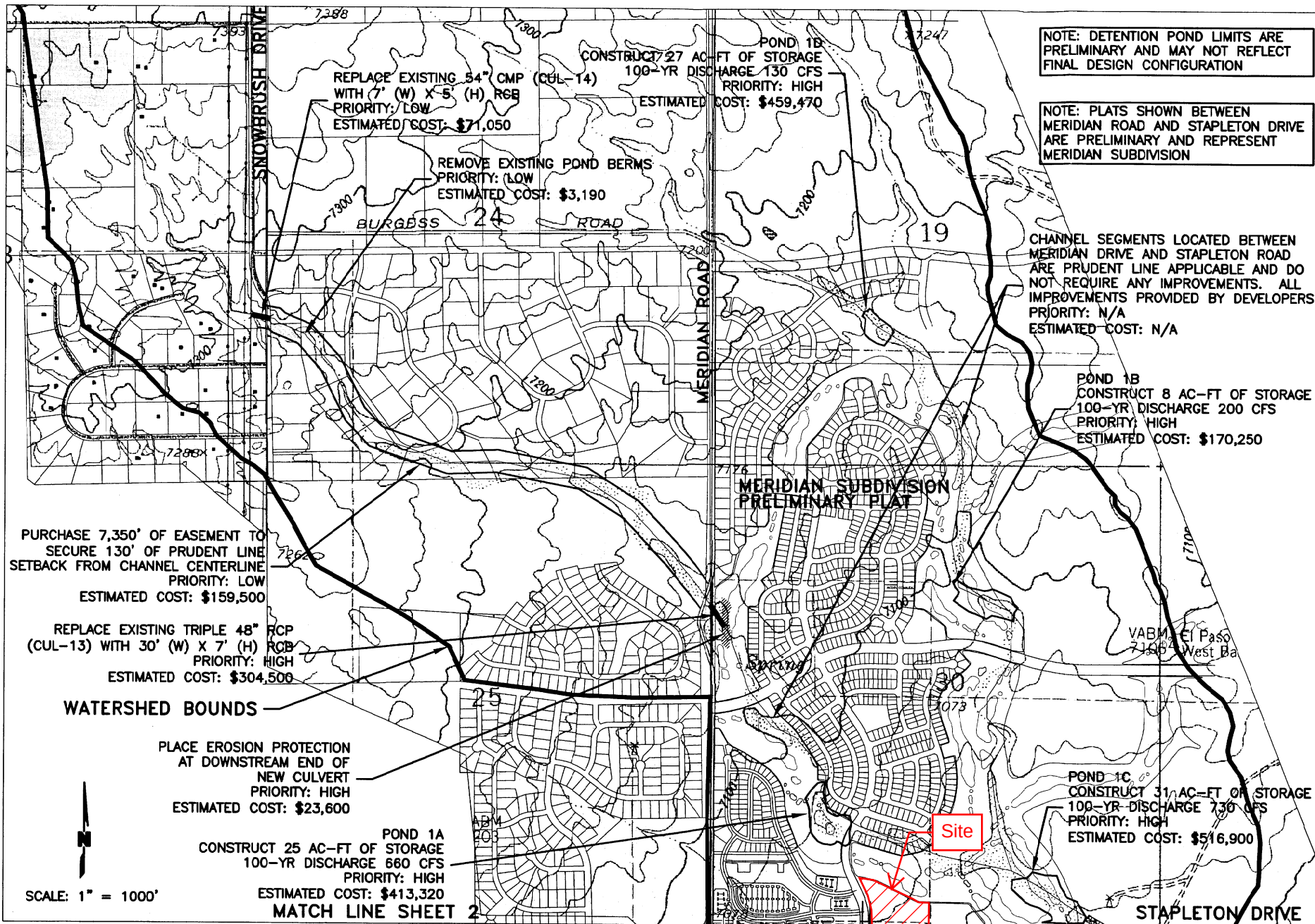


Table 7-2 – Existing and Added Future Developed Impervious Area

Existing Impervious Area in Bennett Ranch Basin			
Area (acres)	Landuse	Percent Impervious	Impervious Area (acres)
102	RR3	7%	7
87	RR3	7%	6
402	RR2	11%	44
217	R	25%	54
29	R1	53%	15
7	RR3	7%	1
3	R	25%	1
1	RR3	7%	0
52	RR1	25%	13
880	RR3	7%	62
5	R2	65%	3
145	RR2	11%	16
3	RR3	7%	0
39	A1	7%	3
Sum = 1973			Sum = 225
Impervious Area to be Added in Bennett Ranch Basin by Future Development			
492	RR3	7%	34
52	A35	2%	1
181	RR2	11%	20
21	1AC Lots	20%	4
210	2DU/AC	25%	52
22	2DU/AC	25%	6
57	3DU/AC	30%	17
25	SCHOOL	50%	13
26	4DU/AC	40%	11
35	4DU/AC	40%	14
36	6DU/AC	48%	17
35	4DU/AC	40%	14
3	SCHOOL	50%	2
30	4DU/AC	40%	12
24	2DU/AC	25%	6
12	Open/Park	7%	1
38	Commercial	95%	36
10	RR1	25%	2
10	4DU/AC	40%	4
10	SCHOOL	50%	5
51	Open/Park	7%	4
85	RR1	25%	21
16	4DU/AC	40%	6
13	RR1	25%	3
2	RR3	7%	0
2	RR1	25%	0
151	4DU/AC	40%	60
138	Open/Park	7%	10
66	6DU/AC	48%	32
56	Commercial	95%	53
28	M	72%	20



NOTE: DETENTION POND LIMITS ARE PRELIMINARY AND MAY NOT REFLECT FINAL DESIGN CONFIGURATION

NOTE: PLATS SHOWN BETWEEN MERIDIAN ROAD AND STAPLETON DRIVE ARE PRELIMINARY AND REPRESENT MERIDIAN SUBDIVISION

FIGURE 7-1
SHEET 1



WATER & ENVIRONMENTAL CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management

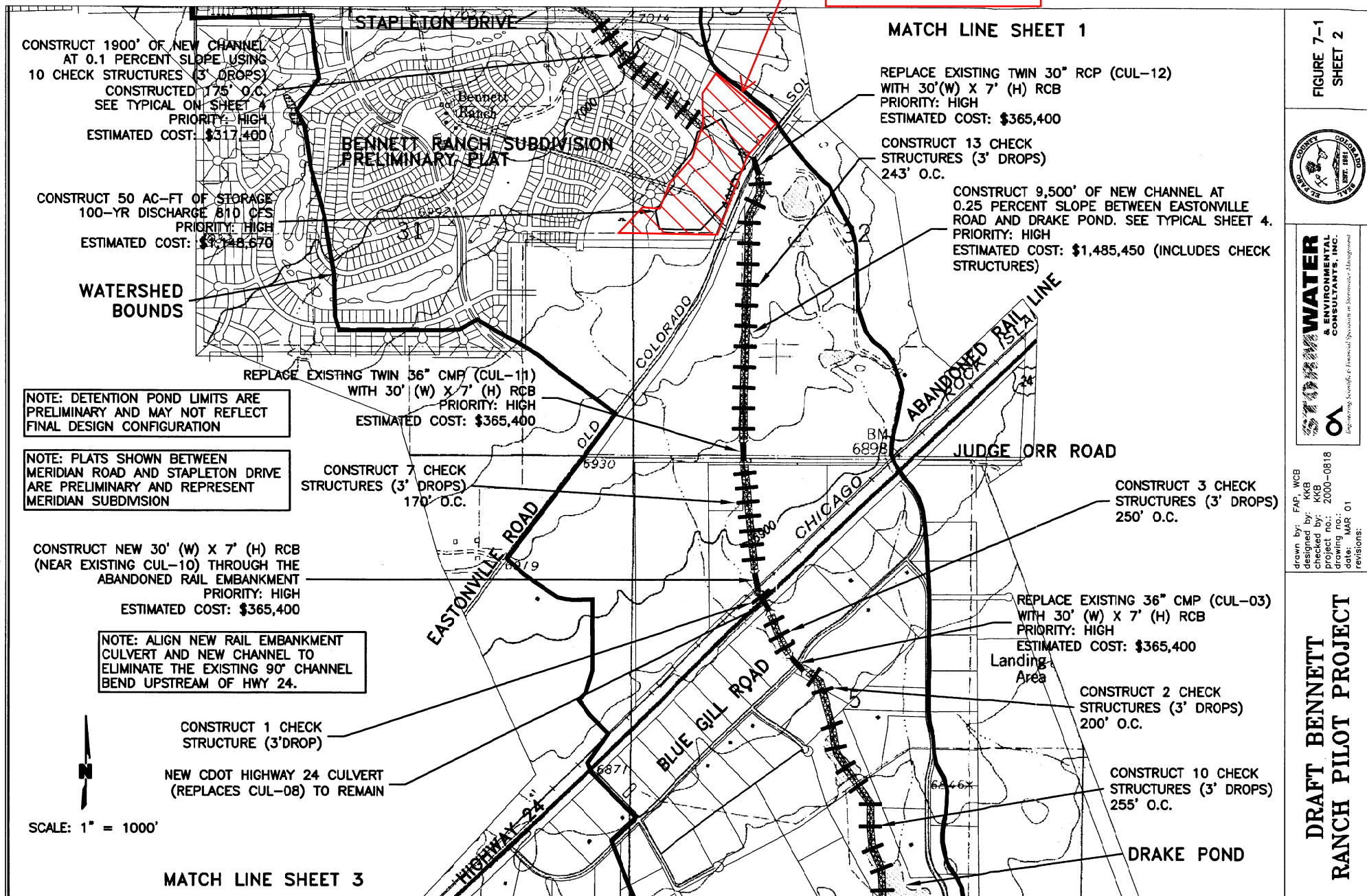
drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:

**DRAFT BENNETT
RANCH PILOT PROJECT**

Bennett Ranch Regional Detention Pond

drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:

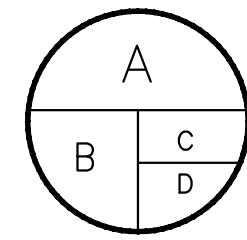
**DRAFT BENNETT
RANCH PILOT PROJECT**



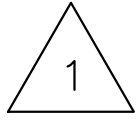
APPENDIX G – DRAINAGE MAPS

WHMD RWRF STORMWATER IMPROVEMENTS
EXISTING DRAINAGE MAP

LEGEND



A = BASIN DESIGNATION
B = AREA (ACRES)
C = IMPERVIOUSNESS
D = 100-YR DESIGN STORM
RUNOFF (CFS)



= DESIGN POINT



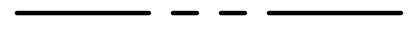
EXISTING FLOW DIRECTION



DRAINAGE BASIN BOUNDARY



EXISTING MAJOR CONTOUR



EXISTING MINOR CONTOUR

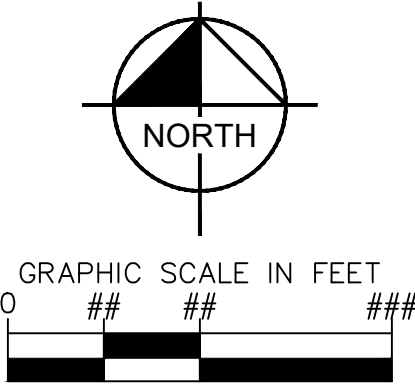
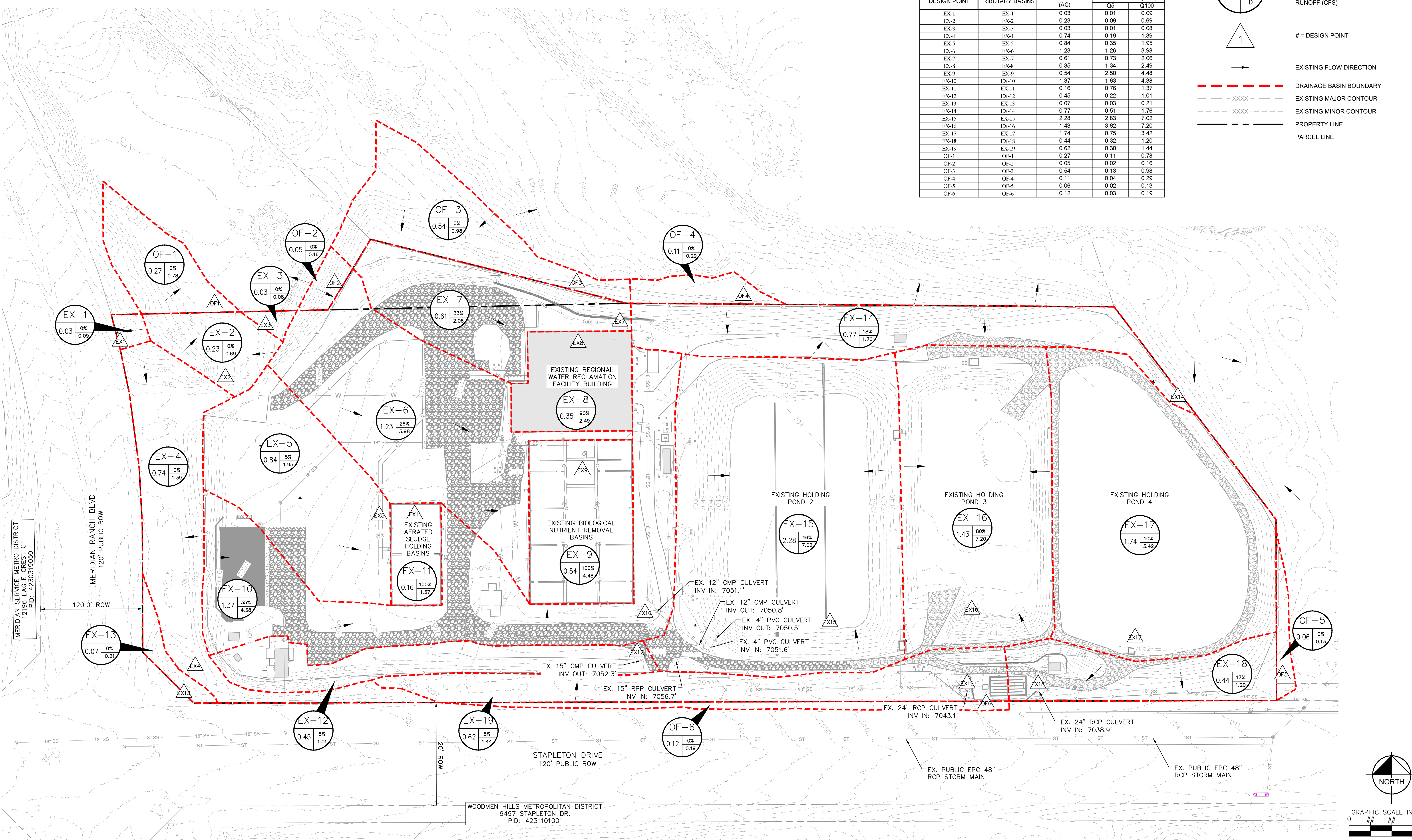


PROPERTY LINE



PARCEL LINE

EXISTING RATIONAL CALCULATIONS SUMMARY				
DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
			Q5	Q100
EX-1	EX-1	0.03	0.01	0.03
EX-2	EX-2	0.23	0.09	0.69
EX-3	EX-3	0.03	0.01	0.08
EX-4	EX-4	0.74	0.19	1.39
EX-5	EX-5	0.84	0.35	1.95
EX-6	EX-6	1.23	1.26	3.98
EX-7	EX-7	0.61	0.73	2.06
EX-8	EX-8	0.35	1.34	2.49
EX-9	EX-9	0.54	2.50	4.48
EX-10	EX-10	1.37	1.63	4.38
EX-11	EX-11	0.16	0.76	1.37
EX-12	EX-12	0.45	0.22	1.01
EX-13	EX-13	0.07	0.03	0.21
EX-14	EX-14	0.77	0.51	1.76
EX-15	EX-15	2.28	2.83	7.02
EX-16	EX-16	1.43	3.62	7.20
EX-17	EX-17	1.74	0.75	3.42
EX-18	EX-18	0.44	0.32	1.20
EX-19	EX-19	0.62	0.30	1.44
OF-1	OF-1	0.27	0.11	0.78
OF-2	OF-2	0.05	0.02	0.16
OF-3	OF-3	0.54	0.13	0.98
OF-4	OF-4	0.11	0.04	0.29
OF-5	OF-5	0.06	0.02	0.13
OF-6	OF-6	0.12	0.03	0.19



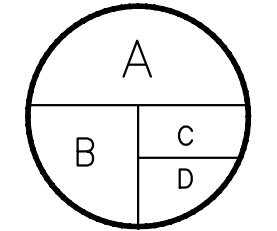
Kimley»Horn

© 2026 KIMLEY-HORN AND ASSOCIATES, INC.
2 NORTH NEVADA AVENUE, SUITE 900
COLORADO SPRINGS, COLORADO 80903 (719) 453-0180

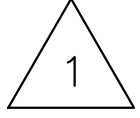
C:\AEC\CD\Kimley-Horn\15611301 WHMD Stormwater Improvements\Exisiting Drainage Map\EX-01.dwg 11/15/2025 11:25 AM Map3.dwg

WHMD RWRF STORMWATER IMPROVEMENTS
PROPOSED DRAINAGE MAP

LEGEND



A = BASIN DESIGNATION
B = AREA (ACRES)
C = IMPERVIOUSNESS
D = 100-YR DESIGN STORM
RUNOFF (CFS)



= DESIGN POINT

EXISTING FLOW DIRECTION
PROPOSED FLOW DIRECTION

DRAINAGE BASIN BOUNDARY
PROPOSED LIMITS OF DISTURBANCE

EXISTING MAJOR CONTOUR
EXISTING MINOR CONTOUR

PROPOSED MAJOR CONTOUR
PROPOSED MINOR CONTOUR

PROPERTY LINE
PARCEL LINE

UTILITY TRENCHING AREA

PROPOSED RATIONAL CALCULATIONS SUMMARY				
DESIGN POINT	TRIBUTARY BASINS	TRIBUTARY AREA (AC)	PEAK FLOWS (CFS)	
P-1	P-1	0.88	2.86	5.79
P-2	P-2	0.13	0.04	0.28
P-3	P-3	0.36	0.12	0.90
P-4	P-4	1.08	2.32	5.33
P-5	P-5	0.78	0.28	1.71
P-6	P-6	0.15	0.09	0.40
P-7	P-7	0.53	0.84	2.22
P-8	P-8	0.04	0.04	0.14
OS-1	OS-1	0.08	0.06	0.26
OS-2	OS-2	0.35	1.29	2.40
OS-3	OS-3	0.77	0.40	1.59
OS-4	OS-4	2.28	2.61	6.45
OS-5	OS-5	1.43	3.81	7.58
OS-6	OS-6	1.74	0.70	3.17
OS-7	OS-7	0.44	0.43	1.59
OS-8	OS-8	0.62	0.26	1.26
OS-9	OS-9	0.45	0.22	1.04
OS-10	OS-10	0.74	0.19	1.40
OS-11	OS-11	0.07	0.03	0.21
OS-12	OS-12	0.03	0.01	0.09
OS-13	OS-13	0.25	0.09	0.65
OS-14	OS-14	0.16	0.76	1.37
OS-15	OS-15	0.57	2.64	4.73
OF-1	OF-1	0.06	0.02	0.14
OF-2	OF-2	0.12	0.03	0.19
OF-3	OF-3	0.27	0.08	0.61
OF-4	OF-4	0.12	0.05	0.37
OF-5	OF-5	0.47	0.14	1.04
OF-6	OF-6	0.11	0.04	0.29

C:\AEC\Projects\WHMD\Drawings\Stormwater\Improvements\DWG\Stormwater\Stormwater_Improvements_Expansions\Map\Map.dwg 12/22/2026 9:32:07 AM: Maria Olvera

