



PHASE III DRAINAGE REPORT
FOR
GRAND PARK – WEST MOUNTAIN -
PLANNING AREA 10W.1 & 11W

PREPARED FOR:

GRAND PARK DEVELOPMENT COMPANY
P.O. BOX 30
WINTER PARK, COLORADO 80482
CONTACT: CLARK LIPSCOMB
PHONE: 970-726-8600

PREPARED BY:

TERRACINA DESIGN, LLC
10200 E. GIRARD AVENUE
BUILDING A, SUITE 314
DENVER, CO 80231
PHONE: 303-632-8867
CONTACT: MARTIN METSKER

FEBRUARY 2026

Engineer's Statement:

This report was prepared by me, or under my direct supervision, in accordance per the Town of Fraser Storm Drainage Design and Technical Criteria which references the Grand County Storm Drainage Design and Technical Criteria Manual, dated August 1st, 2006, and it was designed to comply with the provisions thereof. I understand that Town of Fraser does not and will not assume liability for drainage facilities designed by others.

Martin Metsker, P.E.
Colorado Professional Engineer
License #41743

Owner/Developer's Statement:

I, Grand Park Development Company, hereby certify that the drainage facilities for planning areas 10W.1 and 11W shall be constructed according to the design presented in this report. I understand that the Town of Fraser does not and will not assume liability for drainage facilities designed or reviewed by my engineer. I also understand that the Town of Fraser relies on the representations of others to establish that drainage facilities are designed and built in compliance with applicable guidelines, standards and specifications. Review by the Town of Fraser can therefore in no way limit or diminish any liability which I or any other party may have with respect to the design or construction of such facilities.

Grand Park Development Company

Printed Name

TABLE OF CONTENTS

I.	GENERAL LOCATION AND DESCRIPTION	5
A.	SITE LOCATION	5
B.	DESCRIPTION OF SITE	5
II.	DRAINAGE BASINS AND SUB-BASINS	5
A.	MAJOR DRAINAGE BASINS	5
B.	SUB-BASIN DESCRIPTION	6
III.	DRAINAGE DESIGN CRITERIA	7
A.	REGULATIONS.....	7
B.	DEVELOPMENT OF BASIC DATA AND CONSTRAINTS.....	7
C.	HYDROLOGICAL CRITERIA.....	7
D.	HYDRAULIC CRITERIA.....	8
E.	STORMWATER QUALITY CRITERIA	9
F.	VARIANCES FROM CRITERIA.....	9
IV.	DRAINAGE FACILITY DESIGN	9
A.	GENERAL CONCEPTS	9
B.	SPECIFIC DETAILS.....	9
V.	CONCLUSIONS.....	17
A.	COMPLIANCE WITH STANDARDS	17
B.	DRAINAGE CONCEPT	17
VI.	REFERENCES.....	18

Appendices

Appendix A - General Maps

- Vicinity Map
- Soil Map
- Firm Map
- Precipitation Data

Appendix B - Hydrologic Calculations

- Existing Curve Number Calculations
- Existing Curve Number Adjustment Calculations
- Existing Lag Time Calculations
- Existing Reach Time of Concentration Calculations
- Proposed Curve Number Calculations
- Proposed Curve Number Adjustment Calculations
- Proposed Lag Time Calculations
- Proposed Reach Time of Concentration Calculations
- HEC-HMS Flow Results

Appendix C - Hydraulic Calculations

- Street Capacity Inlet Calculations – MHFD_Inlet_v6.00
- Area Inlet Capacity Calculations – Hydraflow Express
- Curb Cut Capacity Calculations – Hydraflow Express
- Swale Calculations – Hydraflow Express
- Culvert Capacity Calculation – Hydraflow Express
- StormCAD Key Map
- StormCAD Output Tables

Appendix D - Extended Detention Basin/Water Quality Enhancement BMP's

- Pond Percent Imperviousness Calculations
- Temporary Sediment Basin A4 Exhibit and Stage-Storage-Discharge Calculations
- Pond B Detention Sizing – Modified FAA Method
- Pond B HEC-HMS Inflow Results
- Pond B Outlet Structure Design – MHFD-Detention_V4.07
- Temporary Sediment Basin C Exhibit and Stage-Storage-Discharge Calculations

Appendix E - Reference Materials

- Storm Drainage Master Plan for Grand Park by High Country Engineering, Inc.
- A Pragmatic Slope-Adjusted Curve Number Model to Reduce Uncertainty in Predicting Flood Runoff from Steep Watershed by Ajmal, Wassem, Kim, & Kim.
- Sediment Basin Details from MHFD's Urban Storm Drainage Criteria Manual vol. 3.

Appendix F - Drainage Maps

- HEC-HMS Basin Model Map
- HEC-HMS Map
- Proposed Drainage Maps

t e r r a c i n a d e s i g n

Landscape Architecture, Planning & Engineering
10200 E. Girard Avenue, A-314. Denver, CO 80231 PH: 303.632.8867

I. GENERAL LOCATION AND DESCRIPTION

A. Site Location

This Phase III Drainage Report provides remediation for changes in the drainage patterns resulting from the construction of the major infrastructure components for Grand Park 10W.1 & 11W in Fraser, CO, from here on known as the "Site". The Site is currently undeveloped and future development will include single and multi-family lots, open space, and the associated roadway and utility infrastructure. The intent of the report and the Site is to establish drainage patterns for 79 detached residential units. Future areas have been taken into consideration that also will include single family attached and multi-family lots, lodging units, and commercial space.

The Site is approximately 46.1 acres and the inspected drainage area is 78.3 acres. The Site is bound to the west by Spring Meadow drainageway and open space, to the north by planning areas 8W, 9W, and 10W.2, to the east by the Union Pacific Railroad, and to the south by Grand Park Drive. The Site is a part of the northwest quarter of Section 29 and northwest quarter of Section 32, Township 1 South, Range 75 West of the 6th Principal Meridian, Town of Fraser, County of Grand, State of Colorado. A vicinity map for the site can be found in Appendix A.

B. Description of Site

The Site is currently undeveloped with existing native vegetation, and the land uses according to the approved PD are residential, clubhouse and open space containing approximately 46.1 acres. The Site has naturally occurring slopes ranging from 6 to 45 percent, generally slopes from the southwest to the northeast towards the Union Pacific Railroad. The soils within the Site include Cowdrey loam and Frisco-Peeler gravelly sandy loams, and the soil primarily consists of hydrologic soil groups B and C. A soils map has been provided and can be found in Appendix A.

The Site is adjacent to an existing floodplain, and lies within Zone X, "Areas determined to be outside the 0.2% annual chance floodplain," as depicted on the FEMA Flood Insurance Rates Map 08049C0991C Effective January 2, 2008, found in Appendix A. The Site does lie near Leland Creek which is a major drainageway. The Site will not propose modifications or improvements to the floodplain. The Site drainage will not adversely impact the surrounding existing drainage infrastructure.

Historically, discharge from the Site primarily sheet flows northeast to an existing 24-inch culvert that conveys the runoff across the railroad. Ultimately all runoff generated within the Site will be conveyed to the northeast, across US40 and into the Fraser River.

The intent of this project is to construct the necessary roadways and utility infrastructure to begin developing the lots within planning areas 10W.1 and 11W. This report details the general drainage patterns that the planning areas will follow in the final developed conditions.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Drainage Basins

The Site contributes to three major drainage basins: Leland Creek Basin, Grand Park Meadow Basin, and Spring Meadow Basin. See the vicinity map in Appendix A. Runoff generated within the Site will generally follow historic drainage patterns. After being conveyed across the Union Pacific Railroad via various existing culverts, the flows will be conveyed north, under US Highway 40, where it discharges into the Fraser River, which eventually discharges into the Colorado River. Basins C, D, E, OS1, and OS2 contribute to the Leland Creek basin. Runoff generated within Basin C will be conveyed to a temporary sediment basin which will treat the flows before releasing them into Leland Creek Basin.

Basin B and basin OS3 contribute to the Grand Park Meadow basin. Runoff will generally be conveyed to the northeast to Pond B before being discharged towards an existing culvert that will convey the runoff across the railroad. The Grand Park Meadow Basin is bound to the north by US-40, to the east by Grand Park Village and US-40, to the south by Grand Park Drive, and to the west by Outpost Club Drive.

Basin A4 falls within the Spring Meadow Basin, formerly known as No Name basin in the Storm Drainage Master Plan for Grand Park by High Country Engineering dated February 17, 2006 (Ref. H). Spring Meadow Basin includes part of Filing 1 within the West Mountain development. Runoff will generally be conveyed to the north to temporary sediment basin A4 which will treat the flows before releasing them to the north into Spring Meadow Basin. The runoff will then be conveyed to the northeast to an existing 48-inch culvert that will convey the flows across the railroad. The flows will then be conveyed into various existing ponds located in the meadow to the northwest before being conveyed across US-40 by an existing culvert.

The Site falls within Zone X, as shown on the Insurance Rate Map (FIRM) panel 080 designation where there are "Areas of Special Flood Hazard." The development will not influence the Zone X designation. As development increases within the Spring Meadow Basin, the temporary sediment basin will be removed and a DB (Pond A) will be constructed upstream of the existing 48-inch culvert to reduce the increased runoff from the basin (insert name of the drainage report here).

There are no existing or proposed irrigation systems within the Site.

The "Storm Drainage Master Plan for Grand Park" by High Country Engineering, dated February 2006 (Ref. H) analyzes the drainage patterns throughout the West Mountain subdivision, and this drainage report depicts Spring Meadow Basin (formerly No Name Basin) and Leland Creek Basin as major basins associated with the Site.

B. Sub-basin Description

Minor Drainage Basins for the Site have been delineated using the proposed site layout and grading. Roadway grading within planning areas 10W.1 and 11W will be finalized with this submittal package; however, the grading within the lots of these planning areas represents general drainage patterns. Further grading will be required during the plot plan or individual lot development phase. Overall, the proposed drainage patterns for the sub-basins will generally follow the historic patterns prior to development. For sub-basins within the Site, runoff will drain towards low points in the roadways and other design points. The developed minor basins will include overland flow and storm sewer collection systems which will direct stormwater to a detention basin (DB) or a temporary sediment basin that can account for developed runoff from the Site.

Basin A4 in its fully developed conditions will consist of roadways, single-family housing, a temporary sediment basin, and open space. Runoff generated within the basin will be captured by proposed storm infrastructure and conveyed to a temporary sediment basin where it will be treated. The temporary sediment basin will outfall into Spring Meadow Basin towards an existing 48-inch culvert located under the Union Pacific Railroad. This temporary sediment basin was sized according to Table SB-1 in the Sediment Basin Section of the Mile High Flood District (MHFD) Storm Drainage Criteria Manual volume 3 (Ref. E), and this section of the manual has been included in Appendix E. An exhibit has been included in Appendix D showing the methodology used to size this temporary sediment basin. Hydraulic calculations have been included for the stage-storage discharge relationship for the temporary sediment basin and these calculations can also be found in Appendix D.

Basin B in its fully developed conditions will include roadways, single and multi-family housing areas, a DB, and open space. All runoff generated within Basin B will drain to the northeast to the proposed DB pond to the east of the Site. This DB outfalls to the north, where the runoff will be conveyed across the Union Pacific Railroad via an existing 24-inch culvert.

Basin C includes roadways, single family housing areas, a temporary sediment basin, and open space. All runoff generated within Basin C will drain to the south to temporary sediment basin C. This temporary sediment basin will outfall to the south into Leland Creek which conveys flow to an existing 60-inch storm culvert located under the Union Pacific Railroad. This temporary sediment basin will remain in place until the next phase of construction for the development commences. This temporary sediment basin was sized according to Table SB-1 in the Sediment Basin Section of the Mile High Flood District (MHFD) Storm Drainage Criteria Manual volume 3 (Ref. E). See Appendix D for an exhibit showing the methodology used to size this temporary sediment basin. Hydraulic calculations have been included in Appendix D for the stage-storage discharge relationship for the temporary sediment basin.

All D, E, and OS basins will drain to their respective design points and leave the site undetained into the Leland Creek or Grand Park Meadow Basin. These basins will not receive treatment or be detained because DB ponds are not feasible within these basins due to existing site constraints.

III. DRAINAGE DESIGN CRITERIA

A. Regulations

The Town of Fraser has adopted Grand County Storm Drainage Design and Technical Criteria Manual (Ref. A).

This Phase III Report is in accordance with Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A), Fraser's Municipal Code (Ref. B) and the Mile High Flood District (MHFD) Storm Drainage Criteria Manual (Ref. C, D and E). These manuals were used as a basis of design for the Site. The report will analyze the minor (5-year) and major (100-year) storm events. The 5-year storm was used for the minor storm event because there will be curb and gutter throughout the Site which is the criteria for the minor storm to be considered the 5-year storm event per Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A). All applicable figures, tables, and graphs from these manuals have been included in the Appendices.

The drainage design of the Site adheres to the requirements of Section 404 of the Clean Water Act, Section 106 of the National Historic Preservation Act of 1966 and the Endangered Species Act. Additionally, the drainage design conforms to all applicable local, state, and federal requirements for drainage design and stormwater discharge.

B. Development of Basic Data and Constraints

The "Storm Drainage Master Plan for Grand Park" by High Country Engineering, dated February 2006 (Ref. H) analyzes the runoff generated to the southwest of the railroad and the culvert capacities of all railroad crossings within the West Mountain development. This Phase III drainage report will conform to the culvert capacities established in this previously approved drainage report.

The proposed drainage conditions discussed herein will have no adverse impact to surrounding developments or properties.

C. Hydrological Criteria

HEC-HMS is a software developed by US Army Corps of Engineers, and it will be used to generate and route hydrographs for all basins within the Site. The sub-basins were delineated based on the existing and proposed topography developed for the Site. All hydrologic calculations can be found in Appendix B. A proposed drainage map and a map of the HEC-HMS Basin Model Map for the Site can be found in Appendix F.

The intensity-frequency curves used in the hydrologic calculations were taken from Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A) and NOAA ATLAS 14 Point Precipitation Frequency Estimates, which can be found in Appendix A. All drainage infrastructure was analyzed and designed for both the minor (5-year) and major (100-year) storm events. The 5-year storm was used for the minor storm event because there will be curb and gutter throughout the Site which is the criteria for the minor storm to be considered the 5-year storm event per Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A). All applicable figures, tables, and graphs from these manuals have been included in the Appendices.

The SCS Curve Number Loss method was used in HEC-HMS to evaluate how much precipitation will infiltrate before generating runoff. The central assumption made when using the SCS Curve Number Loss method is that the soil will infiltrate up to 20% of the soil's maximum potential retention before producing runoff. We adjusted this assumption to begin producing runoff after only 5% of the soils maximum potential retention has been infiltrated. This assumption makes this analysis a more conservative estimate for the runoff produced within the Site. Modifying this assumption is supported by Ajmal, et. al. (2020) (Ref. J) for steep slopes, forested regions, or mountainous areas because the SCS Curve Number Loss Method was developed for relatively flat agricultural areas which allow significantly more infiltration. See Appendix E for excerpts supporting this modification to the analysis. All curve number and lag time calculations, HEC-HMS inputs, and HEC-HMS outputs can be found in Appendix B. A picture from the HEC-HMS basin model as well as a map showing all elements in the HEC-HMS model and their existing and proposed flow rates have been included in Appendix F.

The proposed DB within Basin B has been provided for water quality treatment and stormwater detention as defined in Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A). The modified FAA procedure was used to size the DB, following section 10.2.2 of the Grand County Storm Drainage Design and Technical Criteria Manual (Ref. A), because the HEC-HMS software was used for hydrologic calculations instead of the rational method. When sizing the required detention volume for the DB, the 10-year storm event was used for the minor storm because section 10.2 of Grand County's Storm Drainage Design and Technical Criteria Manual specifies "For detention purposes, the minor storm event shall be the 10-year recurrence interval, and the major storm event shall be the 100-year recurrence interval." Results for the detention pond sizing can be found in Appendix D.

MHFD's Outlet Structure Design worksheet was used to design the DB's outlet structure to restore developed stormwater flows to their historic conditions before releasing flows to the existing downstream storm infrastructure. No floodplain limits will be adversely impacted by the development of the Site, and downstream properties will not be negatively impacted by the developed stormwater.

D. Hydraulic Criteria

Hydraulic calculations for detention pond sizing were based on the modified FAA method. Hydraulic calculations for the DB outlet structure design were based on the MHFD outlet structure spreadsheet (a part of the MHFD-detention_v4.07 spreadsheet). The results from both of these spreadsheets for Pond B can be found in Appendix D. Temporary sediment basins will be used to treat the runoff generated within Basins A4 and C before being discharged into Spring Meadow Basin or Leland Creek Basin. An exhibit as well as stage storage discharge tables for these temporary sediment basins can be found in Appendix D.

Street and inlet capacity designs were performed and based on Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A) and design spreadsheets provided by MHFD which can be found in Appendix C. Curb cuts will be used to drain the end of two cul de sacs, so hydraulic calculations were performed for the curb cut's capacity using Hydraflow Express and these calculations have been included in Appendix C. Hydraulic calculations for swale capacity and velocity, area inlet Capacities, and culvert capacities were performed using the Hydraflow Express add-on for the Civil3D program,

and the results can be found in Appendix C. Hydraflow Express uses the Manning's equation to compute flow at a known depth or a depth at a known flow.

Hydraulic grade lines and storm pipe capacities were designed and modeled using StormCAD. StormCAD uses the routed hydrograph method and the Manning's equation to compute the hydraulic grade line throughout a pipe network. See Appendix C for the StormCAD Output Tables and keymap.

E. Stormwater Quality Criteria

Water quality measures have been provided with the designs of the proposed DB, forebay, and outlet structure for proposed detention Pond B. The DB will have been designed to incorporate a structure that releases flows for the water quality capture volume (WQCV), minor (10-year) storm event, and the major (100-year) storm event. Please see the Proposed Drainage Map found in Appendix F of this report for basin flow information.

F. Variances from Criteria

No variances are being requested at this time.

IV. DRAINAGE FACILITY DESIGN

A. General Concepts

Low Impact Development (LID) practices and strategies have been applied to the comprehensive land planning and engineering design approach to managing stormwater runoff. The primary objective of these concepts is the preservation of the natural features of the property by arranging the development to minimize Site grading, impacts to existing vegetation and wetlands, as well as providing open space areas. The drainage design will generally maintain the historic drainage patterns and release rates for the Site. The DB for the Site has been located to minimize subsurface systems and control the developed discharge prior to entering the established waterways thus reducing the impact to the surrounding tributaries.

Runoff will be captured by 5-foot, 10-foot, and 15-foot Type R inlets that are on-grade or in sump locations, along with Type C and D inlets for area drains. The runoff will then be conveyed via grass-lined or riprap-lined swales or proposed subsurface storm infrastructure towards its proposed DB or temporary sediment basin. The DB will discharge less than historic rates via a pipe from the outlet structure to an existing storm infrastructure that will convey the flows across the Union Pacific Railroad.

B. Specific Details

Sub-basin A4.1

Sub-basin A4.1 is 2.11 acres comprised of paved area and open space. Runoff generated within the basin will drain northeast to Design Point A4.1 where it will be captured by a proposed on-grade Type-R Inlet. After being captured, the flows will be conveyed to the north to temporary sediment basin A4 via proposed storm infrastructure and a grass lined swale. After being treated by the temporary sediment basin, the flows will be discharged to the north into Spring Meadow Basin which will drain to an existing forty-eight (48") storm pipe that will convey the flows across the Union Pacific Railroad. If the inlet were to get clogged, the runoff would continue east along Grand Park Drive until it is captured by Inlet-40 at Design Point C2.

Sub-basin A4.2

Sub-basin A4.2 is 0.48 acres comprised of paved area. Runoff generated within the basin will drain east to Design Point A4.2 where it will be captured by a proposed on-grade Type-R Inlet. After being captured, the flows will be conveyed to the north to temporary sediment basin A4 via proposed storm infrastructure and a grass lined swale. After being treated by the temporary sediment basin, the flows will be discharged to the north into Spring Meadow Basin which will drain to an existing forty-eight (48") storm pipe that will convey the flows across the Union Pacific Railroad. If the inlet were to get clogged, the runoff would continue east along Grand Park Drive until it is captured by Inlet-41 at Design Point C2.1.

Sub-basin A4.3

Sub-basin A4.3 is 7.33 acres comprised of single-family lots and paved area. Runoff generated within the basin will drain northwest where it will be conveyed by grass lined swales to Design Point A4.3 where it will enter temporary sediment basin A4. After being treated by the temporary sediment basin, the flows will be discharged to the north into Spring Meadow Basin which will drain to an existing forty-eight (48") storm pipe that will convey the flows across the Union Pacific Railroad.

This temporary sediment basin was sized according to Table SB-1 in the Sediment Basin Section of the Mile High Flood District (MHFD) Storm Drainage Criteria Manual volume 3 (Ref. E). An exhibit has been included in Appendix D showing the methodology used to size this temporary sediment basin. Hydraulic calculations have been included for the stage-storage discharge relationship for the temporary sediment basin and these calculations can be found in Appendix D. This temporary sediment basin will remain in place until the next phase of construction for the development commences.

Sub-basin B

Sub-basin B is 5.63 ac open space. The runoff will convey the flows to be discharged to the north (24") inch culvert to

As development increases within the Spring Meadow Basin, the temporary sediment basin will be removed and a DB (Pond A) will be constructed upstream of the existing 48-inch culvert to reduce the increased runoff from the basin (insert name of the drainage report here).

l, and which off will twenty-

Pond B has a total required detention volume of 1.947 acre-feet using the modified FAA which is equal to the combined minor and major required detention volumes. The graded volume of Pond B has 3.737 acre-feet at a depth of 10 feet. The MHFD Outlet Structure Design spreadsheet (MHFD-Detention, Version 4.07, June 2025) was used to design the outlet structure for Pond B. In the 10-year storm, Pond B will detain a maximum volume of 1.635 acre-feet at a depth of 6.52 feet, and in the 100-year storm, Pond B will detain a maximum volume of 2.396 acre-feet at a depth of 7.95 feet. Per the HEC-HMS hydrologic model, the 100-year storm predeveloped peak flow is 37.0 cfs. The pond outlet structure has been designed to release the flows at a peak rate of 26.3 cfs. This pond's release rate is approximately 70% of the predeveloped peak flow rate to account for Basin OS3 being released undetained. The modified FAA method and MHFD Outlet Structure Design spreadsheet output files for DB Pond B have been included in Appendix D.

Sub-basin B1.1

Sub-basin B1.1 is 2.49 acres comprised of roadways and single-family lots. Runoff generated within the basin will drain northeast to a proposed on-grade type R inlet at Design Point B1.1. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and proposed riprap lined swales until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would drain south along Outpost Club Drive until it is captured by Inlet-04 at Design Point B1.4.

Sub-basin B1.2

Sub-basin B1.2 is 1.74 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain northeast to a proposed on-grade type R inlet at Design Point B1.2. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and proposed riprap-lined swales until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would drain south along Outpost Club Drive until it is captured by Inlet-04 at Design Point B1.4.

Sub-basin B1.3

Sub-basin B1.3 is 4.02 acres comprised of single-family lots and open space. Runoff generated within the basin will sheet flow to the east where it will be captured by a proposed grass lined swale that will convey the runoff to a proposed type C inlet at Design Point B1.3. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and proposed riprap-lined swales until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would pond until it can flow into Outpost Club Drive where it will be captured by Inlet-04 at Design Point B1.4.

Sub-basin B1.4

Sub-basin B1.4 is 0.89 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain along Outpost Club Drive to a proposed sump type R inlet at Design Point B1.4. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and proposed riprap-lined swales until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would overtop the crown of the road and it will be captured by Inlet-05 at Design Point B1.5.

Sub-basin B1.5

Sub-basin B1.5 is 1.19 acres comprised of roadways, multi-family lots, and open space. Runoff generated within the basin will drain along Outpost Club Drive to a proposed sump type R inlet at Design Point B1.5. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and proposed riprap-lined swales until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would overtop the curb and it will be captured by FES-02 at Design Point B2.1.

Sub-basin B2.1

Sub-basin B2.1 is 7.77 acres comprised of single and multi-family lots and open space. Runoff generated within the basin will drain east to a proposed type C inlet at Design Point B2.1. After being captured, the runoff will be conveyed to the northeast via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would pond until it can flow into Terrain Way where it will be captured by Inlet-06 at Design Point B2.2.

Sub-basin B2.2

Sub-basin B2.2 is 0.52 acres comprised of roadways. Runoff generated within the basin will drain north or south to a proposed sump type R inlet at Design Point B2.2. After being captured, the runoff will be conveyed to the northeast via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would overtop the crown of the road and it will be captured by Inlet-08 at Design Point B2.4.

Sub-basin B2.3

Sub-basin B2.3 is 0.20 acres comprised of roadways. Runoff generated within the basin will drain south and east to a proposed on-grade type R inlet at Design Point B2.3. After being captured, the runoff will be conveyed to the northeast via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would follow the road's flowline from Overlook Drive onto Bugle Court where the runoff will flow into DB Pond B via a cul de sac curb cut at Design Point B4.

Sub-basin B2.4

Sub-basin B2.4 is 0.40 acres comprised of roadways. Runoff generated within the basin will drain north to a proposed on-grade type R inlet at Design Point B2.4. After being captured, the runoff will be conveyed to the northeast via proposed storm infrastructure and a proposed grass lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Overlook Drive's flowline until it intersects Grand Park Drive, where the runoff will be conveyed to the northeast and captured by Inlet-63 at Design Point D1.2.

Sub-basin B3.1

Sub-basin B3.1 is 3.54 acres comprised of future multi-family lots. Runoff generated within the basin will sheet flow to the east where it will be captured by a proposed grass lined swale that will convey the runoff to a proposed type C inlet at Design Point B3.1. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would pond until it can flow into Terrain Way where it will be captured by Inlet-10 at Design Point B3.3.

Sub-basin B3.2

Sub-basin B3.2 is 3.04 acres comprised of future multi-family lots. Runoff generated within the basin will sheet flow to the east where it will be captured by a proposed grass lined swale that will convey the runoff to a proposed type C inlet at Design Point B3.2. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would pond until it can flow into Terrain Way where it will be captured by Inlet-10 at Design Point B3.3.

Sub-basin B3.3

Sub-basin B3.3 is 0.33 acres comprised of future roadways. Runoff generated within the basin will drain to the north or south where it will be captured by a proposed sump Type R Inlet at Design Point B3.3. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would overtop the crown of the road and it will be captured by Inlet-11 at Design Point B3.4.

Sub-basin B3.4

Sub-basin B3.4 is 0.28 acres comprised of future roadways. Runoff generated within the basin will drain to the north or south where it will be captured by a proposed sump Type R Inlet at Design Point B3.4. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would pond until it can be conveyed along Road A where it will be captured by Inlet-13 at Design Point B3.6.

Sub-basin B3.5

Sub-basin B3.5 is 1.13 acres comprised of future roadways, future multi-family lots, and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point B3.5. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Road A until it is captured by future inlets within the cul de sac at the end of Road A.

Sub-basin B3.6

Sub-basin B3.6 is 0.15 acres comprised of future roadways. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point B3.6. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure and a proposed riprap-lined swale until it is eventually discharged into DB Pond B at design point B. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Road A until it is captured by future inlets within the cul de sac at the end of Road A.

Sub-basin B4

Sub-basin B4 is 4.45 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain to the north where it will be conveyed into DB Pond B via a cul de sac curb cut at Design Point B4. After being detained in DB Pond B, the runoff will be discharged to the north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad. A Hydraflow Express calculation has been performed to analyze the capacity of the curb cut at the end of the cul de sac and this calculation can be found in Appendix C.

Sub-basin C

Sub-basin C is 1.71 acres comprised of a temporary sediment basin and open space. Runoff generated within the basin will drain into the temporary sediment basin at Design Point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. This temporary sediment basin was sized according to Table SB-1 in the Sediment Basin Section of the Mile High Flood District (MHFD) Storm Drainage Criteria Manual volume 3 (Ref. E). An exhibit has been included in Appendix D showing the methodology used to size this temporary sediment basin. Hydraulic calculations have been included for the stage-storage discharge relationship for the temporary sediment basin and these calculations can be found in Appendix D. This temporary sediment basin will remain in place until the next phase of construction for the development commences.

Sub-basin C1

Sub-basin C1 is 2.92 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain to the southeast where it will be conveyed into sub-basin C2.3 via a cul de sac curb cut at Design Point C1. The runoff will then be conveyed through a couple 18-inch culverts before being captured by a proposed Type C inlet at Design Point C2.3. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. A Hydraflow Express calculation has been performed to analyze the capacity of the curb cut at the end of the cul de sac and this calculation can be found in Appendix C.

Sub-basin C2.1

Sub-basin C2.1 is 0.78 acres comprised of roadways and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point C2.1. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-45 at Design Point C2.6.

Sub-basin C2.2

Sub-basin C2.2 is 0.41 acres comprised of roadways and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point C2.2. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-46 at Design Point C2.7.

Sub-basin C2.3

Sub-basin C2.3 is 3.44 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain to the east where it will be conveyed through a couple 18-inch culverts and ultimately captured by a proposed Type C Inlet at Design Point C2.3. After being captured, the runoff will be conveyed to the east via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the

inlet were to get clogged, the runoff would pond until it can be conveyed along Grand Park Drive where it would be captured by Inlet-45 at Design Point C2.6.

Sub-basin C2.4

Sub-basin C2.4 is 1.05 acres comprised of roadways, single-family lots and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point C2.4. After being captured, the runoff will be conveyed to the southeast via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would enter the roundabout and continue to the east along Grand Park Drive until it is captured by Inlet-45 at Design Point C2.6.

Sub-basin C2.5

Sub-basin C2.5 is 0.16 acres comprised of roadways and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point C2.5. After being captured, the runoff will be conveyed to the southeast via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would enter the roundabout and continue to the east along Grand Park Drive until it is captured by Inlet-45 at Design Point C2.6.

Sub-basin C2.6

Sub-basin C2.6 is 1.38 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point C2.6. After being captured, the runoff will be conveyed to the south via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-61 at Design Point D1.1.

Sub-basin C2.7

Sub-basin C2.7 is 0.48 acres comprised of roadways and open space. Runoff generated within the basin will drain to the east where it will be captured by a proposed on-grade Type R Inlet at Design Point C2.7. After being captured, the runoff will be conveyed to the south via proposed storm infrastructure to proposed temporary sediment basin C at design point C. After being held in temporary sediment basin C, the runoff will be discharged to the east into Leland Creek. The runoff will be conveyed to the northeast via Leland Creek and the existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-62 at Design Point D2.

Sub-basin D1.1

Sub-basin D1.1 is 3.92 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain east to an on-grade Type R inlets at Design Point D1.1. After being captured, the runoff will be conveyed to the south into a low tailwater basin before being discharged into Leland Creek via proposed subsurface infrastructure. The runoff will be conveyed to the northeast via Leland Creek and existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-63 at Design Point D1.2.

Sub-basin D1.2

Sub-basin D1.2 is 2.74 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain southeast to an on-grade Type R inlets at Design Point D1.2. After being captured, the runoff will be conveyed to the south into a low tailwater basin before being discharged into Leland Creek via proposed subsurface infrastructure. The runoff will be conveyed to the northeast via Leland Creek and existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-80 at Design Point E1.1.

Sub-basin D2

Sub-basin D2 is 0.32 acres comprised of roadways and open space. Runoff generated within the basin will drain east to an on-grade Type R inlet at Design Point D2. After being captured, the runoff will be conveyed to the south into a low tailwater basin before being discharged into Leland Creek via proposed subsurface infrastructure. The runoff will then be conveyed to the northeast via Leland Creek and existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by Inlet-81 at Design Point E1.2.

Sub-basin E1.1

Sub-basin E1.1 is 2.58 acres comprised of roadways, single-family lots, and open space. Runoff generated within the basin will drain south to an on-grade Type R at Design Point E1.1. After being captured, the runoff will be conveyed to the south into a low tailwater basin before being discharged into Leland Creek via proposed subsurface infrastructure. The runoff will then be conveyed to the northeast via Leland Creek and existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by existing inlets on the west side of the railroad underpass.

Sub-basin E1.2

Sub-basin E1.2 is 0.30 acres comprised of roadways and open space. Runoff generated within the basin will drain south to an on-grade Type R at Design Point E1.1. After being captured, the runoff will be conveyed to the south into a low tailwater basin before being discharged into Leland Creek via proposed subsurface infrastructure. The runoff will then be conveyed to the northeast via Leland Creek and existing storm infrastructure that will convey the runoff across the Union Pacific railroad. If the inlet were to get clogged, the runoff would continue along Grand Park Drive until it is captured by existing inlets on the west side of the railroad underpass.

Sub-basin OS1

Sub-basin OS1 is 0.93 acres comprised of single-family lots and open space. Runoff generated within the basin will drain south to a proposed 24-inch culvert at Design Point OS1. After being captured, the runoff will be conveyed to the south to Leland Creek via proposed subsurface infrastructure. The runoff will be conveyed to the northeast via Leland Creek and existing storm infrastructure that will convey the runoff across the Union Pacific railroad.

Sub-basin OS2

Sub-basin OS2 is 2.42 acres comprised of single-family lots. Runoff generated within the basin will drain southeast to the back of lots where it will follow historic drainage patterns.

Sub-basin OS3

Sub-basin OS3 is 4.11 acres comprised of future multi-family lots and open space. Runoff generated within the basin will drain north to design point OS3, where the runoff will be captured by an existing twenty-four (24") inch culvert that will convey the runoff across the Union Pacific railroad.

V. CONCLUSIONS

A. Compliance with Standards

The drainage design for the Site conforms to Grand County's Storm Drainage Design and Technical Criteria Manual (Ref. A) and the Mile High Flood District (MHFD) Storm Drainage Criteria Manual where applicable. The report outlines the required design and construction of offline water quality basins within each applicable sub-basin.

B. Drainage Concept

The HEC-HMS software was used to create and route hydrographs to determine the historic and developed runoff values for the minor drainage basins throughout the Site. These basins were delineated based on the natural Site topography and the developed Site plan. The proposed DB pond was sized to detain the minor (10-year) and major (100-year) storm events as well as the WQCV. The proposed DB pond will release the developed flows below historic rates. The storm sewer system has been designed to capture the minor (5-year) and major (100-year) storm events. Temporary sediment basins will be used to treat runoff generated by basins whose DB pond has yet to be constructed. These temporary sediment basins will be removed as DB ponds are constructed due to the development entering the next phase of construction. This report has been written as a standalone report.

VI. REFERENCES

- A) Grand County Storm Drainage Design and Technical Criteria Manual, August 1st, 2006
- B) Fraser Municipal Code, Chapter 14: Town of Fraser Design and Construction Standards, 2007, revised 2024.
- C) MHFD (Mile High Flood District). 1969. Urban Storm Drainage Criteria Manual. Volume 1: Management, Hydrology and Hydraulics. Revised March 2024. <https://mhfd.org/resources/criteria-manual>.
- D) MHFD. 1969. Urban Storm Drainage Criteria Manual. Volume 2: Structures, Storage and Recreation. Revised January 2016. <https://mhfd.org/resources/criteria-manual>.
- E) MHFD. 1992. Urban Storm Drainage Criteria Manual. Volume 3: Stormwater Best Management Practices. Revised March 2024. <https://mhfd.org/resources/criteria-manual>.
- F) National Flood Hazard Layer FIRMette Map – 08049C0991C Effective Date January 2, 2008
- G) USDA NRCS Soil Maps – Updated May 7, 2025
- H) Storm Drainage Master Plan For Grand Park, High Country Engineering, February 17, 2006
- I) HEC-HMS Technical Reference Manual. U.S. Army Corps of Engineers, Hydrologic Engineering Center. 2025.
- J) A Pragmatic Slope-Adjusted Curve Number Model to Reduce Uncertainty in Predicting Flood Runoff from Steep Watersheds. Ajmal, M. Wassem, M., Kim, D., & Kim, T. 2020.
- K) Computer Programs:

AutoCAD Civil3D Hydraflow Express Extension by Autodesk Inc. April 2010.

Detention Basin Design Workbook by MHFD, V.7, July 2022

Detention Volume by the Modified FAA Method by Urban Drainage and Flood Control District, V2.35, January 2015

Hydrologic Engineering Center – Hydrologic Modeling System by USACE, V.4.13, July 2025.

OpenFlows StormCAD CONNECT Edition 4 by Bentley Systems. February 2023.

Street and Inlet Hydraulics Workbook by MHFD, V.6 August 2025

APPENDIX A

GENERAL MAPS

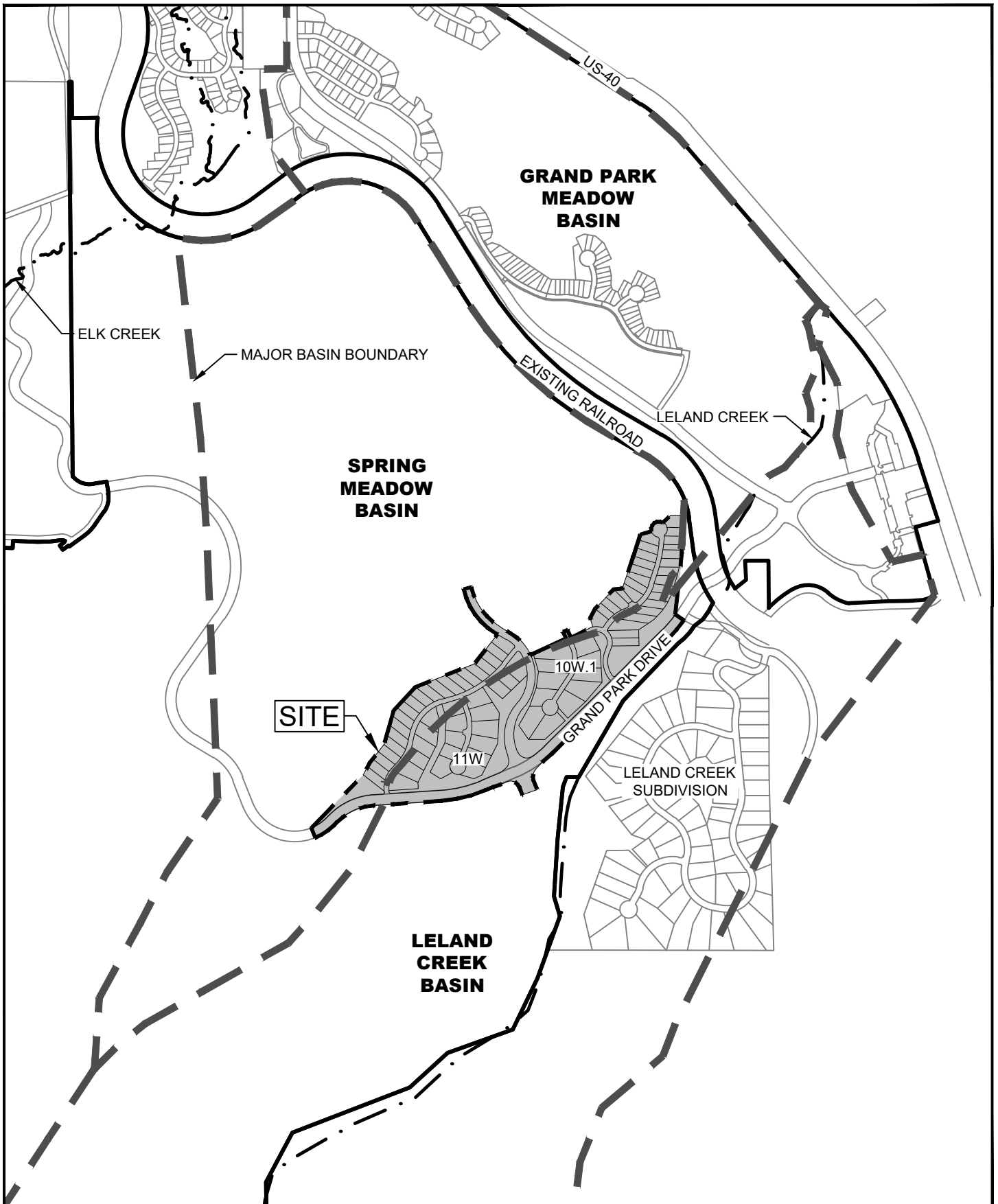
Vicinity Map

Soil Map

Firm Map

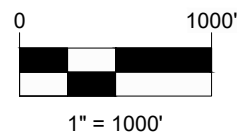
Precipitation Data

1/29/2026 1:18 PM : X:\GRAND PARK\DOCUMENTS\REPORTS\DRAINAGE\16.1 - FILING 1 - 8WB, 9W, 10W, 11W\PHASE 3 - 10WA1 - MAPS (VIC-FEMA-SOILS)\VICINITY MAP - WM 10W.1 & 11W.DWG;

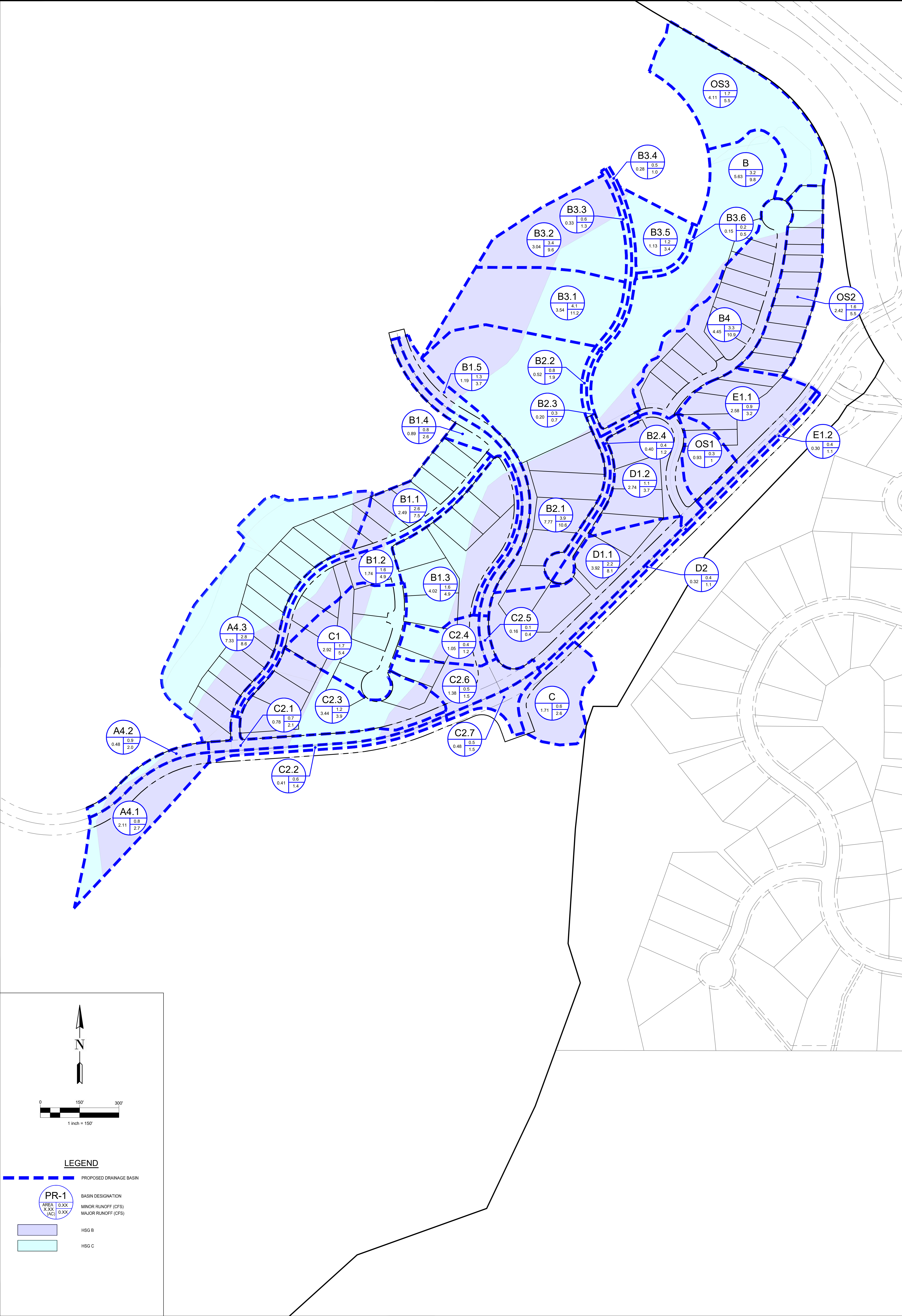


**terraccina
design**
10200 E. Girard Ave, A-314
Denver, CO 80231
ph: 303.632.8867

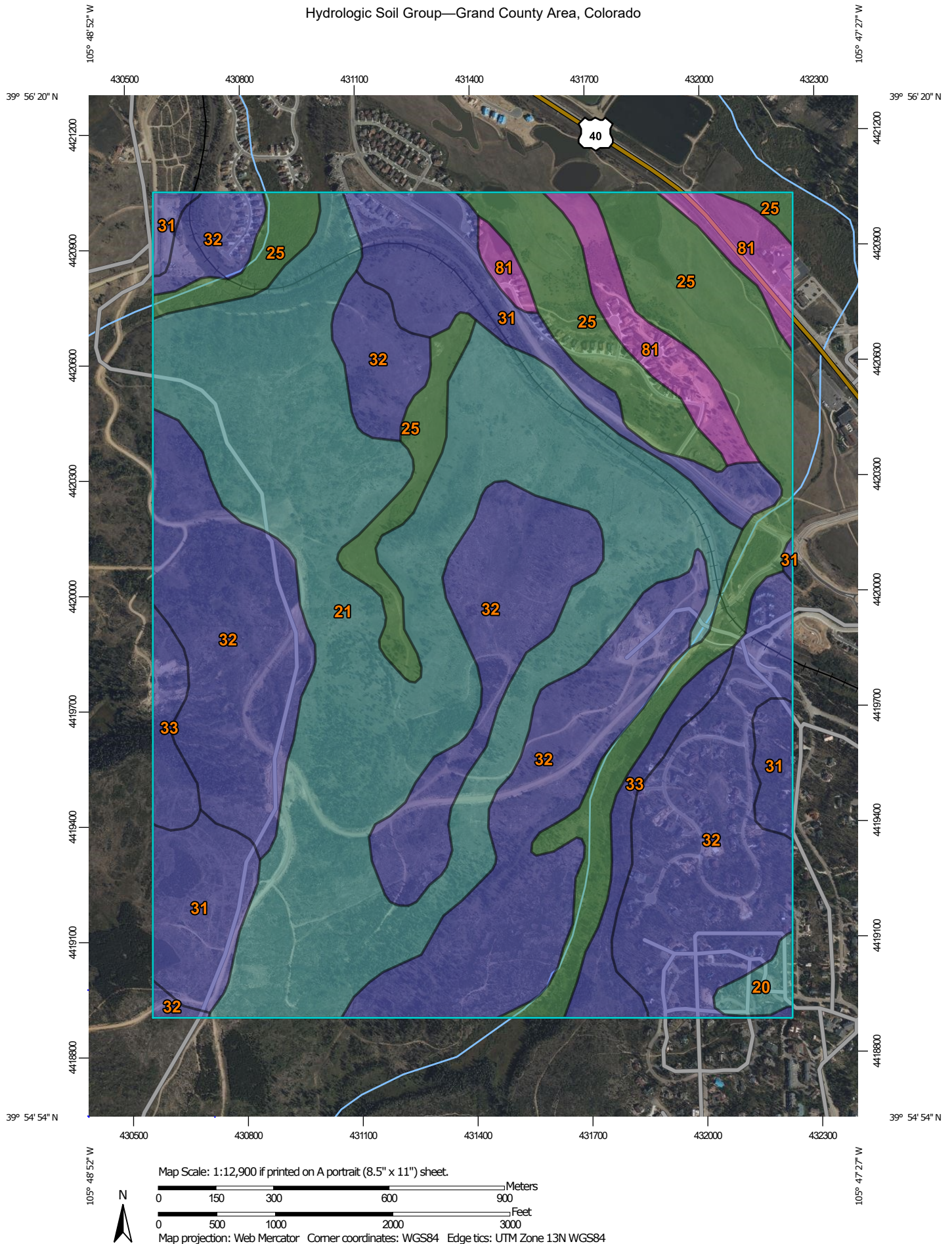
WEST MOUNTAIN 10W.1 & 11W
VICINITY MAP
TOWN OF FRASER, CO DATE: 12/15/2025



1/30/2026 12:26 PM : X:\GRAND PARK\DOCUMENTS\REPORTS\DRAINAGE\16.1 - FILING 1 - 8WB, 9W, 10W, 11W\PHASE 3 - 10W\A1 - MAPS (VIC-FEMA-SOILS)\SITE SOIL MAP.DWG;



Hydrologic Soil Group—Grand County Area, Colorado




**Natural Resources
Conservation Service**

Web Soil Survey
National Cooperative Soil Survey

5/7/2025
Page 1 of 4

MAP LEGEND

Area of Interest (AOI)









 Area of Interest (AOI)

Soils

Soil Rating Polygons





 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points




 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available


Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Grand County Area, Colorado
 Survey Area Data: Version 18, Aug 29, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 25, 2021—Sep 5, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
20	Cowdrey loam, 6 to 15 percent slopes	C	6.1	0.7%
21	Cowdrey loam, 15 to 45 percent slopes	C	288.8	32.4%
25	Cumulic Cryaquolls, nearly level	A/D	137.1	15.4%
31	Frisco-Peeler gravelly sandy loams, 2 to 6 percent slopes	B	81.8	9.2%
32	Frisco-Peeler gravelly sandy loams, 6 to 25 percent slopes	B	310.8	34.9%
33	Frisco-Peeler gravelly sandy loams, 25 to 65 percent slopes	B	28.9	3.2%
81	Tine gravelly sandy loam, 0 to 3 percent slopes	A	36.5	4.1%
Totals for Area of Interest			890.1	100.0%

Description

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

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

NOTES TO USERS

use in administering the National Flood Insurance Program, it is only identity all areas subject to flooding, particularly from local of small size. The community map repository should be updated or additional flood hazard information.

detailed information in areas where Base Flood Elevations have been determined, users are encouraged to consult Floodway Data and/or Summary of Stillwater Elevations within the Flood Insurance Study (FIS) report that accompanies this map. Users should be aware that BFEs shown on the FIRM represent elevations. These BFEs are intended for flood insurance only and should not be used as the sole source of flood information. Accordingly, flood elevation data presented in the FIS should be utilized in conjunction with the FIRM for purposes of floodplain management.

Flood Elevations shown on this map apply only to standard American Vertical Datum of 1988 (NAVD 88). Users of this map should be aware that coastal flood elevations are also provided in the Stillwater Elevations table in the Flood Insurance Study report on. Elevations shown in the Summary of Stillwater Elevations are used for construction and/or floodplain management purposes, higher than the elevations shown on this FIRM.

floodways were computed at cross sections and interpolated sections. The floodways were based on hydraulic considerations and requirements of the National Flood Insurance Program. Floodway pertinent floodway data are provided in the Flood Insurance Study report.

Special Flood Hazard Areas may be protected by flood insurance. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures, etc.

used in the preparation of this map was Universal Transverse Zone 13. The horizontal datum was NAD83, GRS1980. Projections in datum, spherical, projection or UTM zones used in the FIRM for adjacent jurisdictions may result in slight positional map features across jurisdiction boundaries. These differences are the accuracy of the FIRM.

on this map are referenced to the North American Vertical Datum of 1988 (NAVD 88). These flood elevations must be compared to structure and/or elevation data referenced to the same vertical datum. For information on the National Geodetic Vertical Datum of 1929 American Vertical Datum of 1988, visit the National Geodetic Survey at <http://www.ngs.noaa.gov/> or contact the National Geodetic Survey.

Services

Survey

Highway

2010-3282

elevation, description, and/or location information for bench marks on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at www.ngs.noaa.gov/.

ation shown on this FIRM was provided in digital format by the Department of Agriculture/Service Center Agencies; produced from Quadtiles at a scale of 1:12,000, dated 2005 or later as a part of the National Imagery Program.

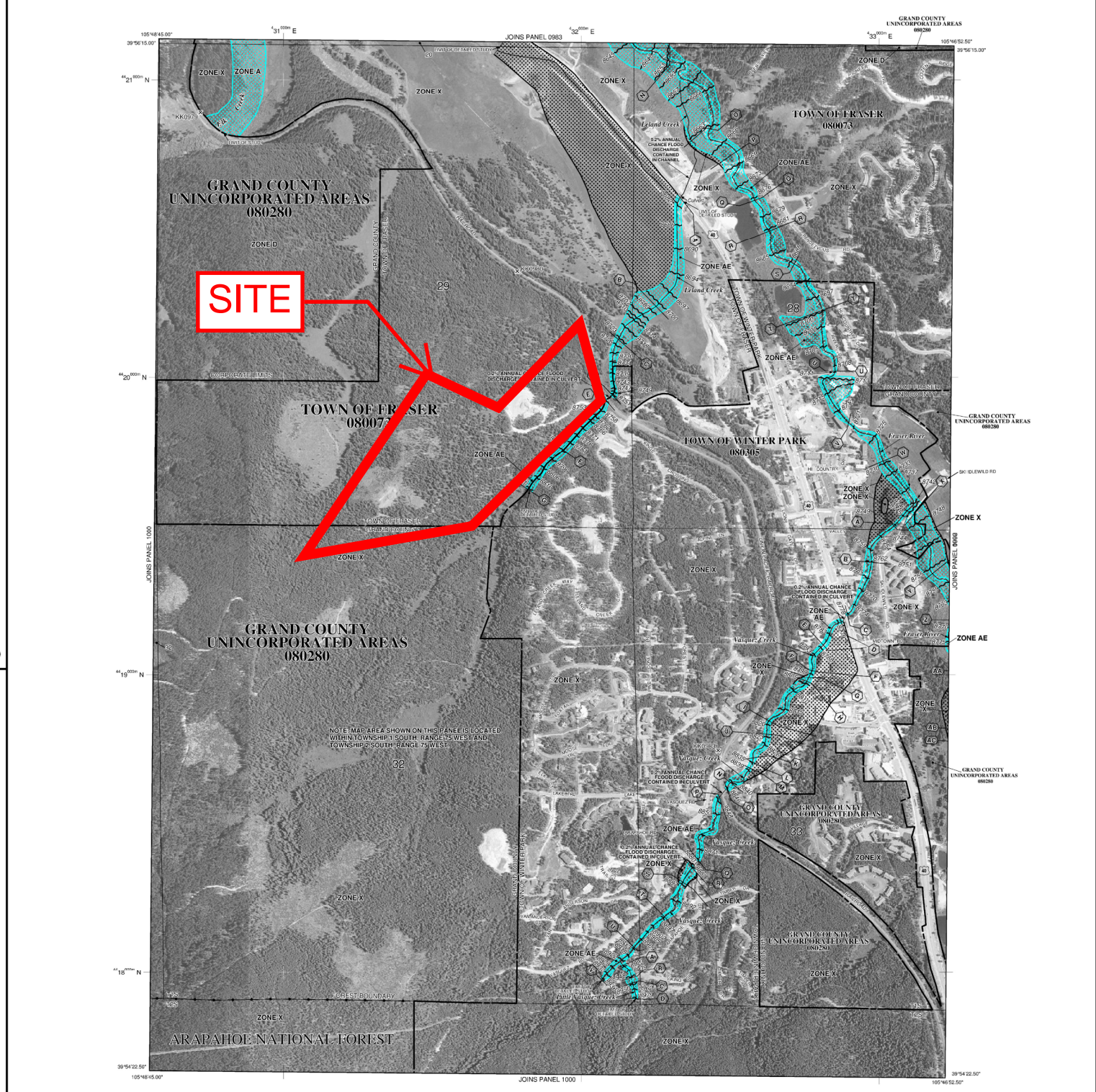
more detailed and up-to-date stream channel configurations are shown on the previous FIRM for this jurisdiction. The floodplains that were transferred from the previous FIRM may have been transferred to these new stream channel configurations. As a result, the Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) may differ from what is shown on this map.

shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may occur after this map was published, map users should contact community officials to verify current corporate limit locations.

he separately printed Map Index for an overview map of the community is available. The community map repository addresses: Community table containing National Flood Insurance Program community as well as a listing of the panels on which each area is shown.

MA Map Service Center at 1-800-358-9616 for information on the FIRM. Available products may include: Letters of Map Change, a Flood Insurance Study report, or a Flood Insurance Rate Map. The FEMA Map Service Center may also be contacted at 1-800-358-9620 and its website at <http://www.msc.fema.gov/>.

uestions about this map or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA-MAP (1-877-336-2827) or visit its website at <http://www.fema.gov/>.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHA) SUBJECT TO FLOODING BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, AV, V and VE. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AR Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevation determined.

ZONE AV Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of sheet flow, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently destroyed. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance greater flood.

ZONE AV Area to be protected from the 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary

0.2% annual chance floodplain boundary

Floodway boundary

Zone boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Areas of different base flood elevations, flood depths or flood velocities.

Base Flood Elevation line and value; elevation in feet*

Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

Cross section line

Transect line

Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)

1000-meter Universal Transverse Mercator grid ticks, zone 13

5000-foot grid ticks: New York State Plane coordinate system, east zone (FIPSZONE 3101), Transverse Mercator

Bench mark (see explanation in Notes to Users section of this FIS panel)

DX5510

M1.5

MAP REPOSITORIES

Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP

January 2, 2008

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6622.

MAP SCALE 1" = 500'

0 500 1000 FEET

0 150 300 METERS

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0991C

FIRM FLOOD INSURANCE RATE MAP

GRAND COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 991 OF 1200

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL SUFFIX
GRAND COUNTY	0991C	C
FRASER, TOWN OF	09073	0901
WINTER PARK, TOWN OF	08035	0901

Notice to User: The Map Number shown below should be used when placing map orders. The Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
0804C0991C

EFFECTIVE DATE
JANUARY 2, 2008

Federal Emergency Management Agency



NOAA Atlas 14, Volume 8, Version 2
Location name: Fraser, Colorado, USA*
Latitude: 39.9249°, Longitude: -105.8001°
Elevation: 8873.92 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 & aeriels](#)

PF tabular

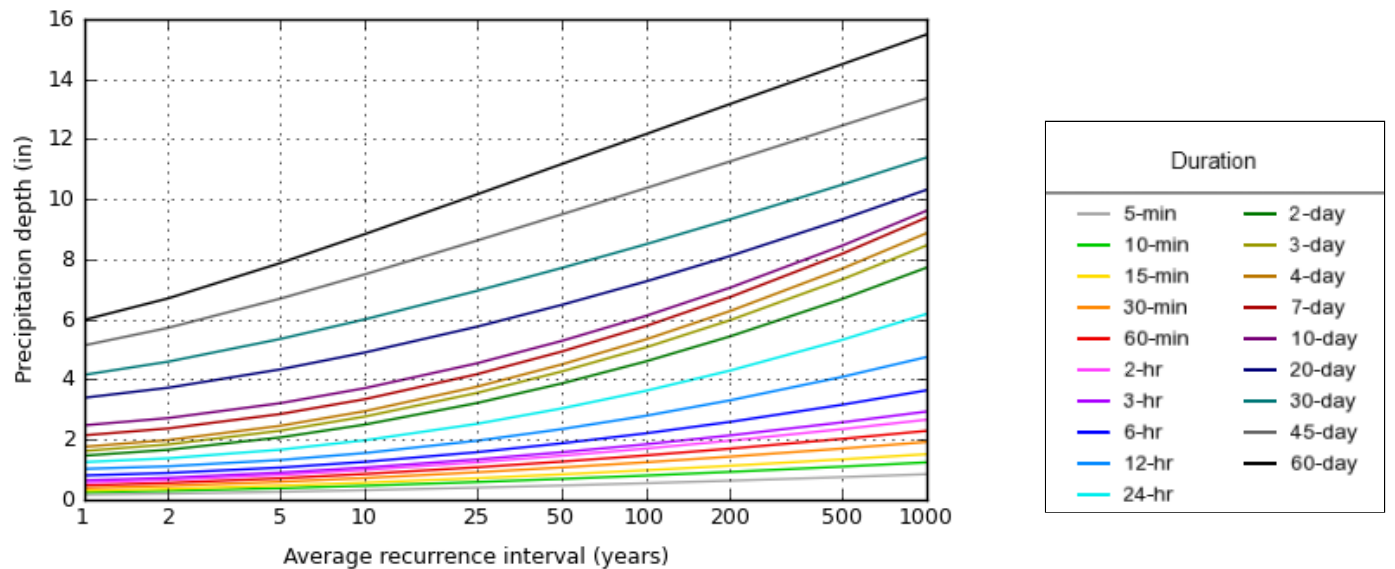
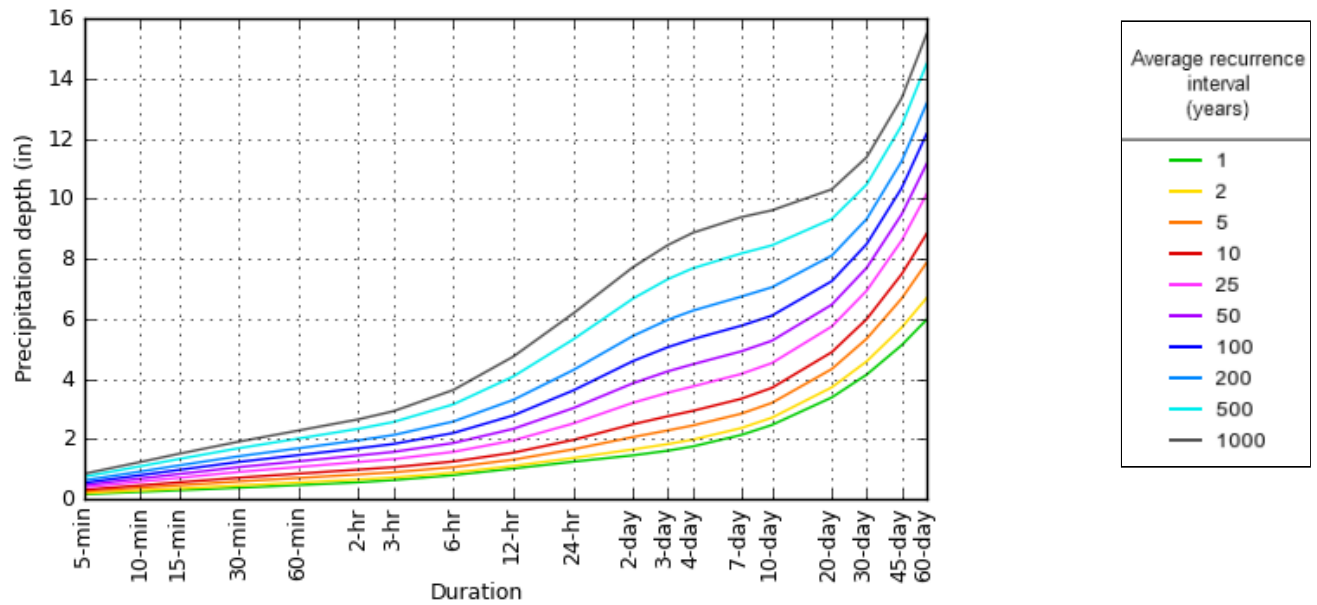
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.169 (0.130-0.219)	0.202 (0.156-0.263)	0.262 (0.201-0.342)	0.317 (0.242-0.416)	0.401 (0.300-0.559)	0.472 (0.344-0.668)	0.548 (0.387-0.800)	0.632 (0.428-0.953)	0.751 (0.490-1.17)	0.848 (0.537-1.34)
10-min	0.247 (0.191-0.321)	0.296 (0.228-0.385)	0.383 (0.294-0.500)	0.464 (0.354-0.609)	0.587 (0.439-0.819)	0.691 (0.504-0.977)	0.803 (0.566-1.17)	0.925 (0.627-1.40)	1.10 (0.717-1.72)	1.24 (0.786-1.96)
15-min	0.301 (0.233-0.392)	0.360 (0.278-0.469)	0.467 (0.359-0.610)	0.566 (0.432-0.743)	0.715 (0.536-0.999)	0.842 (0.614-1.19)	0.979 (0.690-1.43)	1.13 (0.764-1.70)	1.34 (0.875-2.09)	1.51 (0.958-2.39)
30-min	0.385 (0.297-0.500)	0.460 (0.354-0.598)	0.595 (0.457-0.778)	0.720 (0.550-0.946)	0.910 (0.681-1.27)	1.07 (0.780-1.52)	1.24 (0.877-1.81)	1.43 (0.970-2.16)	1.70 (1.11-2.65)	1.92 (1.21-3.02)
60-min	0.476 (0.367-0.618)	0.559 (0.430-0.727)	0.711 (0.546-0.929)	0.855 (0.653-1.12)	1.08 (0.807-1.50)	1.26 (0.924-1.79)	1.47 (1.04-2.15)	1.70 (1.15-2.57)	2.02 (1.32-3.16)	2.29 (1.45-3.61)
2-hr	0.567 (0.443-0.728)	0.658 (0.513-0.846)	0.827 (0.643-1.07)	0.989 (0.764-1.28)	1.24 (0.944-1.72)	1.46 (1.08-2.05)	1.70 (1.21-2.46)	1.96 (1.35-2.94)	2.35 (1.55-3.63)	2.66 (1.70-4.15)
3-hr	0.640 (0.503-0.817)	0.728 (0.572-0.930)	0.900 (0.704-1.15)	1.07 (0.832-1.38)	1.34 (1.03-1.85)	1.58 (1.18-2.21)	1.84 (1.33-2.66)	2.14 (1.48-3.19)	2.57 (1.71-3.96)	2.93 (1.89-4.55)
6-hr	0.805 (0.641-1.01)	0.889 (0.707-1.12)	1.07 (0.847-1.35)	1.26 (0.991-1.60)	1.58 (1.23-2.17)	1.87 (1.42-2.61)	2.21 (1.61-3.17)	2.59 (1.82-3.84)	3.16 (2.13-4.83)	3.64 (2.36-5.59)
12-hr	1.02 (0.825-1.27)	1.11 (0.895-1.39)	1.32 (1.06-1.65)	1.55 (1.24-1.95)	1.96 (1.56-2.69)	2.34 (1.80-3.24)	2.79 (2.07-3.98)	3.31 (2.35-4.87)	4.08 (2.79-6.20)	4.75 (3.12-7.21)
24-hr	1.25 (1.02-1.54)	1.38 (1.12-1.70)	1.66 (1.35-2.05)	1.98 (1.60-2.46)	2.52 (2.03-3.42)	3.03 (2.36-4.14)	3.62 (2.71-5.10)	4.30 (3.09-6.26)	5.32 (3.67-7.99)	6.18 (4.10-9.29)
2-day	1.46 (1.21-1.78)	1.66 (1.37-2.02)	2.07 (1.70-2.53)	2.50 (2.04-3.07)	3.21 (2.61-4.28)	3.86 (3.03-5.20)	4.60 (3.48-6.38)	5.43 (3.94-7.80)	6.68 (4.64-9.90)	7.72 (5.18-11.5)
3-day	1.62 (1.35-1.95)	1.84 (1.53-2.22)	2.29 (1.90-2.78)	2.76 (2.28-3.37)	3.55 (2.90-4.69)	4.26 (3.37-5.69)	5.06 (3.86-6.98)	5.97 (4.36-8.52)	7.32 (5.13-10.8)	8.46 (5.71-12.5)
4-day	1.76 (1.47-2.11)	1.99 (1.66-2.38)	2.46 (2.05-2.96)	2.94 (2.44-3.57)	3.75 (3.08-4.94)	4.49 (3.57-5.97)	5.33 (4.08-7.31)	6.28 (4.60-8.90)	7.68 (5.41-11.3)	8.87 (6.01-13.1)
7-day	2.14 (1.81-2.54)	2.37 (2.00-2.82)	2.85 (2.40-3.40)	3.34 (2.80-4.01)	4.17 (3.45-5.41)	4.92 (3.95-6.46)	5.77 (4.46-7.83)	6.74 (4.99-9.47)	8.18 (5.80-11.9)	9.38 (6.42-13.7)
10-day	2.47 (2.11-2.92)	2.72 (2.31-3.21)	3.21 (2.72-3.80)	3.71 (3.13-4.42)	4.53 (3.77-5.81)	5.27 (4.25-6.86)	6.11 (4.75-8.21)	7.05 (5.24-9.82)	8.45 (6.03-12.2)	9.61 (6.62-14.0)
20-day	3.39 (2.93-3.94)	3.72 (3.21-4.34)	4.33 (3.72-5.07)	4.89 (4.18-5.76)	5.75 (4.79-7.16)	6.47 (5.25-8.21)	7.26 (5.67-9.52)	8.11 (6.07-11.1)	9.32 (6.70-13.2)	10.3 (7.18-14.8)
30-day	4.15 (3.61-4.79)	4.59 (3.99-5.31)	5.34 (4.63-6.21)	6.00 (5.16-7.01)	6.94 (5.79-8.50)	7.70 (6.27-9.63)	8.49 (6.67-11.0)	9.33 (7.01-12.6)	10.5 (7.56-14.7)	11.4 (7.97-16.2)
45-day	5.13 (4.50-5.88)	5.72 (5.01-6.56)	6.69 (5.84-7.70)	7.49 (6.50-8.69)	8.61 (7.22-10.4)	9.48 (7.76-11.7)	10.4 (8.17-13.3)	11.3 (8.49-15.0)	12.4 (9.02-17.2)	13.4 (9.41-18.9)
60-day	5.98 (5.27-6.81)	6.70 (5.90-7.64)	7.87 (6.91-9.02)	8.83 (7.71-10.2)	10.1 (8.54-12.2)	11.2 (9.16-13.7)	12.2 (9.63-15.5)	13.2 (9.98-17.4)	14.5 (10.5-19.9)	15.5 (11.0-21.8)

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](#)

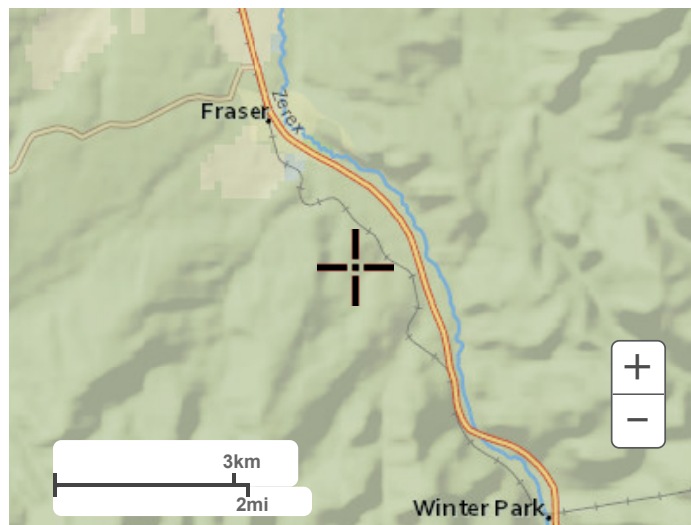
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 39.9249°, Longitude: -105.8001°



Maps & aerials

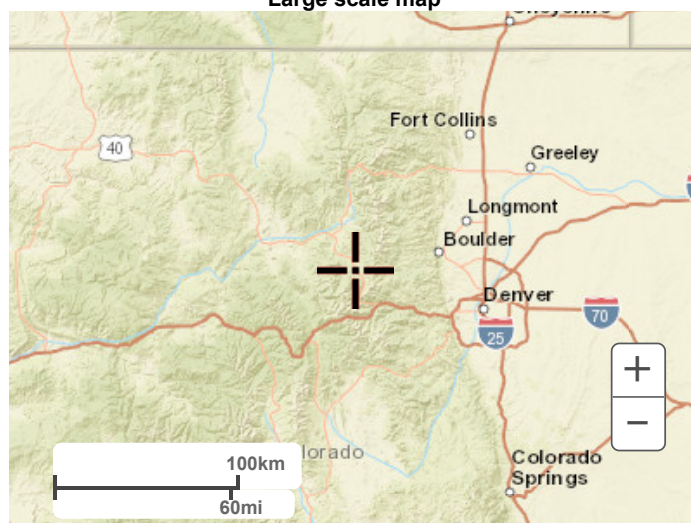
Small scale terrain



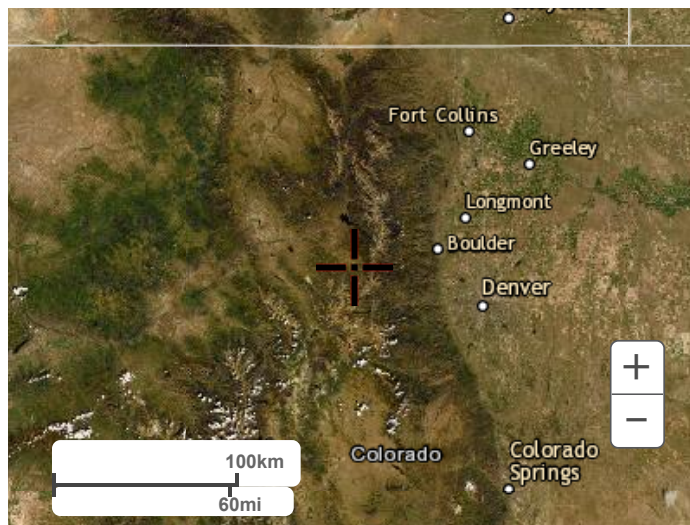
Large scale terrain



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](#)

APPENDIX B

HYDROLOGIC CALCULATIONS

Existing Curve Number Calculation

Existing Curve Number Adjustment Calculations

Existing Lag Time Calculations

Existing Reach Time of Concentration Calculations

Proposed Curve Number Calculation

Proposed Curve Number Adjustment Calculations

Proposed Lag Time Calculations

Proposed Reach Time of Concentration Calculations

HEC-HMS Flow Results

Project Name: West Mountain - Filing 1 - Existing
Prepared By: JNS

Curve Number Calculations

Curve Number calculations based on the CN Tables provided in the USACE HEC-HMS Technical Reference Manual and the section of this manual dedicated to the SCS Curve Number Loss Model

HSG	Land Use CN Values					
	Land Use					
	Historic (Good Brush)	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density (1/4 acre lots)	MFH/SFH - High Density
A	30	98	76	89	61	77
B	48	98	85	92	75	85
C	65	98	89	94	83	90
D	73	98	91	95	87	92
C/D	69	98	90	94.5	85	91

Basin Id	Percent Imperviousness (%)	Soil Type by Percent of Basin			Land Use by Percent of Basin						(Land Use CN Value)*(Soil Type by Percent of Basin)*(Land Use by Percent of Basin)						Sum of CN Values by Soil Number	Composite CN Value		
		A	B	C/D	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density	MFH/SFH - High Density	Soil Type	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density			MFH/SFH - High Density	
A4.1	5	0.0%	81.9%	18.1%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	51.80
											B	39.32	0.00	0.00	0.00	0.00	0.00	B	39.32	
											C/D	12.48	0.00	0.00	0.00	0.00	0.00	C/D	12.48	
A4.2	5	0.00%	65.08%	34.92%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	55.33
											B	31.24	0.00	0.00	0.00	0.00	0.00	B	31.24	
											C/D	24.10	0.00	0.00	0.00	0.00	0.00	C/D	24.10	
A4.3	5	0.00%	22.98%	77.02%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	64.17
											B	11.03	0.00	0.00	0.00	0.00	0.00	B	11.03	
											C/D	53.14	0.00	0.00	0.00	0.00	0.00	C/D	53.14	
B	5	0.00%	9.70%	90.30%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	66.96
											B	4.65	0.00	0.00	0.00	0.00	0.00	B	4.65	
											C/D	62.31	0.00	0.00	0.00	0.00	0.00	C/D	62.31	
B1.1	5	0.00%	34.93%	65.07%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	61.67
											B	16.76	0.00	0.00	0.00	0.00	0.00	B	16.76	
											C/D	44.90	0.00	0.00	0.00	0.00	0.00	C/D	44.90	
B1.2	5	0.00%	62.05%	37.95%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	55.97
											B	29.79	0.00	0.00	0.00	0.00	0.00	B	29.79	
											C/D	26.18	0.00	0.00	0.00	0.00	0.00	C/D	26.18	
B1.3	5	0.00%	37.77%	62.23%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	61.07
											B	18.13	0.00	0.00	0.00	0.00	0.00	B	18.13	
											C/D	42.94	0.00	0.00	0.00	0.00	0.00	C/D	42.94	
B1.4	5	0.00%	53.04%	46.96%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	57.86
											B	25.46	0.00	0.00	0.00	0.00	0.00	B	25.46	
											C/D	32.40	0.00	0.00	0.00	0.00	0.00	C/D	32.40	
B1.5	5	0.00%	72.43%	27.57%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	53.79
											B	34.77	0.00	0.00	0.00	0.00	0.00	B	34.77	
											C/D	19.02	0.00	0.00	0.00	0.00	0.00	C/D	19.02	
B2.1	5	0.00%	55.65%	44.35%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	57.31
											B	26.71	0.00	0.00	0.00	0.00	0.00	B	26.71	
											C/D	30.60	0.00	0.00	0.00	0.00	0.00	C/D	30.60	
B2.2	5	0.00%	72.38%	27.62%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	53.80
											B	34.74	0.00	0.00	0.00	0.00	0.00	B	34.74	
											C/D	19.05	0.00	0.00	0.00	0.00	0.00	C/D	19.05	
B2.3	5	0.00%	46.56%	53.44%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	59.22
											B	22.35	0.00	0.00	0.00	0.00	0.00	B	22.35	
											C/D	36.87	0.00	0.00	0.00	0.00	0.00	C/D	36.87	

Project Name: West Mountain - Filing 1 - Existing
Prepared By: JNS

Curve Number Calculations

Curve Number calculations based on the CN Tables provided in the USACE HEC-HMS Technical Reference Manual and the section of this manual dedicated to the SCS Curve Number Loss Model

HSG	Land Use CN Values					
	Land Use					
	Historic (Good Brush)	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density (1/4 acre lots)	MFH/SFH - High Density
A	30	98	76	89	61	77
B	48	98	85	92	75	85
C	65	98	89	94	83	90
D	73	98	91	95	87	92
C/D	69	98	90	94.5	85	91

Basin Id	Precent Imperviousness (%)	Soil Type by Percent of Basin			Land Use by Percent of Basin						(Land Use CN Value)*(Soil Type by Percent of Basin)*(Land Use by Percent of Basin)						Sum of CN Values by Soil Number	Composite CN Value		
		A	B	C/D	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density	MFH/SFH - High Density	Soil Type	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density			MFH/SFH - High Density	
B2.4	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	48.00
											B	48.00	0.00	0.00	0.00	0.00	0.00	B	48.00	
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00	
B3.1	5	0.00%	49.26%	50.74%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	58.66
											B	23.64	0.00	0.00	0.00	0.00	0.00	B	23.64	
											C/D	35.01	0.00	0.00	0.00	0.00	0.00	C/D	35.01	
B3.2	5	0.00%	67.34%	32.66%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	54.86
											B	32.32	0.00	0.00	0.00	0.00	0.00	B	32.32	
											C/D	22.54	0.00	0.00	0.00	0.00	0.00	C/D	22.54	
B3.3	5	0.00%	18.84%	81.16%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	65.04
											B	9.04	0.00	0.00	0.00	0.00	0.00	B	9.04	
											C/D	56.00	0.00	0.00	0.00	0.00	0.00	C/D	56.00	
B3.4	5	0.00%	18.91%	81.09%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	65.03
											B	9.08	0.00	0.00	0.00	0.00	0.00	B	9.08	
											C/D	55.95	0.00	0.00	0.00	0.00	0.00	C/D	55.95	
B3.5	5	0.00%	1.37%	98.63%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	68.71
											B	0.66	0.00	0.00	0.00	0.00	0.00	B	0.66	
											C/D	68.06	0.00	0.00	0.00	0.00	0.00	C/D	68.06	
B3.6	5	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	69.00
											B	0.00	0.00	0.00	0.00	0.00	0.00	B	0.00	
											C/D	69.00	0.00	0.00	0.00	0.00	0.00	C/D	69.00	
B4	5	0.00%	91.58%	8.42%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	49.77
											B	43.96	0.00	0.00	0.00	0.00	0.00	B	43.96	
											C/D	5.81	0.00	0.00	0.00	0.00	0.00	C/D	5.81	
C	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	48.00
											B	48.00	0.00	0.00	0.00	0.00	0.00	B	48.00	
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00	
C1	5	0.00%	38.51%	61.49%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	60.91
											B	18.48	0.00	0.00	0.00	0.00	0.00	B	18.48	
											C/D	42.43	0.00	0.00	0.00	0.00	0.00	C/D	42.43	
C2.1	5	0.00%	59.83%	40.17%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	56.44
											B	28.72	0.00	0.00	0.00	0.00	0.00	B	28.72	
											C/D	27.72	0.00	0.00	0.00	0.00	0.00	C/D	27.72	
C2.2	5	0.00%	64.65%	35.35%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	55.42
											B	31.03	0.00	0.00	0.00	0.00	0.00	B	31.03	
											C/D	24.39	0.00	0.00	0.00	0.00	0.00	C/D	24.39	
C2.3	5	0.00%	58.74%	41.26%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	56.66
											B	28.20	0.00	0.00	0.00	0.00	0.00	B	28.20	
											C/D	28.47	0.00	0.00	0.00	0.00	0.00	C/D	28.47	

Project Name: West Mountain - Filing 1 - Existing
Prepared By: JNS

Curve Number Calculations

Curve Number calculations based on the CN Tables provided in the USACE HEC-HMS Technical Reference Manual and the section of this manual dedicated to the SCS Curve Number Loss Model

HSG	Land Use CN Values					
	Land Use					
	Historic (Good Brush)	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density (1/4 acre lots)	MFH/SFH - High Density
A	30	98	76	89	61	77
B	48	98	85	92	75	85
C	65	98	89	94	83	90
D	73	98	91	95	87	92
C/D	69	98	90	94.5	85	91

Basin Id	Percent Imperviousness (%)	Soil Type by Percent of Basin			Land Use by Percent of Basin						(Land Use CN Value)*(Soil Type by Percent of Basin)*(Land Use by Percent of Basin)						Sum of CN Values by Soil Number	Composite CN Value		
		A	B	C/D	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density	MFH/SFH - High Density	Soil Type	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density			MFH/SFH - High Density	
C2.4	5	0.00%	59.84%	40.16%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	28.72	0.00	0.00	0.00	0.00	0.00	0.00	B	28.72
											C/D	27.71	0.00	0.00	0.00	0.00	0.00	0.00	C/D	27.71
C2.5	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
C2.6	5	0.00%	84.48%	15.52%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	40.55	0.00	0.00	0.00	0.00	0.00	0.00	B	40.55
											C/D	10.71	0.00	0.00	0.00	0.00	0.00	0.00	C/D	10.71
C2.7	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
D1.1	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
D1.2	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
D2	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
E1.1	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
E1.2	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
OS1	5	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
OS2	5	0.00%	83.20%	16.80%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	39.94	0.00	0.00	0.00	0.00	0.00	0.00	B	39.94
											C/D	11.59	0.00	0.00	0.00	0.00	0.00	0.00	C/D	11.59
OS3	5	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B	0.00
											C/D	69.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	69.00

Project Name: West Mountain - Filing 1 - Existing
Prepared By: JNS

Curve Number and Initial Abstraction Adjustment Calculations

Curve Number adjustment calculations based on the Calculations presented in "A Pragmatic Slope-Adjusted Curve Number Model to Reduce Uncertainty in Predicting Flood Runoff from Steep Watershed" by Ajmal, et .al., dated May 21, 2020

Sub-Basin Data		Default SCS Calculation (20% initial abstraction)			Adjusted SCS Calculations (5% initial abstraction)		
Basin Id	Basin Area (mi ²)	CN	Maximum Potential Retention, S (in)	Initial Abstraction (in)	CN	Maximum Potential Retention, S (in)	Initial Abstraction (in)
A4.1	0.003289	51.80	9.306	1.861	83.16	2.025	0.101
A4.2	0.000757	55.33	8.072	1.614	84.20	1.876	0.094
A4.3	0.011452	64.17	5.583	1.117	86.92	1.505	0.075
B	0.008799	66.96	4.933	0.987	87.82	1.388	0.069
B1.1	0.003897	61.67	6.217	1.243	86.13	1.610	0.081
B1.2	0.002715	55.97	7.867	1.573	84.39	1.849	0.092
B1.3	0.006273	61.07	6.375	1.275	85.95	1.635	0.082
B1.4	0.001397	57.86	7.283	1.457	84.96	1.770	0.088
B1.5	0.001852	53.79	8.591	1.718	83.75	1.941	0.097
B2.1	0.012140	57.31	7.448	1.490	84.80	1.793	0.090
B2.2	0.000816	53.80	8.588	1.718	83.75	1.940	0.097
B2.3	0.000307	59.22	6.885	1.377	85.38	1.713	0.086
B2.4	0.000622	48.00	10.833	2.167	82.07	2.184	0.109
B3.1	0.005536	58.66	7.049	1.410	85.20	1.736	0.087
B3.2	0.004751	54.86	8.229	1.646	84.06	1.896	0.095
B3.3	0.000523	65.04	5.374	1.075	87.20	1.468	0.073
B3.4	0.000437	65.03	5.378	1.076	87.19	1.469	0.073
B3.5	0.001763	68.71	4.553	0.911	88.39	1.314	0.066
B3.6	0.000241	69.00	4.493	0.899	88.48	1.302	0.065
B4	0.006949	49.77	10.093	2.019	82.58	2.110	0.105
C	0.002679	48.00	10.833	2.167	82.07	2.184	0.109
C1	0.004562	60.91	6.417	1.283	85.90	1.642	0.082
C2.1	0.001224	56.44	7.719	1.544	84.53	1.830	0.091
C2.2	0.000634	55.42	8.043	1.609	84.23	1.872	0.094
C2.3	0.005373	56.66	7.648	1.530	84.60	1.820	0.091
C2.4	0.001647	56.43	7.720	1.544	84.53	1.830	0.091
C2.5	0.000242	48.00	10.833	2.167	82.07	2.184	0.109
C2.6	0.002163	51.26	9.508	1.902	83.01	2.047	0.102
C2.7	0.000755	48.00	10.833	2.167	82.07	2.184	0.109
D1.1	0.006129	48.00	10.833	2.167	82.07	2.184	0.109
D1.2	0.004279	48.00	10.833	2.167	82.07	2.184	0.109
D2	0.000501	48.00	10.833	2.167	82.07	2.184	0.109
E1.1	0.004034	48.00	10.833	2.167	82.07	2.184	0.109
E1.2	0.000470	48.00	10.833	2.167	82.07	2.184	0.109
OS1	0.001447	48.00	10.833	2.167	82.07	2.184	0.109
OS2	0.003786	51.53	9.407	1.881	83.09	2.036	0.102
OS3	0.006417	69.00	4.493	0.899	88.48	1.302	0.065

Project Name: West Mountain - Filing 1 - Existing
Prepared By: JNS

Lag Time Calculations (T_{Lag})

100-year 24-hr Precipitation Depth (P₂)= 1.36

Sub-Basin Data		Initial or Overland Flow Time					Channelized Flow Time					Overall Flow Time		
Basin Id	Basin Area (Ac)	Roughness Coefficient	Length (ft)	Elev Change	Slope (%)	T _i (min)	Length (ft)	Elev Change	Slope (%)	Velocity (FPS)	T _t (min)	Comp. T _c	Lag Time	Final T _{Lag} (min)
A4.1	2.11	0.240	300	40	13.2	24.78	545	25	4.6	3.46	2.6	27.4	16.4	16.4
A4.2	0.48	0.011	37	2	6.1	0.54	495	17	3.4	2.99	2.8	3.3	2.0	5.0
A4.3	7.33	0.240	300	19	6.3	33.24	566	36	6.4	4.07	2.3	35.6	21.3	21.3
B	5.63	0.240	153	12	7.8	17.81	1043	46	4.4	3.39	5.1	22.9	13.8	13.8
B1.1	2.49	0.011	17	1	3.0	0.37	1452	52	3.5	3.04	8.0	8.3	5.0	5.0
B1.2	1.74	0.011	17	1	3.0	0.37	1440	52	3.6	3.05	7.9	8.2	4.9	5.0
B1.3	4.02	0.240	270	16	5.9	31.38	566	15	2.7	2.63	3.6	35.0	21.0	21.0
B1.4	0.89	0.011	13	0	3.1	0.31	645	23	3.6	3.07	3.5	3.8	2.3	5.0
B1.5	1.19	0.011	13	0	3.1	0.31	644	23	3.5	3.04	3.5	3.8	2.3	5.0
B2.1	7.77	0.240	300	14	4.7	37.56	392	35	8.9	4.82	1.4	38.9	23.4	23.4
B2.2	0.52	0.011	61	2	3.3	1.03	525	9	1.7	2.11	4.1	5.2	3.1	5.0
B2.3	0.20	0.011	16	0	1.3	0.52	453	10	2.2	2.40	3.1	3.7	2.2	5.0
B2.4	0.40	0.011	75	2	2.7	1.32	640	15	2.3	2.47	4.3	5.6	3.4	5.0
B3.1	3.54	0.011	300	5	1.7	4.81	700	43	6.1	4.00	2.9	7.7	4.6	5.0
B3.2	3.04	0.011	300	9	3.0	3.81	545	30	5.5	3.79	2.4	6.2	3.7	5.0
B3.3	0.33	0.011	19	1	2.6	0.44	434	21	4.8	3.55	2.0	2.5	1.5	5.0
B3.4	0.28	0.011	19	1	2.6	0.44	452	21	4.6	3.48	2.2	2.6	1.6	5.0
B3.5	1.13	0.011	260	36	13.8	1.84	10	1	5.0	3.61	0.0	1.9	1.1	5.0
B3.6	0.15	0.011	16	1	3.1	0.36	325	20	6.0	3.95	1.4	1.7	1.0	5.0
B4	4.45	0.011	248	9	3.7	3.00	846	34	4.0	3.21	4.4	7.4	4.4	5.0
C	1.71	0.240	41	6	14.6	4.84	71	8	11.3	5.42	0.2	5.1	3.0	5.0
C1	2.92	0.240	156	11	6.7	19.23	422	35	8.3	4.65	1.5	20.7	12.4	12.4
C2.1	0.78	0.011	24	1	4.2	0.44	894	45	5.0	3.60	4.1	4.6	2.7	5.0
C2.2	0.41	0.011	24	1	4.2	0.44	904	44	4.8	3.54	4.3	4.7	2.8	5.0
C2.3	3.44	0.240	300	20	6.7	32.57	460	27	5.9	3.91	2.0	34.5	20.7	20.7
C2.4	1.05	0.240	286	19	6.6	31.39	177	3	1.7	2.10	1.4	32.8	19.7	19.7
C2.5	0.16	0.011	22	0	1.4	0.65	156	3	2.1	2.31	1.1	1.8	1.1	5.0
C2.6	1.38	0.240	282	17	6.0	32.27	387	7	1.8	2.17	3.0	35.2	21.1	21.1
C2.7	0.48	0.011	26	1	1.9	0.64	410	6	1.3	1.87	3.7	4.3	2.6	5.0
D1.1	3.92	0.011	300	17	5.7	2.95	482	41	8.5	4.71	1.7	4.7	2.8	5.0
D1.2	2.74	0.240	253	24	9.5	24.68	281	11	3.9	3.17	1.5	26.2	15.7	15.7
D2	0.32	0.011	36	1	2.8	0.72	731	55	7.5	4.41	2.8	3.5	2.1	5.0
E1.1	2.58	0.240	300	42	14.0	24.20	369	30	8.1	4.60	1.3	25.5	15.3	15.3
E1.2	0.30	0.011	25	2	6.0	0.40	702	52	7.4	4.39	2.7	3.1	1.8	5.0
OS1	0.93	0.240	198	16	8.1	21.63	110	24	21.8	7.54	0.2	21.9	13.1	13.1
OS2	2.42	0.240	96	9	8.9	11.66	93	15	16.6	6.57	0.2	11.9	7.1	7.1
OS3	4.11	0.240	300	36	12.0	25.74	620	26	4.2	3.30	3.1	28.9	17.3	17.3

Project Name: West Mountain - Filing 1 - Existing
 Prepared By: JNS



Reach Time of Concentration Calculations (Tc)

Element Information		Channelized Flow Path 1						Overall Flow Time
Element ID	Notes	Length (ft)	Elev Change	Slope (%)	Paved?	Velocity (FPS)	T _c (min)	Comp. T _c (min)
SWALE B	Swale conveying B1.1, B1.2, B1.3, B1.4, B1.5, B2.1, B2.2, B2.3, and B2.4 runoff to Pond B	1043	46	4.41%	N	3.39	5.1	5.1
SWALE B2.1	Swale conveying B1.1, B1.2, B1.3, B1.4, B1.5 runoff to DP B2.3	277	22	7.94%	N	4.55	1.0	1.0

Project Name: West Mountain - F1 - 10W
Prepared By: JNS

Curve Number Calculations

Curve Number calculations based on the CN Tables provided in the USACE HEC-HMS Technical Reference Manual and the section of this manual dedicated to the SCS Curve Number Loss Model

Land Use CN Values						
HSG	Land Use					
	Historic (Good Brush)	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density (1/4 acre lots)	MFH/SFH - High Density
A	30	98	76	89	61	77
B	48	98	85	92	75	85
C	65	98	89	94	83	90
D	73	98	91	95	87	92
C/D	69	98	90	94.5	85	91

Basin Id	Percent Imperviousness (%)	Soil Type by Percent of Basin			Land Use by Percent of Basin						(Land Use CN Value)*(Soil Type by Percent of Basin)*(Land Use by Percent of Basin)						Sum of CN Values by Soil Number	Composite CN Value	
		A	B	C/D	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density	MFH/SFH - High Density	Soil Type	(Land Use CN Value)		(Soil Type by Percent of Basin)		(Land Use by Percent of Basin)			
												Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density			MFH/SFH - High Density
A4.1	42.8	0.0%	81.9%	18.1%	47.62%	28.98%	0.00%	0.00%	23.40%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	18.73	23.26	0.00	0.00	14.38	0.00	B	56.37
											C/D	5.94	5.13	0.00	0.00	3.60	0.00	C/D	14.67
A4.2	95.0	0.00%	65.08%	34.92%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	0.00	63.78	0.00	0.00	0.00	0.00	B	63.78
											C/D	0.00	34.22	0.00	0.00	0.00	0.00	C/D	34.22
A4.3	32.0	0.00%	22.98%	77.02%	48.53%	0.00%	0.00%	0.00%	51.47%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	5.35	0.00	0.00	0.00	8.87	0.00	B	14.22
											C/D	25.79	0.00	0.00	0.00	33.70	0.00	C/D	59.49
B	47.0	0.00%	9.70%	90.30%	38.14%	0.00%	1.14%	0.00%	3.18%	57.55%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	1.77	0.00	0.09	0.00	0.23	4.74	B	6.84
											C/D	23.77	0.00	0.92	0.00	2.44	47.29	C/D	74.42
B1.1	64.8	0.00%	34.93%	65.07%	0.69%	25.42%	0.00%	0.00%	73.89%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	0.12	8.70	0.00	0.00	19.35	0.00	B	28.17
											C/D	0.31	16.21	0.00	0.00	40.87	0.00	C/D	57.39
B1.2	51.6	0.00%	62.05%	37.95%	11.12%	33.16%	0.00%	0.00%	55.72%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	3.31	20.17	0.00	0.00	25.93	0.00	B	49.41
											C/D	2.91	12.33	0.00	0.00	17.97	0.00	C/D	33.22
B1.3	25.6	0.00%	37.77%	62.23%	31.44%	0.00%	0.00%	0.00%	68.56%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	5.70	0.00	0.00	0.00	19.42	0.00	B	25.12
											C/D	13.50	0.00	0.00	0.00	36.27	0.00	C/D	49.77
B1.4	61.6	0.00%	53.04%	46.96%	27.50%	50.79%	0.00%	0.00%	21.71%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	7.00	26.40	0.00	0.00	8.64	0.00	B	42.04
											C/D	8.91	23.37	0.00	0.00	8.67	0.00	C/D	40.95
B1.5	70.6	0.00%	72.43%	27.57%	20.45%	55.75%	0.00%	0.00%	0.00%	23.79%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	7.11	39.58	0.00	0.00	0.00	14.65	B	61.34
											C/D	3.89	15.06	0.00	0.00	0.00	5.97	C/D	24.92
B2.1	55.7	0.00%	55.65%	44.35%	4.25%	0.00%	0.00%	0.00%	32.96%	62.79%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	1.14	0.00	0.00	0.00	13.75	29.70	B	44.59
											C/D	1.30	0.00	0.00	0.00	12.42	25.34	C/D	39.07
B2.2	87.3	0.00%	72.38%	27.62%	8.58%	91.42%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	2.98	64.85	0.00	0.00	0.00	0.00	B	67.83
											C/D	1.64	24.74	0.00	0.00	0.00	0.00	C/D	26.38
B2.3	86.0	0.00%	46.56%	53.44%	10.02%	89.98%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	2.24	41.06	0.00	0.00	0.00	0.00	B	43.29
											C/D	3.70	47.12	0.00	0.00	0.00	0.00	C/D	50.82

Project Name: West Mountain - F1 - 10W
Prepared By: JNS

Curve Number Calculations

Curve Number calculations based on the CN Tables provided in the USACE HEC-HMS Technical Reference Manual and the section of this manual dedicated to the SCS Curve Number Loss Model

Land Use CN Values						
HSG	Land Use					
	Historic (Good Brush)	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density (1/4 acre lots)	MFH/SFH - High Density
A	30	98	76	89	61	77
B	48	98	85	92	75	85
C	65	98	89	94	83	90
D	73	98	91	95	87	92
C/D	69	98	90	94.5	85	91

Basin Id	Percent Imperviousness (%)	Soil Type by Percent of Basin			Land Use by Percent of Basin						(Land Use CN Value)*(Soil Type by Percent of Basin)*(Land Use by Percent of Basin)						Sum of CN Values by Soil Number	Composite CN Value		
		A	B	C/D	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density	MFH/SFH - High Density	Soil Type	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density			MFH/SFH - High Density	
B2.4	77.0	0.00%	100.00%	0.00%	20.03%	79.97%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	9.61	78.37	0.00	0.00	0.00	0.00	0.00	B	87.99
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
B3.1	70.0	0.00%	49.26%	50.74%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.00	0.00	0.00	0.00	0.00	0.00	41.87	B	41.87
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	46.18	C/D	46.18
B3.2	70.0	0.00%	67.34%	32.66%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.00	0.00	0.00	0.00	0.00	0.00	57.24	B	57.24
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	29.72	C/D	29.72
B3.3	95.0	0.00%	18.84%	81.16%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.00	18.46	0.00	0.00	0.00	0.00	0.00	B	18.46
											C/D	0.00	79.54	0.00	0.00	0.00	0.00	0.00	C/D	79.54
B3.4	95.0	0.00%	18.91%	81.09%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.00	18.53	0.00	0.00	0.00	0.00	0.00	B	18.53
											C/D	0.00	79.47	0.00	0.00	0.00	0.00	0.00	C/D	79.47
B3.5	52.0	0.00%	1.37%	98.63%	31.13%	9.01%	0.00%	0.00%	0.00%	59.86%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.20	0.12	0.00	0.00	0.00	0.00	0.69	B	1.02
											C/D	21.19	8.71	0.00	0.00	0.00	0.00	53.73	C/D	83.62
B3.6	95.0	0.00%	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B	0.00
											C/D	0.00	98.00	0.00	0.00	0.00	0.00	0.00	C/D	98.00
B4	54.7	0.00%	91.58%	8.42%	17.59%	21.31%	0.00%	0.00%	61.10%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	7.73	19.12	0.00	0.00	0.00	41.97	0.00	B	68.82
											C/D	1.02	1.76	0.00	0.00	4.37	0.00	0.00	C/D	7.16
C	11.7	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	48.00	0.00	0.00	0.00	0.00	0.00	0.00	B	48.00
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
C1	39.7	0.00%	38.51%	61.49%	17.97%	16.80%	0.00%	0.00%	65.22%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	3.32	6.34	0.00	0.00	0.00	18.84	0.00	B	28.50
											C/D	7.63	10.13	0.00	0.00	0.00	34.09	0.00	C/D	51.84
C2.1	57.8	0.00%	59.83%	40.17%	41.36%	58.64%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	11.88	34.38	0.00	0.00	0.00	0.00	0.00	B	46.26
											C/D	11.46	23.08	0.00	0.00	0.00	0.00	0.00	C/D	34.55
C2.2	84.7	0.00%	64.65%	35.35%	11.39%	88.61%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	3.54	56.14	0.00	0.00	0.00	0.00	0.00	B	59.68
											C/D	2.78	30.70	0.00	0.00	0.00	0.00	0.00	C/D	33.47
C2.3	25.4	0.00%	58.74%	41.26%	40.96%	4.46%	0.00%	0.00%	54.59%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00	
											B	11.55	2.57	0.00	0.00	0.00	24.05	0.00	B	38.16
											C/D	11.66	1.80	0.00	0.00	0.00	19.14	0.00	C/D	32.60

Project Name: West Mountain - F1 - 10W
Prepared By: JNS

Curve Number Calculations

Curve Number calculations based on the CN Tables provided in the USACE HEC-HMS Technical Reference Manual and the section of this manual dedicated to the SCS Curve Number Loss Model

Land Use CN Values						
HSG	Land Use					
	Historic (Good Brush)	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density (1/4 acre lots)	MFH/SFH - High Density
A	30	98	76	89	61	77
B	48	98	85	92	75	85
C	65	98	89	94	83	90
D	73	98	91	95	87	92
C/D	69	98	90	94.5	85	91

Basin Id	Percent Imperviousness (%)	Soil Type by Percent of Basin			Land Use by Percent of Basin						(Land Use CN Value)*(Soil Type by Percent of Basin)*(Land Use by Percent of Basin)						Sum of CN Values by Soil Number	Composite CN Value	
		A	B	C/D	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density	MFH/SFH - High Density	Soil Type	Historic	Paved Area	Gravel	Commercial	SFH - Rural/Medium Density			MFH/SFH - High Density
C2.4	30.1	0.00%	59.84%	40.16%	33.60%	8.59%	0.00%	0.00%	57.80%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	9.65	5.04	0.00	0.00	25.94	0.00	B	40.63
											C/D	9.31	3.38	0.00	0.00	19.73	0.00	C/D	32.43
C2.5	75.4	0.00%	100.00%	0.00%	21.79%	78.21%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	10.46	76.65	0.00	0.00	0.00	0.00	B	87.11
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
C2.6	34.5	0.00%	84.48%	15.52%	50.65%	24.44%	0.00%	0.00%	24.91%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	20.54	20.24	0.00	0.00	15.78	0.00	B	56.55
											C/D	5.42	3.72	0.00	0.00	3.29	0.00	C/D	12.43
C2.7	70.3	0.00%	100.00%	0.00%	27.41%	72.59%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	13.16	71.14	0.00	0.00	0.00	0.00	B	84.29
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
D1.1	30.2	0.00%	100.00%	0.00%	38.13%	10.99%	0.00%	0.00%	50.88%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	18.30	10.77	0.00	0.00	38.16	0.00	B	67.23
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
D1.2	36.5	0.00%	100.00%	0.00%	24.30%	14.35%	0.00%	0.00%	61.36%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	11.66	14.06	0.00	0.00	46.02	0.00	B	71.74
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
D2	79.4	0.00%	100.00%	0.00%	17.35%	82.65%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	8.33	80.99	0.00	0.00	0.00	0.00	B	89.32
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
E1.1	40.3	0.00%	100.00%	0.00%	39.39%	12.59%	0.00%	0.00%	48.02%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	18.91	12.34	0.00	0.00	36.01	0.00	B	67.26
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
E1.2	79.1	0.00%	100.00%	0.00%	17.65%	82.35%	0.00%	0.00%	0.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	8.47	80.71	0.00	0.00	0.00	0.00	B	89.18
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
OS1	19.5	0.00%	100.00%	0.00%	70.99%	0.00%	0.00%	0.00%	29.01%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	34.08	0.00	0.00	0.00	21.76	0.00	B	55.83
											C/D	0.00	0.00	0.00	0.00	0.00	0.00	C/D	0.00
OS2	55.0	0.00%	83.20%	16.80%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	0.00	0.00	0.00	0.00	62.40	0.00	B	62.40
											C/D	0.00	0.00	0.00	0.00	14.28	0.00	C/D	14.28
OS3	22.6	0.00%	0.00%	100.00%	72.93%	0.00%	0.19%	0.00%	0.00%	26.88%	A	0.00	0.00	0.00	0.00	0.00	0.00	A	0.00
											B	0.00	0.00	0.00	0.00	0.00	0.00	B	0.00
											C/D	50.32	0.00	0.17	0.00	0.00	24.46	C/D	74.95

Project Name: West Mountain - F1 - 10W

Prepared By: JNS

Curve Number and Initial Abstraction Adjustment Calculations

Curve Number adjustment calculations based on the Calculations presented in "A Pragmatic Slope-Adjusted Curve Number Model to Reduce Uncertainty in Predicting Flood Runoff from Steep Watershed" by Ajmal, et .al., dated May 21, 2020

Sub-Basin Data		Default SCS Calculation (20% initial abstraction)			Adjusted SCS Calculations (5% initial abstraction)		
Basin Id	Basin Area (mi ²)	CN	Maximum Potential Retention, S (in)	Initial Abstraction (in)	CN	Maximum Potential Retention, S (in)	Initial Abstraction (in)
A4.1	0.003289	71.04	4.077	0.815	89.16	1.216	0.061
A4.2	0.000757	98.00	0.204	0.041	99.17	0.084	0.004
A4.3	0.011452	73.71	3.566	0.713	90.06	1.104	0.055
B	0.008799	81.26	2.306	0.461	92.70	0.787	0.039
B1.1	0.003897	85.56	1.688	0.338	94.28	0.606	0.030
B1.2	0.002715	82.62	2.103	0.421	93.20	0.730	0.036
B1.3	0.006273	74.89	3.354	0.671	90.46	1.055	0.053
B1.4	0.001397	82.99	2.050	0.410	93.33	0.715	0.036
B1.5	0.001852	86.26	1.593	0.319	94.54	0.577	0.029
B2.1	0.012140	83.66	1.953	0.391	93.58	0.686	0.034
B2.2	0.000816	94.21	0.615	0.123	97.62	0.243	0.012
B2.3	0.000307	94.11	0.625	0.125	97.59	0.247	0.012
B2.4	0.000622	87.99	1.365	0.273	95.20	0.505	0.025
B3.1	0.005536	88.04	1.358	0.272	95.22	0.502	0.025
B3.2	0.004751	86.96	1.500	0.300	94.81	0.548	0.027
B3.3	0.000523	98.00	0.204	0.041	99.17	0.084	0.004
B3.4	0.000437	98.00	0.204	0.041	99.17	0.084	0.004
B3.5	0.001763	84.64	1.814	0.363	93.94	0.645	0.032
B3.6	0.000241	98.00	0.204	0.041	99.17	0.084	0.004
B4	0.006949	75.98	3.162	0.632	90.84	1.009	0.050
C	0.002679	48.00	10.833	2.167	82.07	2.184	0.109
C1	0.004562	80.34	2.447	0.489	92.37	0.826	0.041
C2.1	0.001224	80.81	2.375	0.475	92.54	0.806	0.040
C2.2	0.000634	93.15	0.735	0.147	97.20	0.288	0.014
C2.3	0.005373	70.77	4.131	0.826	89.06	1.228	0.061
C2.4	0.001647	73.06	3.688	0.738	89.83	1.132	0.057
C2.5	0.000242	87.11	1.480	0.296	94.86	0.542	0.027
C2.6	0.002163	68.99	4.496	0.899	88.47	1.303	0.065
C2.7	0.000755	84.29	1.863	0.373	93.81	0.660	0.033
D1.1	0.006129	67.23	4.874	0.975	87.90	1.376	0.069
D1.2	0.004279	71.74	3.939	0.788	89.39	1.187	0.059
D2	0.000501	89.32	1.195	0.239	95.71	0.448	0.022
E1.1	0.004034	67.26	4.867	0.973	87.91	1.375	0.069
E1.2	0.000470	89.18	1.214	0.243	95.65	0.455	0.023
OS1	0.001447	55.83	7.911	1.582	84.35	1.855	0.093
OS2	0.003786	76.68	3.041	0.608	91.08	0.979	0.049
OS3	0.006417	74.95	3.342	0.668	90.48	1.052	0.053

Project Name: West Mountain - F1 - 10W
Prepared By: JNS

Lag Time Calculations (TLag)

100-year 24-hr Precipitation Depth (P_2)= 1.36

Sub-Basin Data		Initial or Overland Flow Time					Channelized Flow Time					Overall Flow Time		
Basin Id	Basin Area (Ac)	Roughness Coefficient	Length (ft)	Elev Change	Slope (%)	T_i (min)	Length (ft)	Elev Change	Slope (%)	Velocity (FPS)	T_t (min)	Comp. T_c	Lag Time	Final T_{Lag} (min)
A4.1	2.11	0.240	300	40	13.2	24.78	545	25	4.6	3.46	2.6	27.4	16.4	16.4
A4.2	0.48	0.011	37	2	6.1	0.54	495	17	3.4	2.99	2.8	3.3	2.0	5.0
A4.3	7.33	0.240	300	19	6.3	33.24	566	36	6.4	4.07	2.3	35.6	21.3	21.3
B	5.63	0.240	153	12	7.8	17.81	1043	46	4.4	3.39	5.1	22.9	13.8	13.8
B1.1	2.49	0.011	17	1	3.0	0.37	1452	52	3.5	3.04	8.0	8.3	5.0	5.0
B1.2	1.74	0.011	17	1	3.0	0.37	1440	52	3.6	3.05	7.9	8.2	4.9	5.0
B1.3	4.02	0.240	270	16	5.9	31.38	566	15	2.7	2.63	3.6	35.0	21.0	21.0
B1.4	0.89	0.011	13	0	3.1	0.31	645	23	3.6	3.07	3.5	3.8	2.3	5.0
B1.5	1.19	0.011	13	0	3.1	0.31	644	23	3.5	3.04	3.5	3.8	2.3	5.0
B2.1	7.77	0.240	300	14	4.7	37.56	392	35	8.9	4.82	1.4	38.9	23.4	23.4
B2.2	0.52	0.011	61	2	3.3	1.03	525	9	1.7	2.11	4.1	5.2	3.1	5.0
B2.3	0.20	0.011	16	0	1.3	0.52	453	10	2.2	2.40	3.1	3.7	2.2	5.0
B2.4	0.40	0.011	75	2	2.7	1.32	640	15	2.3	2.47	4.3	5.6	3.4	5.0
B3.1	3.54	0.011	300	5	1.7	4.81	700	43	6.1	4.00	2.9	7.7	4.6	5.0
B3.2	3.04	0.011	300	9	3.0	3.81	545	30	5.5	3.79	2.4	6.2	3.7	5.0
B3.3	0.33	0.011	19	1	2.6	0.44	434	21	4.8	3.55	2.0	2.5	1.5	5.0
B3.4	0.28	0.011	19	1	2.6	0.44	452	21	4.6	3.48	2.2	2.6	1.6	5.0
B3.5	1.13	0.011	260	36	13.8	1.84	10	1	5.0	3.61	0.0	1.9	1.1	5.0
B3.6	0.15	0.011	16	1	3.1	0.36	325	20	6.0	3.95	1.4	1.7	1.0	5.0
B4	4.45	0.011	248	9	3.7	3.00	846	34	4.0	3.21	4.4	7.4	4.4	5.0
C	1.71	0.240	41	6	14.6	4.84	71	8	11.3	5.42	0.2	5.1	3.0	5.0
C1	2.92	0.240	156	11	6.7	19.23	422	35	8.3	4.65	1.5	20.7	12.4	12.4
C2.1	0.78	0.011	24	1	4.2	0.44	894	45	5.0	3.60	4.1	4.6	2.7	5.0
C2.2	0.41	0.011	24	1	4.2	0.44	904	44	4.8	3.54	4.3	4.7	2.8	5.0
C2.3	3.44	0.240	300	20	6.7	32.57	460	27	5.9	3.91	2.0	34.5	20.7	20.7
C2.4	1.05	0.240	286	19	6.6	31.39	177	3	1.7	2.10	1.4	32.8	19.7	19.7
C2.5	0.16	0.011	22	0	1.4	0.65	156	3	2.1	2.31	1.1	1.8	1.1	5.0
C2.6	1.38	0.240	282	17	6.0	32.27	387	7	1.8	2.17	3.0	35.2	21.1	21.1
C2.7	0.48	0.011	26	1	1.9	0.64	410	6	1.3	1.87	3.7	4.3	2.6	5.0
D1.1	3.92	0.011	300	17	5.7	2.95	482	41	8.5	4.71	1.7	4.7	2.8	5.0
D1.2	2.74	0.240	253	24	9.5	24.68	281	11	3.9	3.17	1.5	26.2	15.7	15.7
D2	0.32	0.011	36	1	2.8	0.72	731	55	7.5	4.41	2.8	3.5	2.1	5.0
E1.1	2.58	0.240	300	42	14.0	24.20	369	30	8.1	4.60	1.3	25.5	15.3	15.3
E1.2	0.30	0.011	25	2	6.0	0.40	702	52	7.4	4.39	2.7	3.1	1.8	5.0
OS1	0.93	0.240	198	16	8.1	21.63	110	24	21.8	7.54	0.2	21.9	13.1	13.1
OS2	2.42	0.240	96	9	8.9	11.66	93	15	16.6	6.57	0.2	11.9	7.1	7.1
OS3	4.11	0.240	300	36	12.0	25.74	620	26	4.2	3.30	3.1	28.9	17.3	17.3

Project Name: West Mountain - Filing 1 - Proposed
 Prepared By: JNS



Reach Time of Concentration Calculations (Tc)

Element Information		Channelized Flow Path 1						Overall Flow Time
Element ID	Notes	Length (ft)	Elev Change	Slope (%)	Paved?	Velocity (FPS)	T _c (min)	Comp. T _c (min)
SWALE B	Swale conveying B1.1, B1.2, B1.3, B1.4, B1.5, B2.1, B2.2, B2.3, and B2.4 runoff to Pond B	1043	46	4.4%	N	3.39	5.1	5.1
SWALE B2.1	Swale conveying B1.1, B1.2, B1.3, B1.4. and B1.5 runoff to DP B2.3	277	22	7.9%	N	4.55	1.0	1.0

Project: West Mountain - F1 - 10W
 Prepared by: JNS
 Date: 1/12/2026

HEC-HMS Flow results

Existing Conditions				
Element	Area (Ac)	Percent Imperviousness	Q5 (CFS)	Q100 (CFS)
A4.1	2.11	5%	0.5	1.9
A4.2	0.48	5%	0.2	0.9
A4.3	7.33	5%	2.2	7.2
B	5.63	5%	2.1	7.4
B1.1	2.49	5%	1.2	4.7
B1.2	1.74	5%	0.7	3.0
B1.3	4.02	5%	1.1	3.8
B1.4	0.89	5%	0.4	1.6
B1.5	1.19	5%	0.5	2.0
B2.1	7.77	5%	1.9	6.4
B2.2	0.52	5%	0.2	0.8
B2.3	0.20	5%	0.1	0.3
B2.4	0.40	5%	0.1	0.6
B3.1	3.54	5%	1.6	6.3
B3.2	3.04	5%	1.3	5.2
B3.3	0.33	5%	0.2	0.6
B3.4	0.28	5%	0.1	0.5
B3.5	1.13	5%	0.7	2.5
B3.6	0.15	5%	0.1	0.3
B4	4.45	5%	1.6	6.9
C	1.71	5%	0.6	2.6
C1	2.92	5%	1.0	3.6
C2.1	0.78	5%	0.3	1.3
C2.2	0.41	5%	0.2	0.7
C2.3	3.44	5%	0.9	3.0
C2.4	1.05	5%	0.3	0.9
C2.5	0.16	5%	0.0	0.2
C2.6	1.38	5%	0.3	1.1
C2.7	0.48	5%	0.2	0.8
D1.1	3.92	5%	1.4	5.9
D1.2	2.74	5%	0.6	2.5
D2	0.32	5%	0.1	0.5
E1.1	2.58	5%	0.6	2.3
E1.2	0.30	5%	0.1	0.5
OS1	0.93	5%	0.2	0.9
OS2	2.42	5%	0.8	3.4
OS3	4.11	5%	1.5	4.9

Proposed Conditions				
Element	Area (Ac)	Percent Imperviousness	Q5 (CFS)	Q100 (CFS)
A4.1	2.11	42.8%	0.8	2.7
A4.2	0.48	95.0%	0.9	2.0
A4.3	7.33	32.0%	2.8	8.6
B	5.63	47.0%	3.2	9.8
B1.1	2.49	64.8%	2.6	7.5
B1.2	1.74	51.6%	1.6	4.9
B1.3	4.02	25.6%	1.6	4.9
B1.4	0.89	61.6%	0.8	2.6
B1.5	1.19	70.6%	1.3	3.7
B2.1	7.77	55.7%	3.9	10.6
B2.2	0.52	87.3%	0.8	1.9
B2.3	0.20	86.0%	0.3	0.7
B2.4	0.40	77.0%	0.4	1.2
B3.1	3.54	70.0%	4.1	11.2
B3.2	3.04	70.0%	3.4	9.6
B3.3	0.33	95.0%	0.6	1.3
B3.4	0.28	95.0%	0.5	1.0
B3.5	1.13	52.0%	1.2	3.4
B3.6	0.15	95.0%	0.2	0.5
B4	4.45	54.7%	3.3	10.9
C	1.71	11.7%	0.6	2.6
C1	2.92	39.7%	1.7	5.4
C2.1	0.78	57.8%	0.7	2.1
C2.2	0.41	84.7%	0.6	1.4
C2.3	3.44	25.4%	1.2	3.9
C2.4	1.05	30.1%	0.4	1.2
C2.5	0.16	75.4%	0.1	0.4
C2.6	1.38	34.5%	0.5	1.5
C2.7	0.48	70.3%	0.5	1.5
D1.1	3.92	30.2%	2.2	8.1
D1.2	2.74	36.5%	1.1	3.7
D2	0.32	79.4%	0.4	1.1
E1.1	2.58	40.3%	0.9	3.2
E1.2	0.30	79.1%	0.4	1.1
OS1	0.93	19.5%	0.3	1
OS2	2.42	55.0%	1.6	5.5
OS3	4.11	22.6%	1.7	5.5

Project: West Mountain - F1 - 10W
 Prepared by: JNS
 Date: #####

OUTFALL ELEMENT

HEC-HMS Flow results

Existing Conditions				
Element	Area (Ac)	Percent Imperviousness	Q5 (CFS)	Q100 (CFS)
A4_OUT	-	-	2.8	9.3
A4.1	2.11	5%	0.5	1.9
A4.2	0.48	5%	0.2	0.9
A4.3	7.33	5%	2.2	7.2
B	5.63	5%	2.1	7.4
B1.1	2.49	5%	1.2	4.7
B1.2	1.74	5%	0.7	3.0
B1.3	4.02	5%	1.1	3.8
B1.4	0.89	5%	0.4	1.6
B1.5	1.19	5%	0.5	2.0
B2.1	7.77	5%	1.9	6.4
B2.2	0.52	5%	0.2	0.8
B2.3	0.20	5%	0.1	0.3
B2.4	0.40	5%	0.1	0.6
B3.1	3.54	5%	1.6	6.3
B3.2	3.04	5%	1.3	5.2
B3.3	0.33	5%	0.2	0.6
B3.4	0.28	5%	0.1	0.5
B3.5	1.13	5%	0.7	2.5
B3.6	0.15	5%	0.1	0.3
B4	4.45	5%	1.6	6.9
C	1.71	5%	0.6	2.6
C1	2.92	5%	1.0	3.6
C2.1	0.78	5%	0.3	1.3
C2.2	0.41	5%	0.2	0.7
C2.3	3.44	5%	0.9	3.0
C2.4	1.05	5%	0.3	0.9
C2.5	0.16	5%	0.0	0.2
C2.6	1.38	5%	0.3	1.1
C2.7	0.48	5%	0.2	0.8
DP_A4.3	-	-	3.3	11.4
DP_B1.5	-	-	3.1	12.4
DP_B2.3	-	-	5.0	15.1
DP_B3.6	-	-	3.9	15.4
D1.1	3.92	5%	1.4	5.9
D1.2	2.74	5%	0.6	2.5
D2	0.32	5%	0.1	0.5
E1.1	2.58	5%	0.6	2.3
E1.2	0.30	5%	0.1	0.5
LELAND CREEK	-	-	5.6	20
OS1	0.93	5%	0.2	0.9
OS2	2.42	5%	0.8	3.4
OS2_OUT	-	-	0.8	3.4
OS3	4.11	5%	1.5	4.9
OS3_OUT	-	-	11.5	40.8
POND_B	-	-	10.1	37
POND_C	-	-	3.1	10.6
SWALE B	-	-	5.0	15.1
SWALE B2.1	-	-	2.9	11.8

Proposed Conditions				
Element	Area (Ac)	Percent Imperviousness	Q5 (CFS)	Q100 (CFS)
A4_OUT	-	-	0.0	4.0
A4.1	2.11	42.8%	0.8	2.7
A4.2	0.48	95.0%	0.9	2.0
A4.3	7.33	32.0%	2.8	8.6
B	5.63	47.0%	3.2	9.8
B1.1	2.49	64.8%	2.6	7.5
B1.2	1.74	51.6%	1.6	4.9
B1.3	4.02	25.6%	1.6	4.9
B1.4	0.89	61.6%	0.8	2.6
B1.5	1.19	70.6%	1.3	3.7
B2.1	7.77	55.7%	3.9	10.6
B2.2	0.52	87.3%	0.8	1.9
B2.3	0.20	86.0%	0.3	0.7
B2.4	0.40	77.0%	0.4	1.2
B3.1	3.54	70.0%	4.1	11.2
B3.2	3.04	70.0%	3.4	9.6
B3.3	0.33	95.0%	0.6	1.3
B3.4	0.28	95.0%	0.5	1.0
B3.5	1.13	52.0%	1.2	3.4
B3.6	0.15	95.0%	0.2	0.5
B4	4.45	54.7%	3.3	10.9
C	1.71	11.7%	0.6	2.6
C1	2.92	39.7%	1.7	5.4
C2.1	0.78	57.8%	0.7	2.1
C2.2	0.41	84.7%	0.6	1.4
C2.3	3.44	25.4%	1.2	3.9
C2.4	1.05	30.1%	0.4	1.2
C2.5	0.16	75.4%	0.1	0.4
C2.6	1.38	34.5%	0.5	1.5
C2.7	0.48	70.3%	0.5	1.5
DP_A4.3	-	-	0.1	5.3
DP_B1.5	-	-	6.8	20.3
DP_B2.3	-	-	8.9	26.5
DP_B3.6	-	-	9.9	27
D1.1	3.92	30.2%	2.2	8.1
D1.2	2.74	36.5%	1.1	3.7
D2	0.32	79.4%	0.4	1.1
E1.1	2.58	40.3%	0.9	3.2
E1.2	0.30	79.1%	0.4	1.1
LELAND CREEK	-	-	4.1	14.5
OS1	0.93	19.5%	0.3	1
OS2	2.42	55.0%	1.6	5.5
OS2_OUT	-	-	1.6	5.5
OS3	4.11	22.6%	1.7	5.5
OS3_OUT	-	-	2.6	28.8
POND_B	-	-	1.3	25.8
POND_C	-	-	0.1	7.2
SWALE B	-	-	8.9	26.5
SWALE B2.1	-	-	6.5	19.6

APPENDIX C

HYDRAULIC CALCULATIONS

Street Inlet Calculations – MHFD_Inlet_v6.00

Area Inlet Capacity Calculations - Hydraflow Express

Curb Cut Capacity Calculations - Hydraflow Express

Swale Calculations - Hydraflow Express

Culvert Capacity Calculations - Hydraflow Express

StormCAD Key Map

StormCAD Output Tables

INLET MANAGEMENT

Project: Grand Park - 10W**Minor:** 5-year**Major:** 100-year

Worksheet Protected

INLET NAME	Inlet A4.1	Inlet A4.2
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	2	2

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.80	0.90
Major Peak Flow, Q (cfs)	2.70	2.00

Bypass (Carry-Over) Flow from Upstream

Inlets must be organized from upstream (left) to downstream (right) in order for bypass

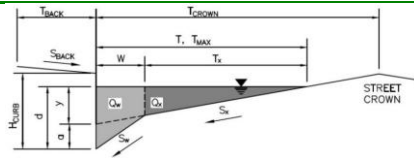
Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):		
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.80	0.90
Major Total Design Peak Flow, Q (cfs)	2.70	2.00
Minor Inlet Interception Capacity, Q_a (cfs)	0.80	0.90
Major Inlet Interception Capacity, Q_a (cfs)	2.70	2.00
Minor Flow Bypassed Downstream, Q_b (cfs)	0.00	0.00
Major Flow Bypassed Downstream, Q_b (cfs)	0.00	0.00
Minor Flow Capture Percentage, C%	100%	100%
Major Flow Capture Percentage, C%	100%	100%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **Grand Park - 10W**Inlet ID: **Inlet A4.1****Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	26.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_x =$	0.020	ft/ft
$S_w =$	0.083	ft/ft
$S_o =$	0.030	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	10.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

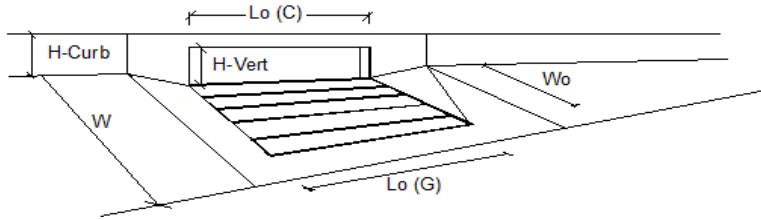
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	4.2	13.0	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.80 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.70 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

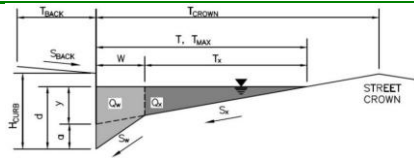
MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$					
Total Inlet Interception Capacity		Q_a =	0.8	2.7	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0	cfs
Capture Percentage = Q_a/Q_o		C% =	100	100	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **Grand Park - 10W**Inlet ID: **Inlet A4.2****Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	26.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_x =$	0.020	ft/ft
$S_w =$	0.083	ft/ft
$S_o =$	0.030	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	10.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

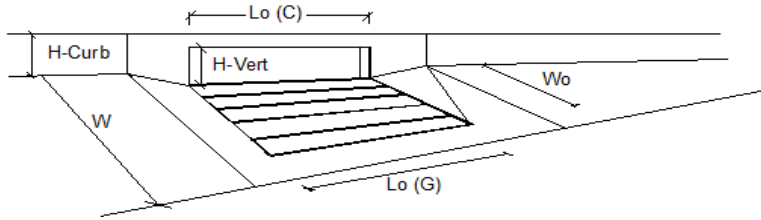
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	4.2	13.0	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.90 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.00 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$					
Total Inlet Interception Capacity		Q_a =	0.9	2.0	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0	cfs
Capture Percentage = Q_a/Q_o		C% =	100	100	%

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet B1.1	Inlet B1.2	Inlet B1.4
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	2	2	2

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	2.60	1.60	0.80
Major Peak Flow, Q (cfs)	7.50	4.90	2.60

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	User-Defined
Bypass Flow Description (Optional):			B1.1 & B1.2
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	0.00	1.64

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	2.60	1.60	0.80
Major Total Design Peak Flow, Q (cfs)	7.50	4.90	4.24
Minor Inlet Interception Capacity, Q_a (cfs)	2.60	1.60	3.93
Major Inlet Interception Capacity, Q_a (cfs)	6.02	4.73	5.84
Minor Flow Bypassed Downstream, Q_b (cfs)	0.00	0.00	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	1.48	0.17	N/A
Minor Flow Capture Percentage, C%	100%	100%	100%
Major Flow Capture Percentage, C%	80%	97%	100%

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet B1.5	Inlet B2.2	Inlet B2.3
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	1	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	1.30	0.80	0.30
Major Peak Flow, Q (cfs)	3.70	1.90	0.70

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):			
Minor Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00
Major Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	1.30	0.80	0.30
Major Total Design Peak Flow, Q (cfs)	3.70	1.90	0.70
Minor Inlet Interception Capacity, Q _a (cfs)	2.76	2.76	0.30
Major Inlet Interception Capacity, Q _a (cfs)	9.87	5.37	0.70
Minor Flow Bypassed Downstream, Q _b (cfs)	N/A	N/A	0.00
Major Flow Bypassed Downstream, Q _b (cfs)	N/A	N/A	0.00
Minor Flow Capture Percentage, C%	100%	100%	100%
Major Flow Capture Percentage, C%	100%	100%	100%

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet B2.4	Inlet B3.3	Inlet B3.4
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	On Grade	In Sump	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	1	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.40	0.60	0.50
Major Peak Flow, Q (cfs)	1.20	1.30	1.00

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):			
Minor Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00
Major Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.40	0.60	0.50
Major Total Design Peak Flow, Q (cfs)	1.20	1.30	1.00
Minor Inlet Interception Capacity, Q _a (cfs)	0.40	2.76	2.76
Major Inlet Interception Capacity, Q _a (cfs)	1.20	5.37	3.81
Minor Flow Bypassed Downstream, Q _b (cfs)	0.00	N/A	N/A
Major Flow Bypassed Downstream, Q _b (cfs)	0.00	N/A	N/A
Minor Flow Capture Percentage, C%	100%	100%	100%
Major Flow Capture Percentage, C%	100%	100%	100%

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet B3.5	Inlet B3.6
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	2	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.80	0.20
Major Peak Flow, Q (cfs)	2.20	0.50

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):		
Minor Bypass Flow Received, Q _b (cfs)	0.00	0.00
Major Bypass Flow Received, Q _b (cfs)	0.00	0.00

CALCULATED OUTPUT

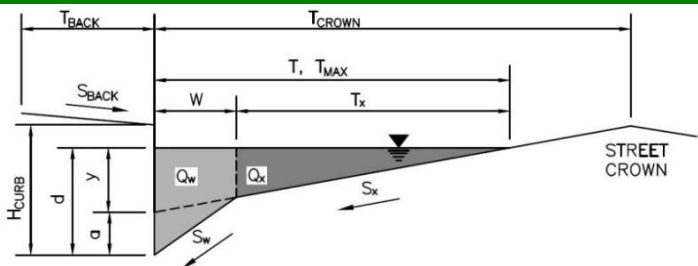
Minor Total Design Peak Flow, Q (cfs)	0.80	0.20
Major Total Design Peak Flow, Q (cfs)	2.20	0.50
Minor Inlet Interception Capacity, Q _a (cfs)	0.80	0.20
Major Inlet Interception Capacity, Q _a (cfs)	2.20	0.50
Minor Flow Bypassed Downstream, Q _b (cfs)	0.00	0.00
Major Flow Bypassed Downstream, Q _b (cfs)	0.00	0.00
Minor Flow Capture Percentage, C%	100%	100%
Major Flow Capture Percentage, C%	100%	100%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B1.1



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} = 7.0$ ft
 $S_{BACK} = 0.020$ ft/ft
 $n_{BACK} = 0.013$

$H_{CURB} = 4.00$ inches
 $T_{CROWN} = 13.0$ ft
 $W = 1.00$ ft
 $S_x = 0.020$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.015$ ft/ft
 $n_{STREET} = 0.013$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	13.0	13.0	ft
$d_{MAX} =$	4.0	5.7	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

$Q_{allow} =$

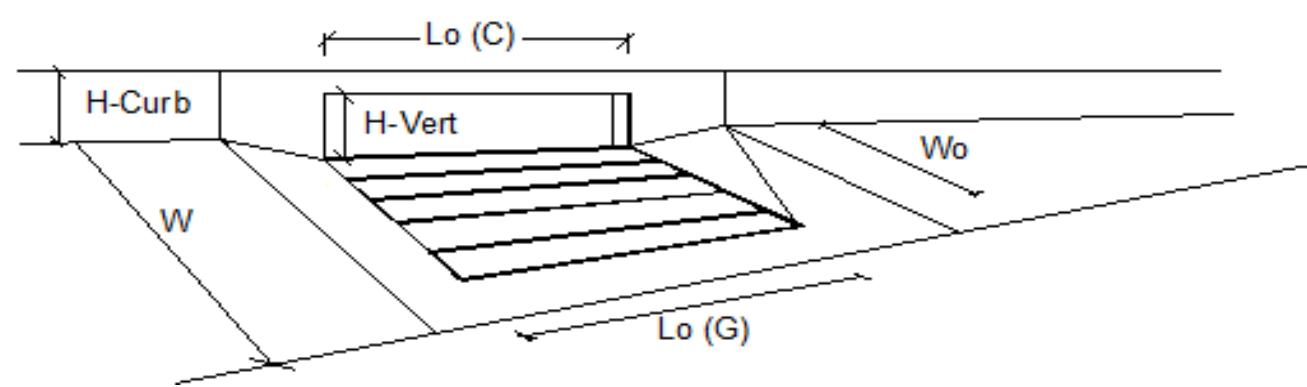
Minor Storm	Major Storm
7.6	7.6

 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 2.60 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 7.50 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



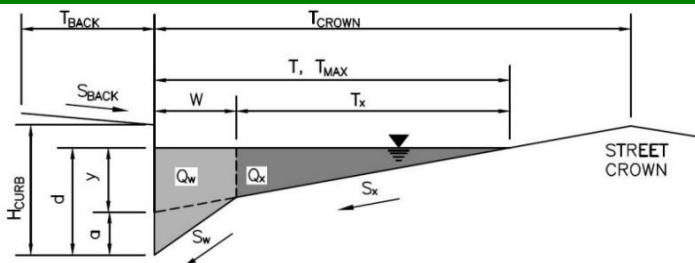
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR
Total Inlet Interception Capacity		Q _a =	2.6	6.0 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	1.5 cfs
Capture Percentage = Q _a /Q _o		C% =	100	80 %

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B1.2



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

T_{BACK} = 3.0 ft
S_{BACK} = 0.020 ft/ft
n_{BACK} = 0.013

H_{CURB} = 4.00 inches
T_{CROWN} = 13.0 ft
W = 2.00 ft
S_X = 0.020 ft/ft
S_W = 0.083 ft/ft
S_O = 0.014 ft/ft
n_{STREET} = 0.013

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
T _{MAX}	13.0	13.0
d _{MAX}	4.0	4.7

☐ ☐

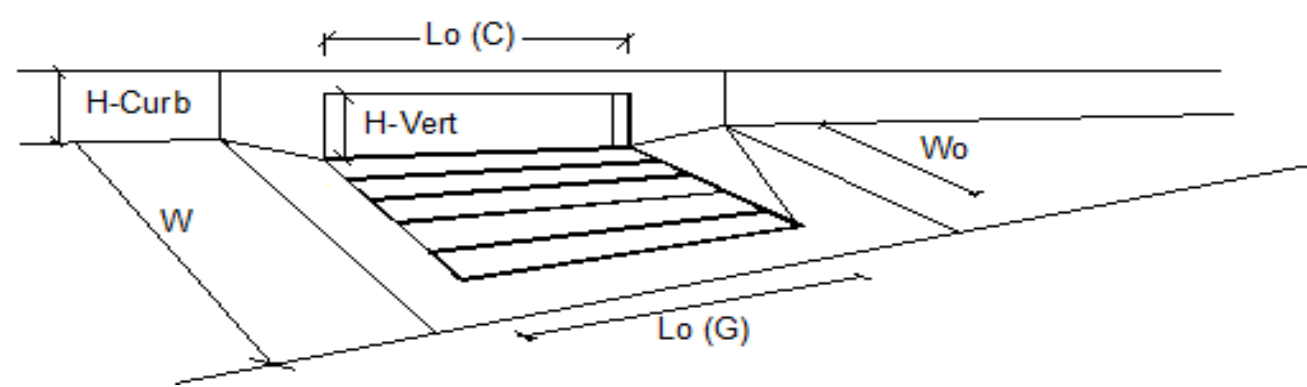
MINOR STORM Allowable Capacity is based on Depth Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

Q_{allow} = 4.9 8.2 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.60 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 4.90 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



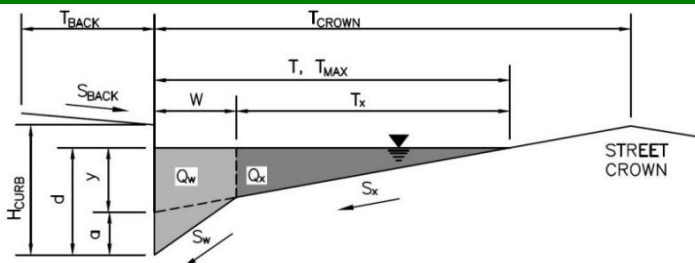
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR
Total Inlet Interception Capacity		Q _a =	1.6	4.7 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	0.2 cfs
Capture Percentage = Q _a /Q _o		C% =	100	97 %

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B1.4



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

T_{BACK} = 3.0 ft
S_{BACK} = 0.020 ft/ft
n_{BACK} = 0.013

H_{CURB} = 4.00 inches
T_{CROWN} = 13.0 ft
W = 1.00 ft
S_X = 0.020 ft/ft
S_W = 0.083 ft/ft
S_O = 0.000 ft/ft
n_{STREET} = 0.013

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm
T _{MAX} =	9.0	13.0
d _{MAX} =	4.0	4.7
	<input type="checkbox"/>	<input type="checkbox"/>

MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

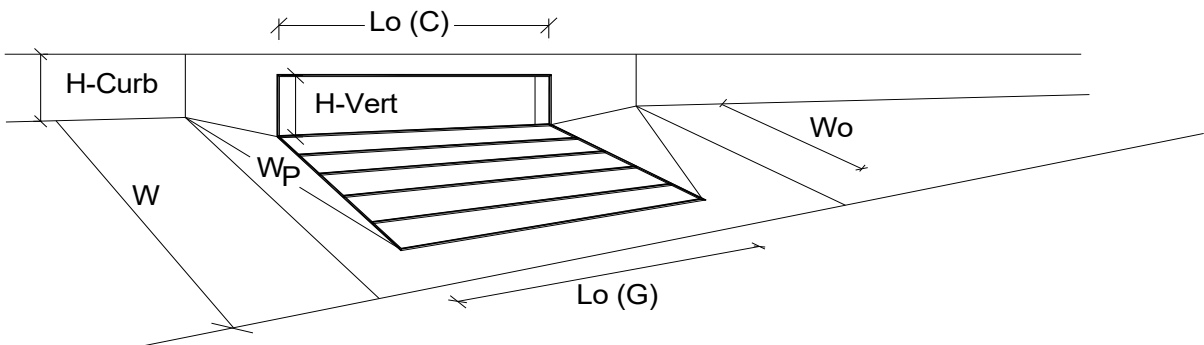
Q_{allow} =

Minor Storm	Major Storm
SUMP	SUMP

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)			
Type of Inlet	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)			
Number of Unit Inlets (Grate or Curb Opening)			
Water Depth at Flowline (outside of local depression)			
Grate Information			
Length of a Unit Grate			
Width of a Unit Grate			
Open Area Ratio for a Grate (typical values 0.15-0.90)			
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)			
Grate Weir Coefficient (typical value 2.15 - 3.60)			
Grate Orifice Coefficient (typical value 0.60 - 0.80)			
Curb Opening Information			
Length of a Unit Curb Opening			
Height of Vertical Curb Opening in Inches			
Height of Curb Orifice Throat in Inches			
Angle of Throat			
Side Width for Depression Pan (typically the gutter width of 2 feet)			
Clogging Factor for a Single Curb Opening (typical value 0.10)			
Curb Opening Weir Coefficient (typical value 2.3-3.7)			
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)			
Low Head Performance Reduction (Calculated)			
Depth for Grate Midwidth			
Depth for Curb Opening Weir Equation			
Grated Inlet Performance Reduction Factor for Long Inlets			
Curb Opening Performance Reduction Factor for Long Inlets			
Combination Inlet Performance Reduction Factor for Long Inlets			
Total Inlet Interception Capacity (assumes clogged condition)			
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)			

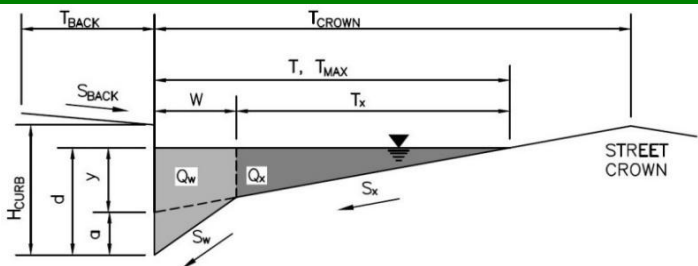
	MINOR	MAJOR	
Type =	CDOT Type R Curb Opening		
a _{local} =	5.00	5.00	inches
No =	2	2	
Ponding Depth =	4.0	4.7	inches
	MINOR	MAJOR	<input checked="" type="checkbox"/> Override Depths
L _o (G) =	N/A	N/A	feet
W _o =	N/A	N/A	feet
A _{ratio} =	N/A	N/A	
C _f (G) =	N/A	N/A	
C _w (G) =	N/A	N/A	
C _o (G) =	N/A	N/A	
	MINOR	MAJOR	
L _o (C) =	5.00	5.00	feet
H _{vert} =	6.00	6.00	inches
H _{throat} =	6.00	6.00	inches
Theta =	63.40	63.40	degrees
W _p =	1.00	1.00	feet
C _f (C) =	0.10	0.10	
C _w (C) =	3.60	3.60	
C _o (C) =	0.67	0.67	
	MINOR	MAJOR	
d _{Grate} =	N/A	N/A	ft
d _{Curb} =	0.25	0.31	ft
RF _{Grate} =	N/A	N/A	
RF _{Curb} =	0.79	0.85	
RF _{Combination} =	N/A	N/A	
	MINOR	MAJOR	
Q _a =	3.9	5.8	cfs
Q _{PEAK REQUIRED} =	0.8	4.2	cfs

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B1.5



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} = 17.0$ ft
 $S_{BACK} = 0.020$ ft/ft
 $n_{BACK} = 0.013$

$H_{CURB} = 4.00$ inches
 $T_{CROWN} = 13.0$ ft
 $W = 1.00$ ft
 $S_x = 0.020$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.000$ ft/ft
 $n_{STREET} = 0.013$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm
$T_{MAX} =$	9.0	13.0
$d_{MAX} =$	4.0	8.1
	<input type="checkbox"/>	<input type="checkbox"/>

MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

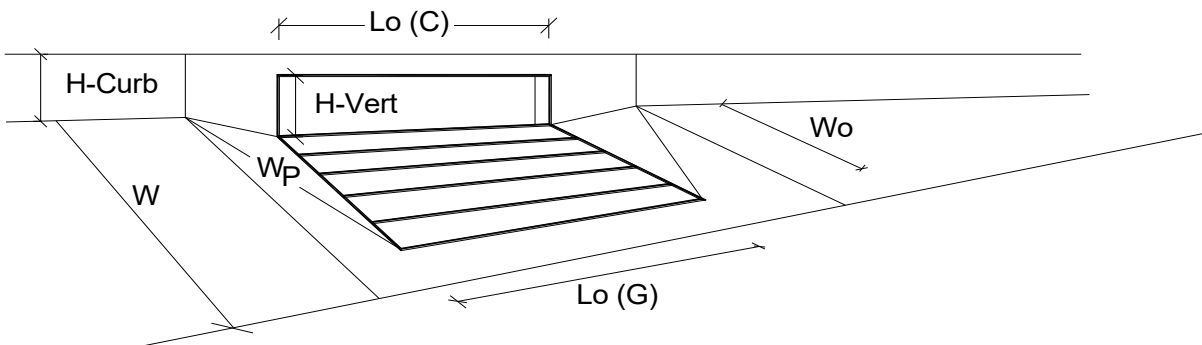
$Q_{allow} =$

Minor Storm	Major Storm
SUMP	SUMP

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



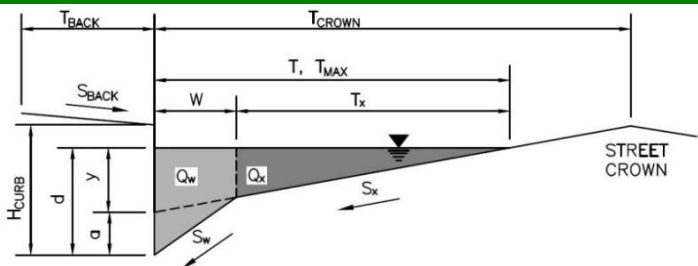
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	5.00	5.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	4.0	8.1	inches
<u>Grate Information</u>			MINOR	MAJOR	<input checked="" type="checkbox"/> Override Depths
Length of a Unit Grate		L _o (G) =	N/A	N/A	feet
Width of a Unit Grate		W _o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	N/A	N/A	
<u>Curb Opening Information</u>			MINOR	MAJOR	
Length of a Unit Curb Opening		L _o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.67	0.67	
<u>Low Head Performance Reduction (Calculated)</u>			MINOR	MAJOR	
Depth for Grate Midwidth		d _{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.25	0.59	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)			MINOR	MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _a =	2.8	9.9	cfs
		Q _{PEAK REQUIRED} =	1.3	3.7	cfs

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B2.2



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

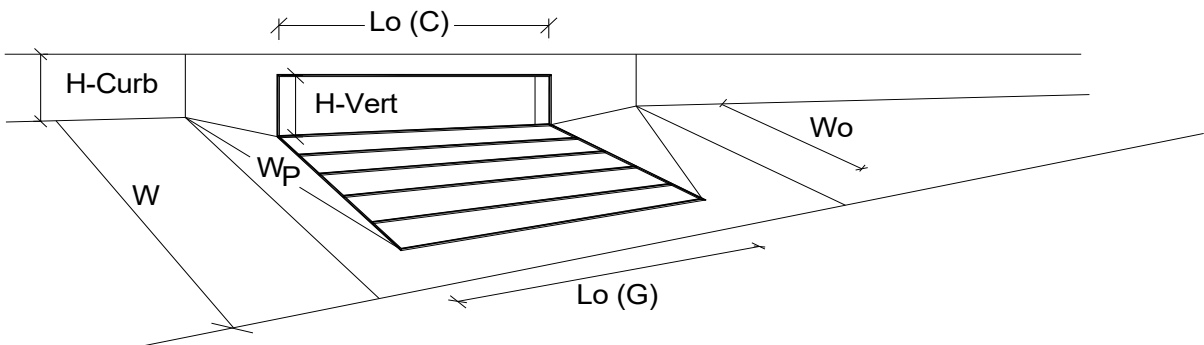
Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

T_{BACK}	=	7.0	ft
S_{BACK}	=	0.020	ft/ft
n_{BACK}	=	0.013	
H_{CURB}	=	4.00	inches
T_{CROWN}	=	13.0	ft
W	=	1.00	ft
S_x	=	0.020	ft/ft
S_w	=	0.083	ft/ft
S_o	=	0.000	ft/ft
n_{STREET}	=	0.013	
T_{MAX}	=	Minor Storm 13.0	Major Storm 13.0 ft
d_{MAX}	=	4.0	5.7 inches
		<input type="checkbox"/>	<input type="checkbox"/>
Q_{allow}	=	Minor Storm SUMP	Major Storm SUMP cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)	
Type of Inlet	CDOT Type R Curb Opening
Local Depression (additional to continuous gutter depression 'a' from above)	
Number of Unit Inlets (Grate or Curb Opening)	
Water Depth at Flowline (outside of local depression)	
Grate Information	
Length of a Unit Grate	
Width of a Unit Grate	
Open Area Ratio for a Grate (typical values 0.15-0.90)	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	
Grate Weir Coefficient (typical value 2.15 - 3.60)	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	
Curb Opening Information	
Length of a Unit Curb Opening	
Height of Vertical Curb Opening in Inches	
Height of Curb Orifice Throat in Inches	
Angle of Throat	
Side Width for Depression Pan (typically the gutter width of 2 feet)	
Clogging Factor for a Single Curb Opening (typical value 0.10)	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	
Low Head Performance Reduction (Calculated)	
Depth for Grate Midwidth	
Depth for Curb Opening Weir Equation	
Grated Inlet Performance Reduction Factor for Long Inlets	
Curb Opening Performance Reduction Factor for Long Inlets	
Combination Inlet Performance Reduction Factor for Long Inlets	
Total Inlet Interception Capacity (assumes clogged condition)	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	

	MINOR	MAJOR	
Type =	CDOT Type R Curb Opening		
a _{local} =	5.00	5.00	inches
No =	1	1	
Ponding Depth =	4.0	5.7	inches
	MINOR	MAJOR	<input checked="" type="checkbox"/> Override Depths
L _o (G) =	N/A	N/A	feet
W _o =	N/A	N/A	feet
A _{ratio} =	N/A	N/A	
C _f (G) =	N/A	N/A	
C _w (G) =	N/A	N/A	
C _o (G) =	N/A	N/A	
	MINOR	MAJOR	
L _o (C) =	5.00	5.00	feet
H _{vert} =	6.00	6.00	inches
H _{throat} =	6.00	6.00	inches
Theta =	63.40	63.40	degrees
W _p =	1.00	1.00	feet
C _f (C) =	0.10	0.10	
C _w (C) =	3.60	3.60	
C _o (C) =	0.67	0.67	
	MINOR	MAJOR	
d _{Grate} =	N/A	N/A	ft
d _{Curb} =	0.25	0.39	ft
RF _{Grate} =	N/A	N/A	
RF _{Curb} =	1.00	1.00	
RF _{Combination} =	N/A	N/A	
	MINOR	MAJOR	
Q _a =	2.8	5.4	cfs
Q _{PEAK REQUIRED} =	0.8	1.9	cfs

$T_{\text{BACK}} =$	7.0	ft
$S_{\text{BACK}} =$	0.020	ft/ft
$n_{\text{BACK}} =$	0.013	

H_{CURB}	4.00	inches
T_{CROWN}	13.0	ft
W	1.00	ft
S_x	0.020	ft/ft
S_w	0.083	ft/ft
S_o	0.040	ft/ft
n_{STREET}	0.013	

	Minor Storm	Major Storm	
T_{MAX} =	13.0	13.0	ft
d_{MAX} =	4.0	5.7	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

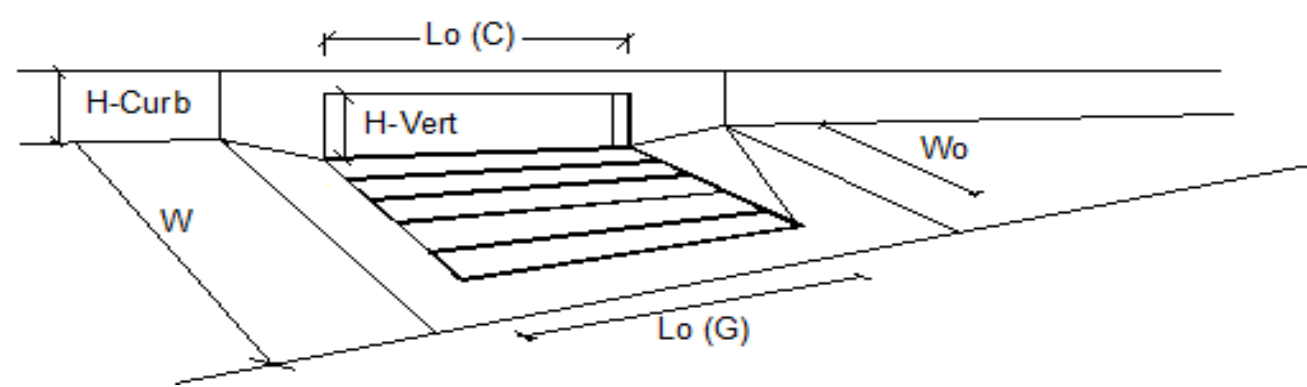
	Minor Storm	Major Storm
Q_{allow} =	12.4	12.4

cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.30 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 0.70 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR
Total Inlet Interception Capacity		Q _a =	0.3	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	%

T_{BACK}	3.0	ft
S_{BACK}	0.020	ft/ft
n_{BACK}	0.020	

H_{CURB}	4.00	inches
T_{CROWN}	13.0	ft
W	1.00	ft
S_X	0.020	ft/ft
S_W	0.083	ft/ft
S_O	0.040	ft/ft
n_{STREET}	0.013	

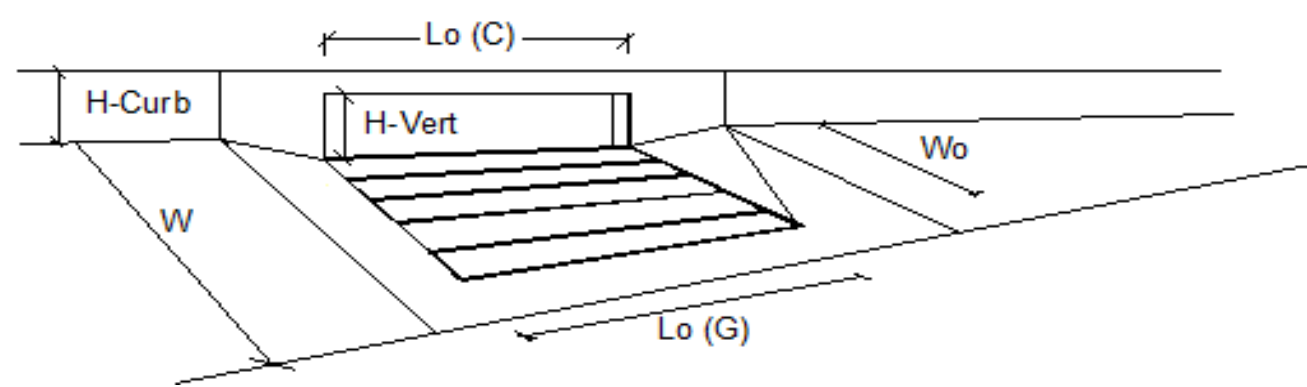
	Minor Storm	Major Storm	
T_{MAX} =	13.0	13.0	ft
d_{MAX} =	4.0	4.7	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

	Minor Storm	Major Storm	
Q_{allow} =	12.4	12.4	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.40 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.20 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



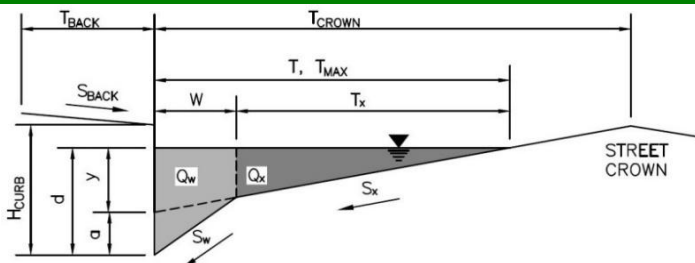
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR
Total Inlet Interception Capacity		Q _a =	0.4	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B3.3



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

T_{BACK} = 7.0 ft
S_{BACK} = 0.020 ft/ft
n_{BACK} = 0.013

H_{CURB} = 4.00 inches
T_{CROWN} = 13.0 ft
W = 1.00 ft
S_X = 0.020 ft/ft
S_W = 0.083 ft/ft
S_O = 0.000 ft/ft
n_{STREET} = 0.013

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm
T _{MAX}	13.0	13.0
d _{MAX}	4.0	5.7

☐ ☐

MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

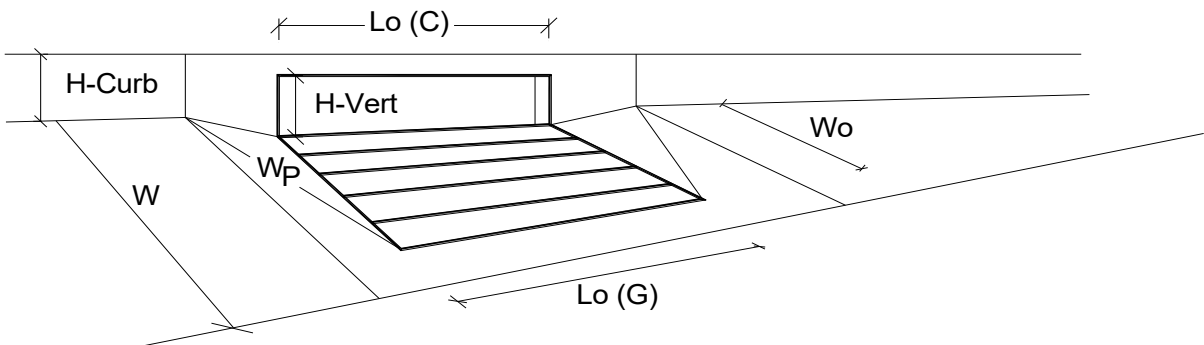
Q_{allow} =

Minor Storm	Major Storm
SUMP	SUMP

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)

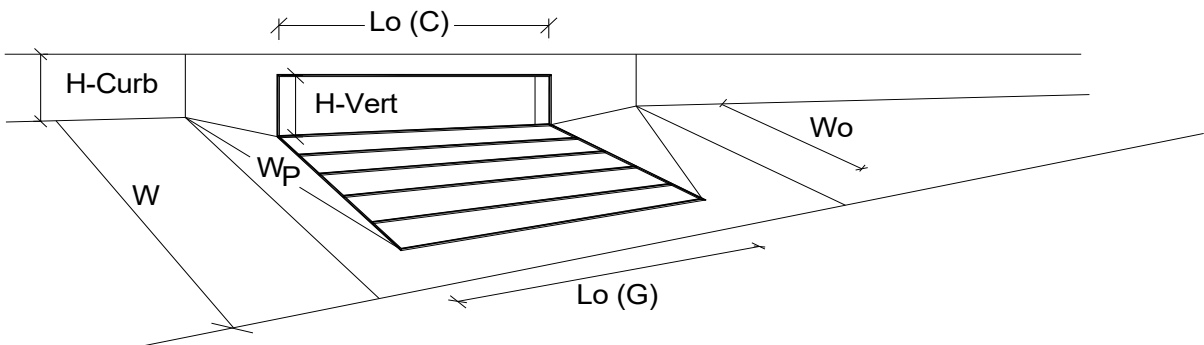


Design Information (Input)			
Type of Inlet	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)			
Number of Unit Inlets (Grate or Curb Opening)			
Water Depth at Flowline (outside of local depression)			
Grate Information			
Length of a Unit Grate			
Width of a Unit Grate			
Open Area Ratio for a Grate (typical values 0.15-0.90)			
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)			
Grate Weir Coefficient (typical value 2.15 - 3.60)			
Grate Orifice Coefficient (typical value 0.60 - 0.80)			
Curb Opening Information			
Length of a Unit Curb Opening			
Height of Vertical Curb Opening in Inches			
Height of Curb Orifice Throat in Inches			
Angle of Throat			
Side Width for Depression Pan (typically the gutter width of 2 feet)			
Clogging Factor for a Single Curb Opening (typical value 0.10)			
Curb Opening Weir Coefficient (typical value 2.3-3.7)			
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)			
Low Head Performance Reduction (Calculated)			
Depth for Grate Midwidth			
Depth for Curb Opening Weir Equation			
Grated Inlet Performance Reduction Factor for Long Inlets			
Curb Opening Performance Reduction Factor for Long Inlets			
Combination Inlet Performance Reduction Factor for Long Inlets			
Total Inlet Interception Capacity (assumes clogged condition)			
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)			

	MINOR	MAJOR	
Type =	CDOT Type R Curb Opening		
a _{local} =	5.00	5.00	inches
No =	1	1	
Ponding Depth =	4.0	5.7	inches
	MINOR	MAJOR	<input checked="" type="checkbox"/> Override Depths
L _o (G) =	N/A	N/A	feet
W _o =	N/A	N/A	feet
A _{ratio} =	N/A	N/A	
C _f (G) =	N/A	N/A	
C _w (G) =	N/A	N/A	
C _o (G) =	N/A	N/A	
	MINOR	MAJOR	
L _o (C) =	5.00	5.00	feet
H _{vert} =	6.00	6.00	inches
H _{throat} =	6.00	6.00	inches
Theta =	63.40	63.40	degrees
W _p =	1.00	1.00	feet
C _f (C) =	0.10	0.10	
C _w (C) =	3.60	3.60	
C _o (C) =	0.67	0.67	
	MINOR	MAJOR	
d _{Grate} =	N/A	N/A	ft
d _{Curb} =	0.25	0.39	ft
RF _{Grate} =	N/A	N/A	
RF _{Curb} =	1.00	1.00	
RF _{Combination} =	N/A	N/A	
	MINOR	MAJOR	
Q _a =	2.8	5.4	cfs
Q _{PEAK REQUIRED} =	0.6	1.3	cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



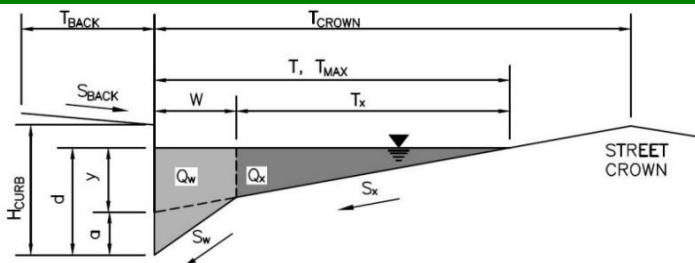
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	5.00	5.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	4.0	4.7	inches
<u>Grate Information</u>			MINOR	MAJOR	<input checked="" type="checkbox"/> Override Depths
Length of a Unit Grate		L _o (G) =	N/A	N/A	feet
Width of a Unit Grate		W _o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	N/A	N/A	
<u>Curb Opening Information</u>			MINOR	MAJOR	
Length of a Unit Curb Opening		L _o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.67	0.67	
<u>Low Head Performance Reduction (Calculated)</u>			MINOR	MAJOR	
Depth for Grate Midwidth		d _{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.25	0.31	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)			MINOR	MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _a =	2.8	3.8	cfs
		Q _{PEAK REQUIRED} =	0.5	1.0	cfs

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet B3.5



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} = 3.0$ ft
 $S_{BACK} = 0.020$ ft/ft
 $n_{BACK} = 0.020$

$H_{CURB} = 4.00$ inches
 $T_{CROWN} = 13.0$ ft
 $W = 1.00$ ft
 $S_x = 0.020$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.040$ ft/ft
 $n_{STREET} = 0.013$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
$T_{MAX} =$	13.0	13.0
$d_{MAX} =$	4.0	4.7

ft
inches

☐ ☐

MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

$Q_{allow} =$

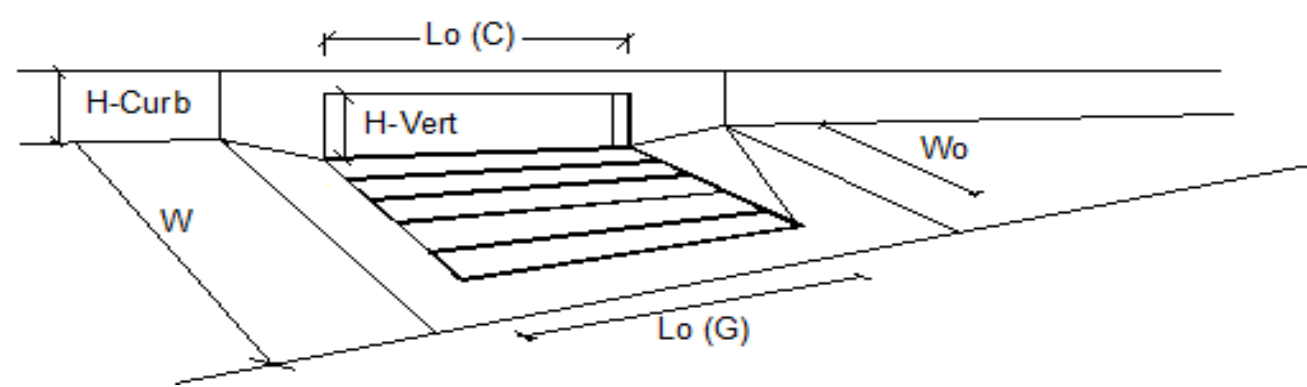
Minor Storm	Major Storm
12.4	12.4

 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.80 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.20 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



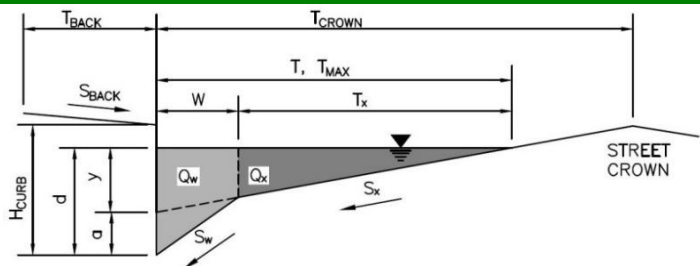
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR
Total Inlet Interception Capacity		Q_a =	0.8	2.2 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0 cfs
Capture Percentage = Q_a/Q_o		$C\%$ =	100	100 %

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **Grand Park - 10W**

Inlet ID: **Inlet B3.6**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} = 7.0$ ft
 $S_{BACK} = 0.020$ ft/ft
 $n_{BACK} = 0.013$

$H_{CURB} = 4.00$ inches
 $T_{CROWN} = 13.0$ ft
 $W = 1.00$ ft
 $S_x = 0.020$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.040$ ft/ft
 $n_{STREET} = 0.013$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
$T_{MAX} =$	13.0	13.0
$d_{MAX} =$	4.0	5.7
	<input type="checkbox"/>	<input type="checkbox"/>

MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

$Q_{allow} =$

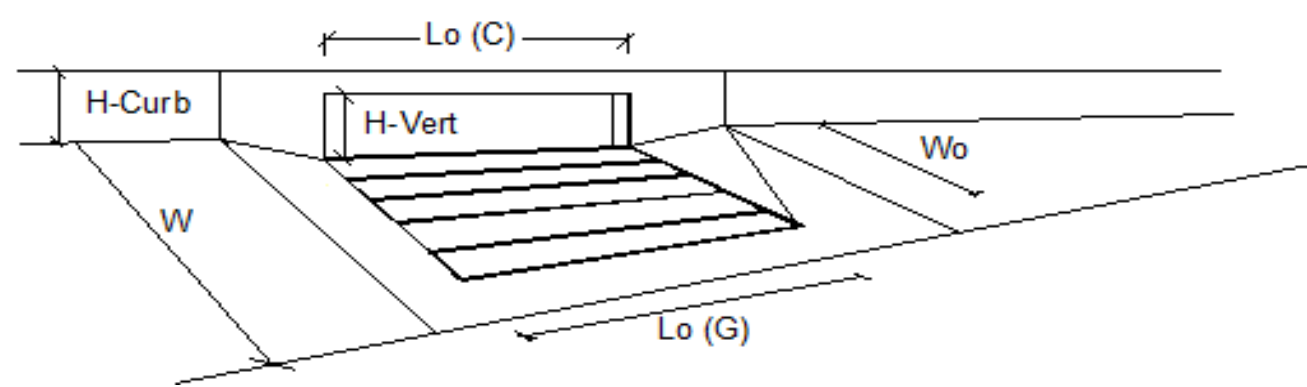
Minor Storm	Major Storm
12.4	12.4

 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.20 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 0.50 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity			MINOR		MAJOR
Total Inlet Interception Capacity		Q _a =	0.2	0.5	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	100	%

INLET MANAGEMENT

Project: Grand Park - 10W
Minor: 5-year
Major: 100-year

Worksheet Protected

INLET NAME	Inlet C2.1	Inlet C2.2	Inlet C2.4
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	1	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.70	0.60	0.70
Major Peak Flow, Q (cfs)	2.10	1.40	2.40

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
Bypass Flow Description (Optional):			
Minor Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00
Major Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.70	0.60	0.70
Major Total Design Peak Flow, Q (cfs)	2.10	1.40	2.40
Minor Inlet Interception Capacity, Q _a (cfs)	0.70	0.60	0.70
Major Inlet Interception Capacity, Q _a (cfs)	1.83	1.37	1.98
Minor Flow Bypassed Downstream, Q _b (cfs)	0.00	0.00	0.00
Major Flow Bypassed Downstream, Q _b (cfs)	0.27	0.03	0.42
Minor Flow Capture Percentage, C%	100%	100%	100%
Major Flow Capture Percentage, C%	87%	98%	82%

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet C2.5	Inlet C2.6	Inlet C2.7
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	1	2	2

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.10	0.80	0.50
Major Peak Flow, Q (cfs)	0.40	3.00	1.50

Bypass (Carry-Over) Flow from Upstream

I

Receive Bypass Flow from:	No Bypass Flow Received	User-Defined	Inlet C2.2
Bypass Flow Description (Optional):		Inlets C2.1, C2.4, and C2.5	
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	0.45	0.03

CALCULATED OUTPUT

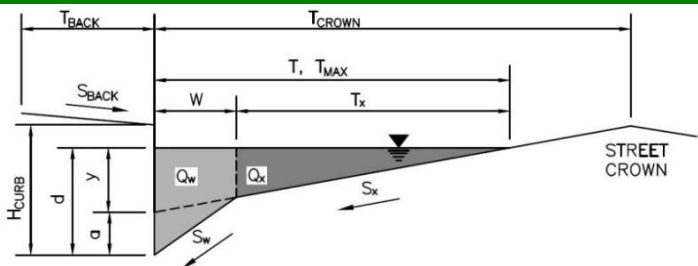
Minor Total Design Peak Flow, Q (cfs)	0.10	0.80	0.50
Major Total Design Peak Flow, Q (cfs)	0.40	3.45	1.53
Minor Inlet Interception Capacity, Q_a (cfs)	0.10	0.80	0.50
Major Inlet Interception Capacity, Q_a (cfs)	0.40	3.45	1.53
Minor Flow Bypassed Downstream, Q_b (cfs)	0.00	0.00	0.00
Major Flow Bypassed Downstream, Q_b (cfs)	0.00	0.00	0.00
Minor Flow Capture Percentage, C%	100%	100%	100%
Major Flow Capture Percentage, C%	100%	100%	100%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet C2.1



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} = 1.0$ ft
 $S_{BACK} = 0.020$ ft/ft
 $n_{BACK} = 0.013$

$H_{CURB} = 4.00$ inches
 $T_{CROWN} = 14.0$ ft
 $W = 1.00$ ft
 $S_x = 0.020$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.020$ ft/ft
 $n_{STREET} = 0.013$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
$T_{MAX} =$	9.0	14.0
$d_{MAX} =$	4.0	4.2

ft
inches

☐ ☐

MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

$Q_{allow} =$

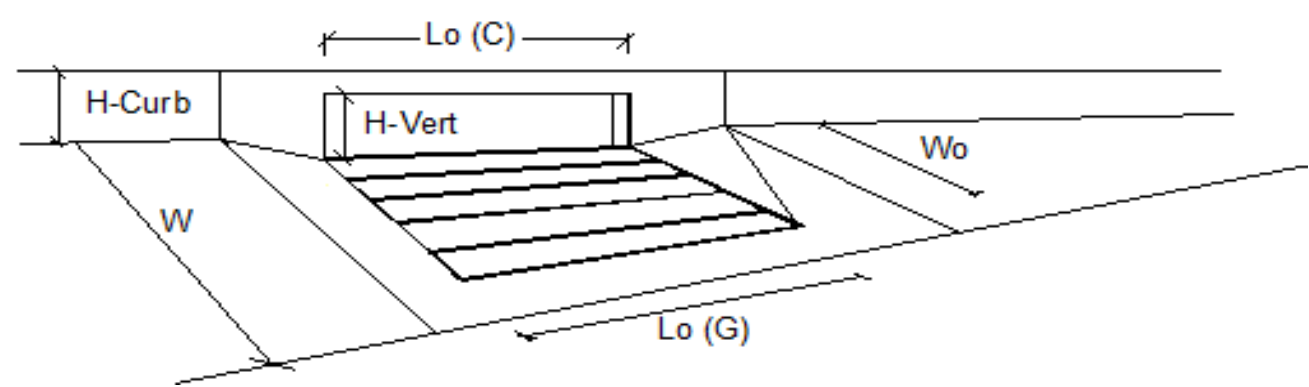
Minor Storm	Major Storm
3.4	10.6

 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.70 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.10 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



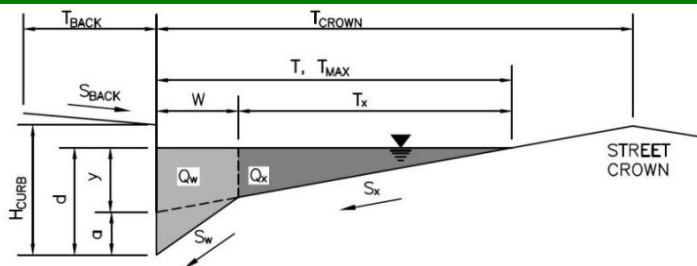
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		$a_{LOCAL} =$	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		$N_o =$	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		$L_o =$	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		$W_o =$	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G) =$	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C) =$	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR
Total Inlet Interception Capacity		$Q_a =$	0.7	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		$Q_b =$	0.0	cfs
Capture Percentage = Q_a/Q_o		$C\% =$	100	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet C2.2



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

TBACK = 26.0 ft
SBACK = 0.020 ft/ft
nBACK = 0.013

HCURB = 4.00 inches
Tcrown = 14.0 ft
W = 1.00 ft
Sx = 0.020 ft/ft
Sw = 0.083 ft/ft
So = 0.020 ft/ft
nSTREET = 0.013

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
TMAX =	9.0	14.0
dMAX =	4.0	10.2

☐ ☐

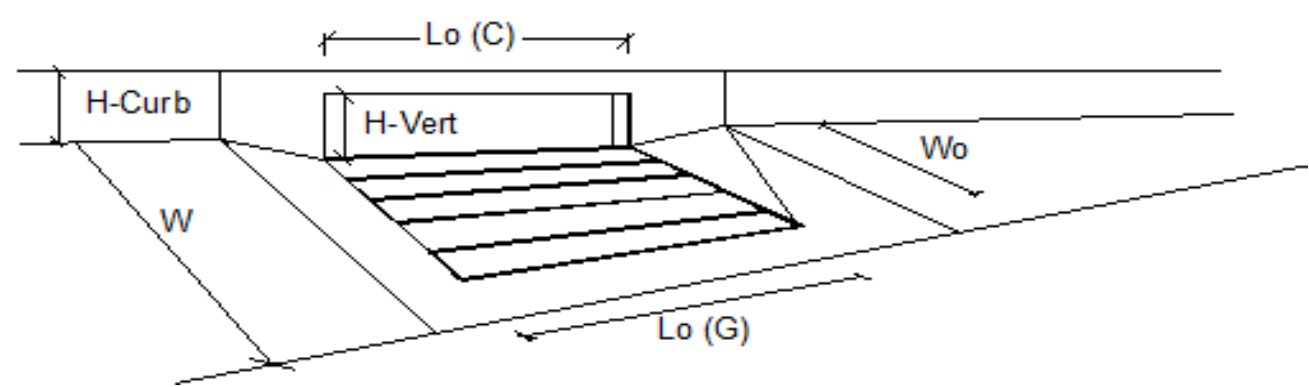
MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

Qallow = 3.4 10.6 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.60 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.40 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



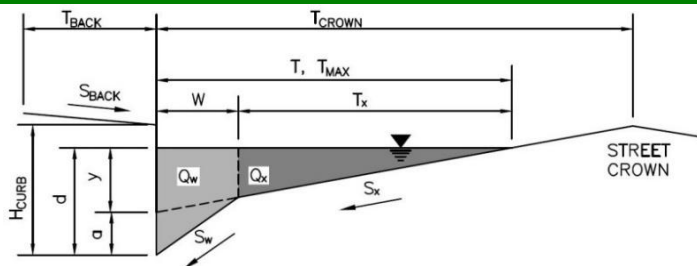
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		$a_{LOCAL} =$	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		$N_o =$	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		$L_o =$	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		$W_o =$	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G) =$	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C) =$	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR
Total Inlet Interception Capacity		$Q_a =$	0.6	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		$Q_b =$	0.0	cfs
Capture Percentage = Q_a/Q_o		$C\% =$	100	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet C2.4



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 17.0$ ft
 $S_{BACK} = 0.020$ ft/ft
 $n_{BACK} = 0.013$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 4.00$ inches
 $T_{CROWN} = 13.0$ ft
 $W = 1.00$ ft
 $S_x = 0.020$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.020$ ft/ft
 $n_{STREET} = 0.013$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
$T_{MAX} =$	8.0	13.0
$d_{MAX} =$	4.0	8.1
	<input type="checkbox"/>	<input type="checkbox"/>

MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

$Q_{allow} =$

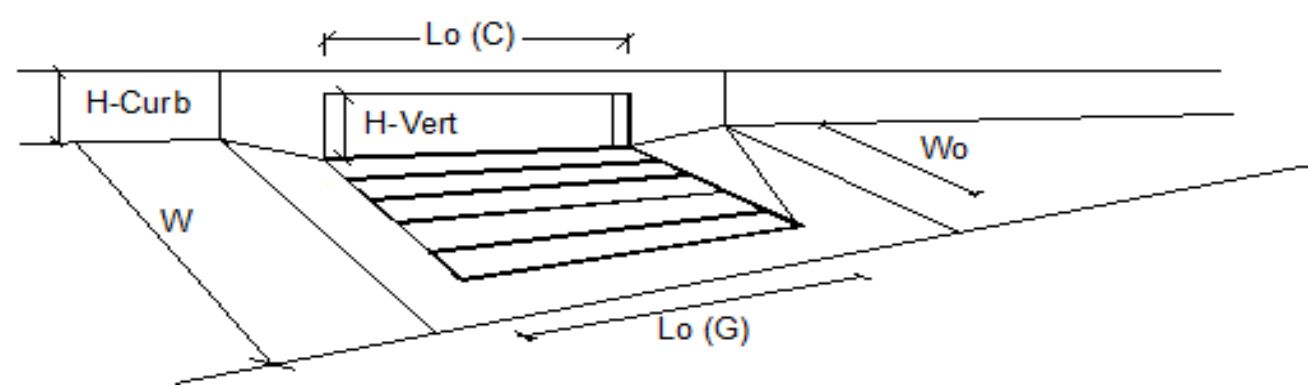
Minor Storm	Major Storm
2.6	8.7

 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.70 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.40 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$					
Total Inlet Interception Capacity		Q_a =	0.7	2.0	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.4	cfs
Capture Percentage = Q_a/Q_o		C% =	100	82	%

The diagram illustrates a road cross-section with various dimensions and parameters. The top part shows horizontal distances: T_{TRACK} from the left edge to the start of the track, T_{CROWN} from the start of the track to the street crown, T and T_{MAX} from the start of the track to the water table location, W from the start of the track to the water table location, and T_x from the water table location to the street crown. A slope S_{BACK} is indicated on the left. The bottom part shows vertical dimensions: H_{CURB} from the bottom to the curb, d from the bottom to the water table, y from the curb to the water table, and a from the bottom to the water table. A dashed line indicates the water table depth at the curb. The water table is labeled Q_w and Q_x . Slopes S_w and S_x are indicated at the bottom. The right side is labeled STREET CROWN.

$T_{\text{BACK}} =$	17.0	ft
$S_{\text{BACK}} =$	0.020	ft/ft
$n_{\text{BACK}} =$	0.013	

H_{CURB}	4.00	inches
T_{CROWN}	13.0	ft
W	1.00	ft
S_x	0.020	ft/ft
S_w	0.083	ft/ft
S_o	0.020	ft/ft
n_{STREET}	0.013	

	Minor Storm	Major Storm	
T_{MAX} =	8.0	13.0	ft
d_{MAX} =	4.0	8.1	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

$Q_{allow} =$

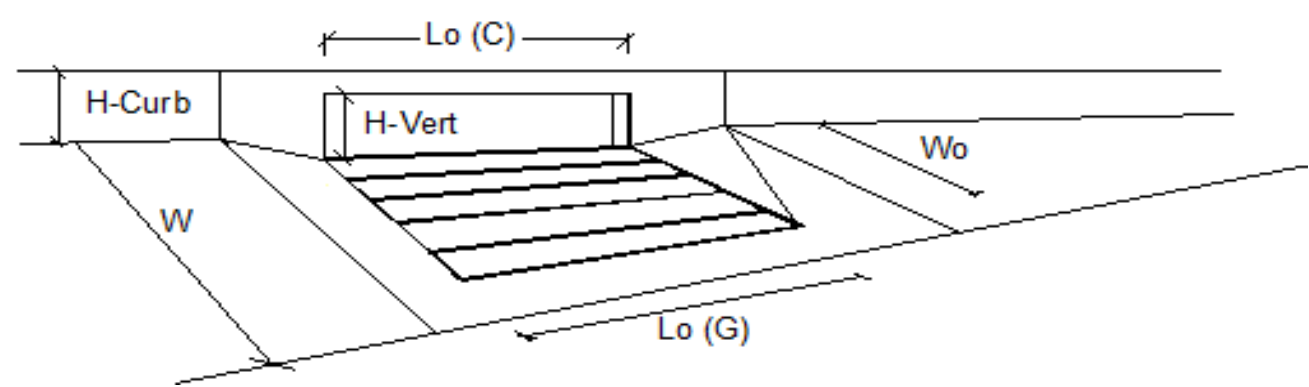
Minor Storm	Major Storm
2.6	8.7

 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.10 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 0.40 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



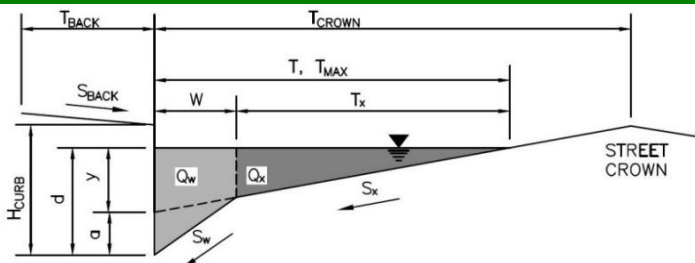
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR	
Total Inlet Interception Capacity		Q _a =	0.1	0.4	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	100	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet C2.6



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

TBACK = 1.0 ft
SBACK = 0.020 ft/ft
nBACK = 0.013

HCURB = 4.00 inches
Tcrown = 13.0 ft
W = 1.00 ft
Sx = 0.020 ft/ft
Sw = 0.083 ft/ft
So = 0.020 ft/ft
nSTREET = 0.013

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

Minor Storm Major Storm
TMAX = 8.0 13.0 ft
dMAX = 4.0 8.1 inches
☐ ☐

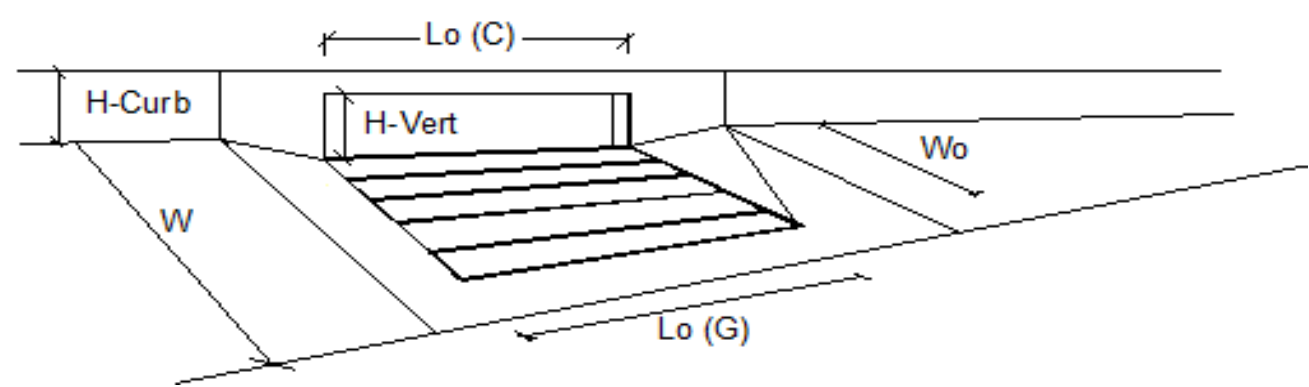
MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

Minor Storm Major Storm
Qallow = 2.6 8.7 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.80 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 3.45 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



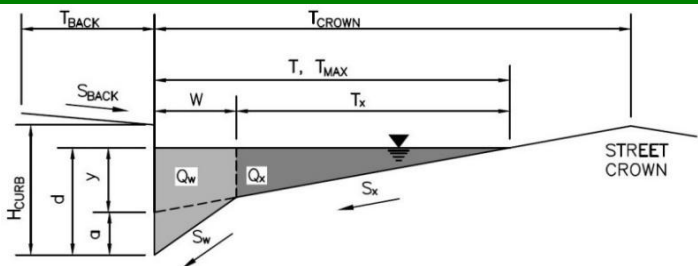
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		$a_{LOCAL} =$	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		$N_o =$	2	2
Length of a Single Unit Inlet (Grate or Curb Opening)		$L_o =$	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		$W_o =$	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G) =$	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C) =$	0.10	0.10
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR
Total Inlet Interception Capacity		$Q_a =$	0.8	3.4 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		$Q_b =$	0.0	0.0 cfs
Capture Percentage = Q_a/Q_o		$C\% =$	100	100 %

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet C2.7



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

T_{BACK} = 1.0 ft
S_{BACK} = 0.020 ft/ft
n_{BACK} = 0.013

H_{CURB} = 4.00 inches
T_{CROWN} = 13.0 ft
W = 1.00 ft
S_x = 0.020 ft/ft
S_w = 0.083 ft/ft
S_o = 0.020 ft/ft
n_{STREET} = 0.013

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm
T _{MAX}	9.0	13.0
d _{MAX}	4.0	8.1

☐ ☐

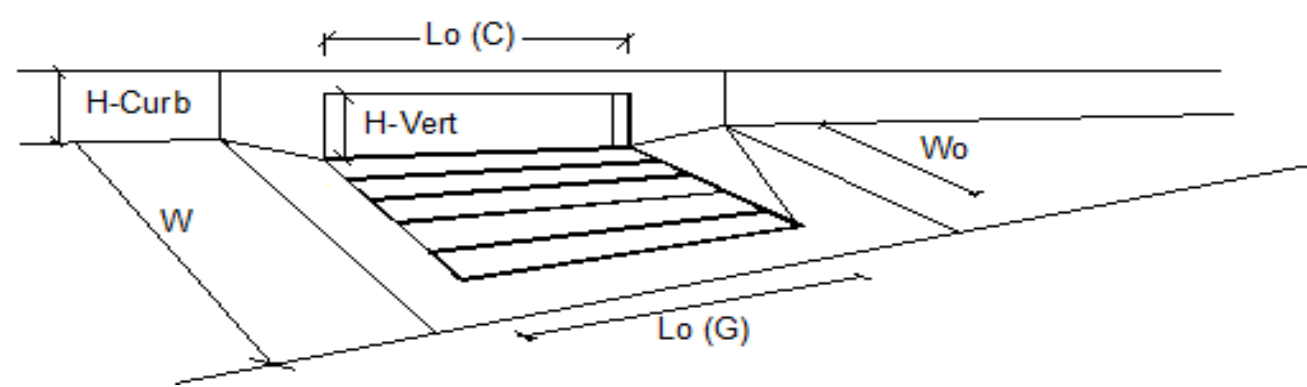
MINOR STORM Allowable Capacity is based on Spread Criterion
MAJOR STORM Allowable Capacity is based on Spread Criterion

Q_{allow} = 3.4 8.7 cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.50 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.53 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	Type = CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		$a_{LOCAL} =$	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2
Length of a Single Unit Inlet (Grate or Curb Opening)		$L_o =$	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		$W_o =$	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G) =$	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C) =$	0.10	0.10
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR
Total Inlet Interception Capacity		$Q_a =$	0.5	1.5 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		$Q_b =$	0.0	0.0 cfs
Capture Percentage = Q_a/Q_o		$C\% =$	100	100 %

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet D1.1	Inlet D1.2
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	2	3

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	2.20	1.10
Major Peak Flow, Q (cfs)	8.10	3.70

Bypass (Carry-Over) Flow from Upstream

Inlets must be organized from upstream (left) to downstream (right) in order for I

Receive Bypass Flow from:	No Bypass Flow Received	Inlet D1.1
Bypass Flow Description (Optional):		
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	1.71

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	2.20	1.10
Major Total Design Peak Flow, Q (cfs)	8.10	5.41
Minor Inlet Interception Capacity, Q_a (cfs)	2.20	1.10
Major Inlet Interception Capacity, Q_a (cfs)	6.39	5.41
Minor Flow Bypassed Downstream, Q_b (cfs)	0.00	0.00
Major Flow Bypassed Downstream, Q_b (cfs)	1.71	0.00
Minor Flow Capture Percentage, C%	100%	100%
Major Flow Capture Percentage, C%	79%	100%

INLET MANAGEMENT

Project: Grand Park - 10W

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	Inlet D2	Inlet E1.1	Inlet E1.2
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening
Number of Inlet Units	1	2	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.40	0.90	0.40
Major Peak Flow, Q (cfs)	1.10	3.20	1.10

Bypass (Carry-Over) Flow from Upstream

[bypass flows to be linked.](#)

Receive Bypass Flow from:	No Bypass Flow Received	Inlet D1.2	Inlet D2
Bypass Flow Description (Optional):		0	
Minor Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00
Major Bypass Flow Received, Q _b (cfs)	0.00	0.00	0.00

CALCULATED OUTPUT

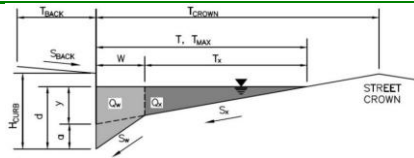
Minor Total Design Peak Flow, Q (cfs)	0.40	0.90	0.40
Major Total Design Peak Flow, Q (cfs)	1.10	3.20	1.10
Minor Inlet Interception Capacity, Q _a (cfs)	0.40	0.90	0.40
Major Inlet Interception Capacity, Q _a (cfs)	1.10	3.20	1.10
Minor Flow Bypassed Downstream, Q _b (cfs)	0.00	0.00	0.00
Major Flow Bypassed Downstream, Q _b (cfs)	0.00	0.00	0.00
Minor Flow Capture Percentage, C%	100%	100%	100%
Major Flow Capture Percentage, C%	100%	100%	100%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet D1.1

**Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	26.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_x =$	0.020	ft/ft
$S_w =$	0.083	ft/ft
$S_o =$	0.050	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	10.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

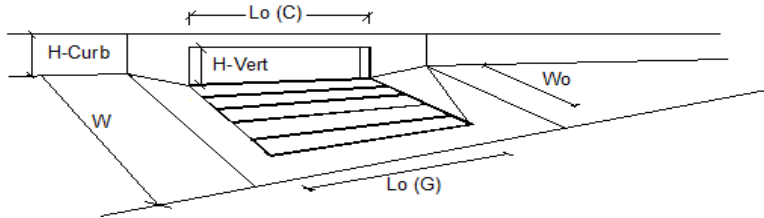
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	5.4	16.8	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 2.20 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 8.10 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

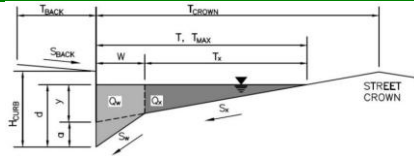
MHH-D-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$					
Total Inlet Interception Capacity		Q_a =	2.2	6.4	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	1.7	cfs
Capture Percentage = Q_a/Q_o		C% =	100	79	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **Grand Park - 10W**Inlet ID: **Inlet D1.2****Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	26.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_X =$	0.020	ft/ft
$S_W =$	0.083	ft/ft
$S_O =$	0.050	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	10.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

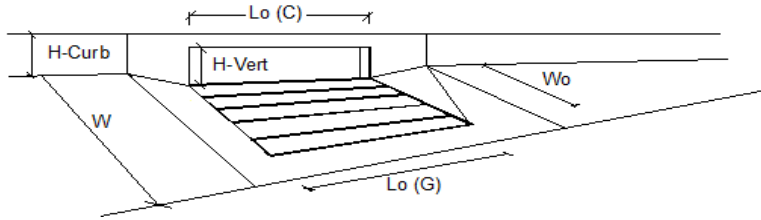
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	5.4	16.8	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.10 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 5.41 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

MHH-D-Inlet, Version 6.00 (August 2025)



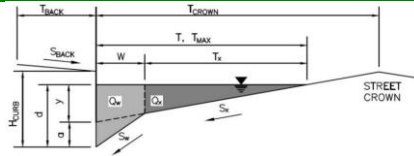
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$					
Total Inlet Interception Capacity		Q_a =	1.1	5.4	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0	cfs
Capture Percentage = Q_a/Q_o		C% =	100	100	%

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet D2

**Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	5.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_x =$	0.020	ft/ft
$S_w =$	0.083	ft/ft
$S_o =$	0.050	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	5.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

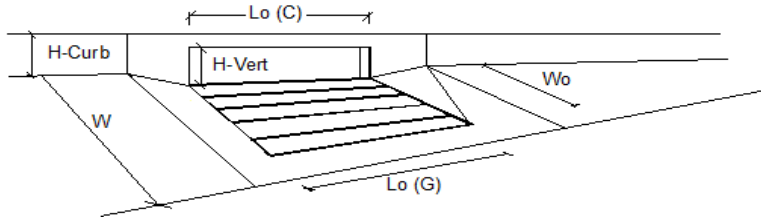
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	5.4	16.8	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.40 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.10 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

MHH-D-Inlet, Version 6.00 (August 2025)



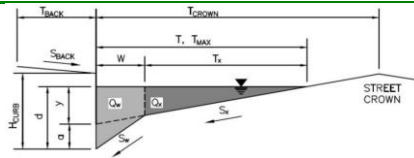
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		$a_{LOCAL} =$	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		$N_o =$	1	1
Length of a Single Unit Inlet (Grate or Curb Opening)		$L_o =$	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		$W_o =$	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G) =$	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C) =$	0.10	0.10
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR
Total Inlet Interception Capacity		$Q_a =$	0.4	1.1 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		$Q_b =$	0.0	0.0 cfs
Capture Percentage = Q_a/Q_o		$C\% =$	100	100 %

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet E1.1

**Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	26.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_x =$	0.020	ft/ft
$S_w =$	0.083	ft/ft
$S_o =$	0.080	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	10.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

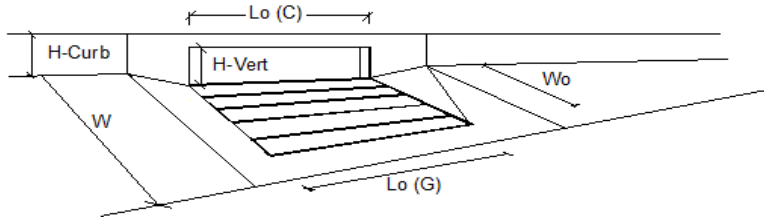
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	6.9	21.2	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.90 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 3.20 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

MHH-D-Inlet, Version 6.00 (August 2025)



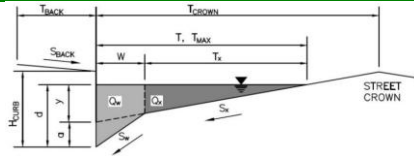
Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	2	2
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$				
Total Inlet Interception Capacity		Q_a =	0.9	3.2 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0 cfs
Capture Percentage = Q_a/Q_o		C% =	100	100 %

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Grand Park - 10W

Inlet ID: Inlet E1.2

**Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$T_{BACK} =$	5.0	ft
$S_{BACK} =$	0.020	ft/ft
$n_{BACK} =$	0.013	

$H_{CURB} =$	4.00	inches
$T_{CROWN} =$	14.0	ft
$W =$	1.00	ft
$S_x =$	0.020	ft/ft
$S_w =$	0.083	ft/ft
$S_o =$	0.080	ft/ft
$n_{STREET} =$	0.013	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	9.0	14.0	ft
$d_{MAX} =$	4.0	10.2	inches
	<input type="checkbox"/>	<input type="checkbox"/>	

MINOR STORM Allowable Capacity is based on Spread Criterion

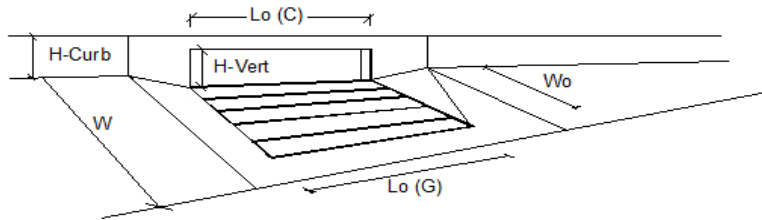
MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	6.9	21.2	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.40 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.10 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

MHH-D-Inlet, Version 6.00 (August 2025)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	5.0	5.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$					
Total Inlet Interception Capacity		Q_a =	0.4	1.1	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0	cfs
Capture Percentage = Q_a/Q_o		C% =	100	100	%

Inlet Report

Inlet B1.3 Capacity Calculation

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 4.50
Grate Width (ft)	= 3.00
Grate Length (ft)	= 3.00

Gutter

Slope, Sw (ft/ft)	= 0.250
Slope, Sx (ft/ft)	= 0.250
Local Depr (in)	= -0-
Gutter Width (ft)	= 3.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

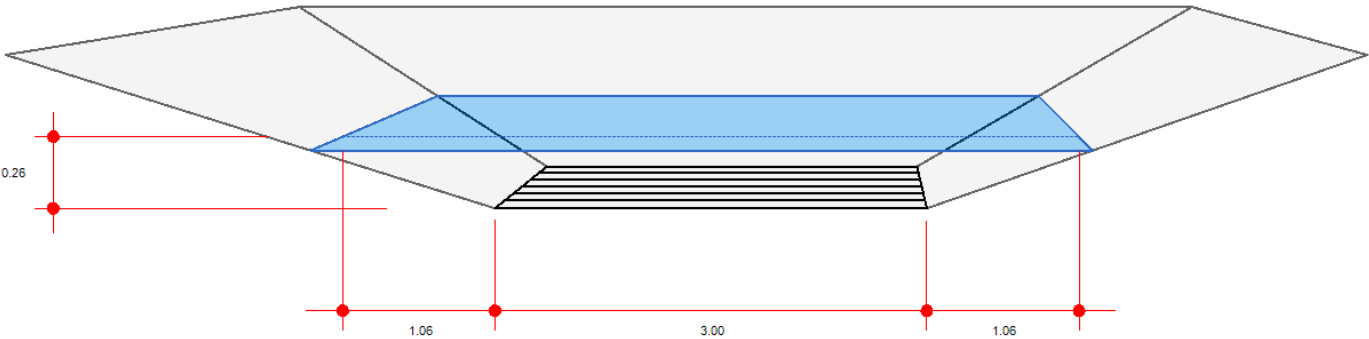
Calculations

Compute by:	Known Q
Q (cfs)	= 4.90

Highlighted

Q Total (cfs)	= 4.90
Q Capt (cfs)	= 4.90
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 3.17
Efficiency (%)	= 100
Gutter Spread (ft)	= 5.12
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Inlet Report

Inlet B3.1 & B3.2 Capacity Calculation

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 4.50
Grate Width (ft)	= 3.00
Grate Length (ft)	= 3.00

Gutter

Slope, Sw (ft/ft)	= 0.250
Slope, Sx (ft/ft)	= 0.250
Local Depr (in)	= -0-
Gutter Width (ft)	= 3.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

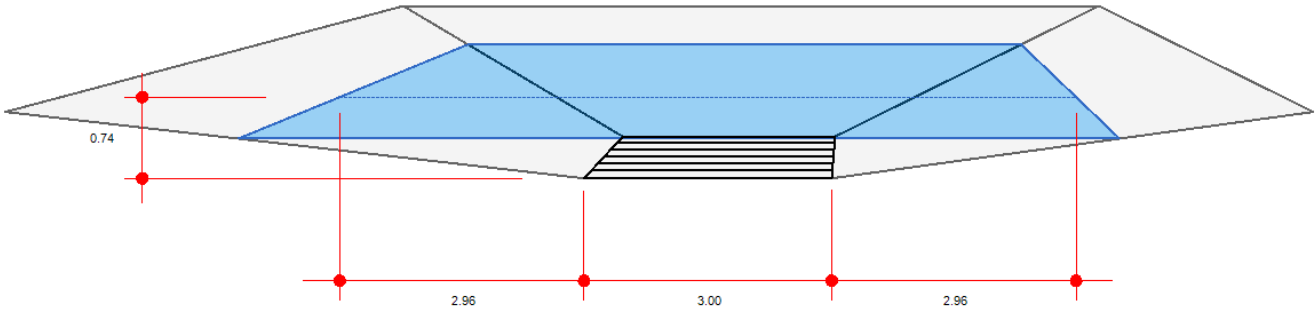
Calculations

Compute by:	Known Q
Q (cfs)	= 20.80

Highlighted

Q Total (cfs)	= 20.80
Q Capt (cfs)	= 20.80
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 8.88
Efficiency (%)	= 100
Gutter Spread (ft)	= 8.92
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Inlet Report

Inlet C2.3 Capacity Calculation

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 4.50
Grate Width (ft)	= 3.00
Grate Length (ft)	= 3.00

Gutter

Slope, Sw (ft/ft)	= 0.250
Slope, Sx (ft/ft)	= 0.250
Local Depr (in)	= -0-
Gutter Width (ft)	= 3.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

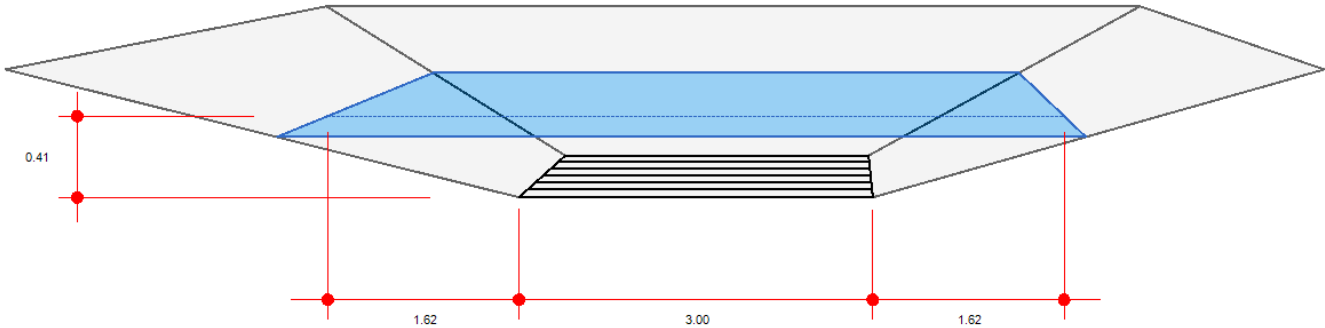
Calculations

Compute by:	Known Q
Q (cfs)	= 9.30

Highlighted

Q Total (cfs)	= 9.30
Q Capt (cfs)	= 9.30
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 4.87
Efficiency (%)	= 100
Gutter Spread (ft)	= 6.24
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Channel Report

Cul De Sac Curb Cut Capacity Calculation

Trapezoidal

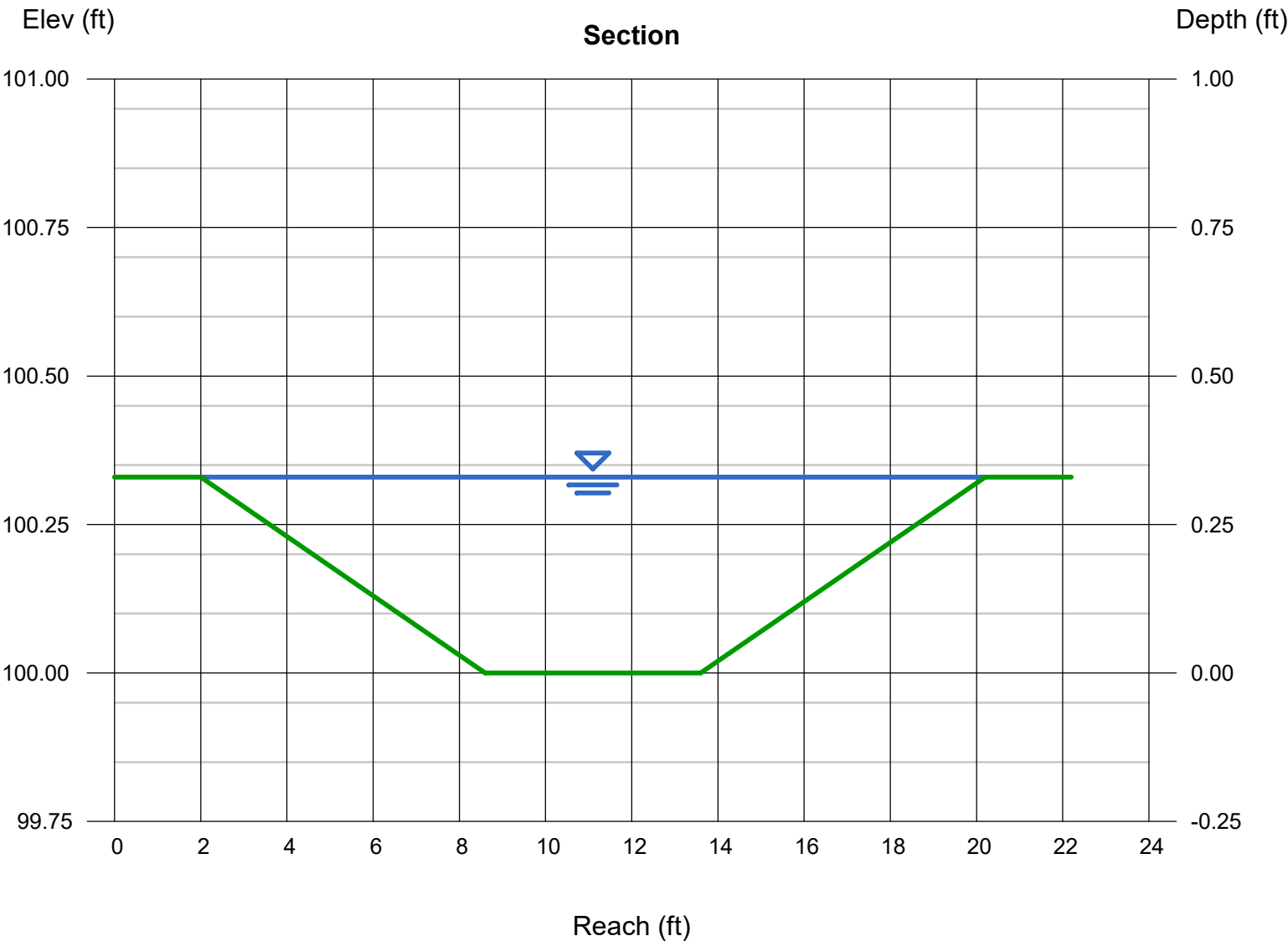
Bottom Width (ft) = 5.00
Side Slopes (z:1) = 20.00, 20.00
Total Depth (ft) = 0.33
Invert Elev (ft) = 100.00
Slope (%) = 1.00
N-Value = 0.013

Highlighted

Depth (ft) = 0.33
Q (cfs) = 15.46
Area (sqft) = 3.83
Velocity (ft/s) = 4.04
Wetted Perim (ft) = 18.22
Crit Depth, Yc (ft) = 0.33
Top Width (ft) = 18.20
EGL (ft) = 0.58

Calculations

Compute by: Q vs Depth
No. Increments = 10



Channel Report

SWALE B1.3 - 1.85% - 5 YR

Triangular

Side Slopes (z:1) = 4.00, 4.00
Total Depth (ft) = 2.00

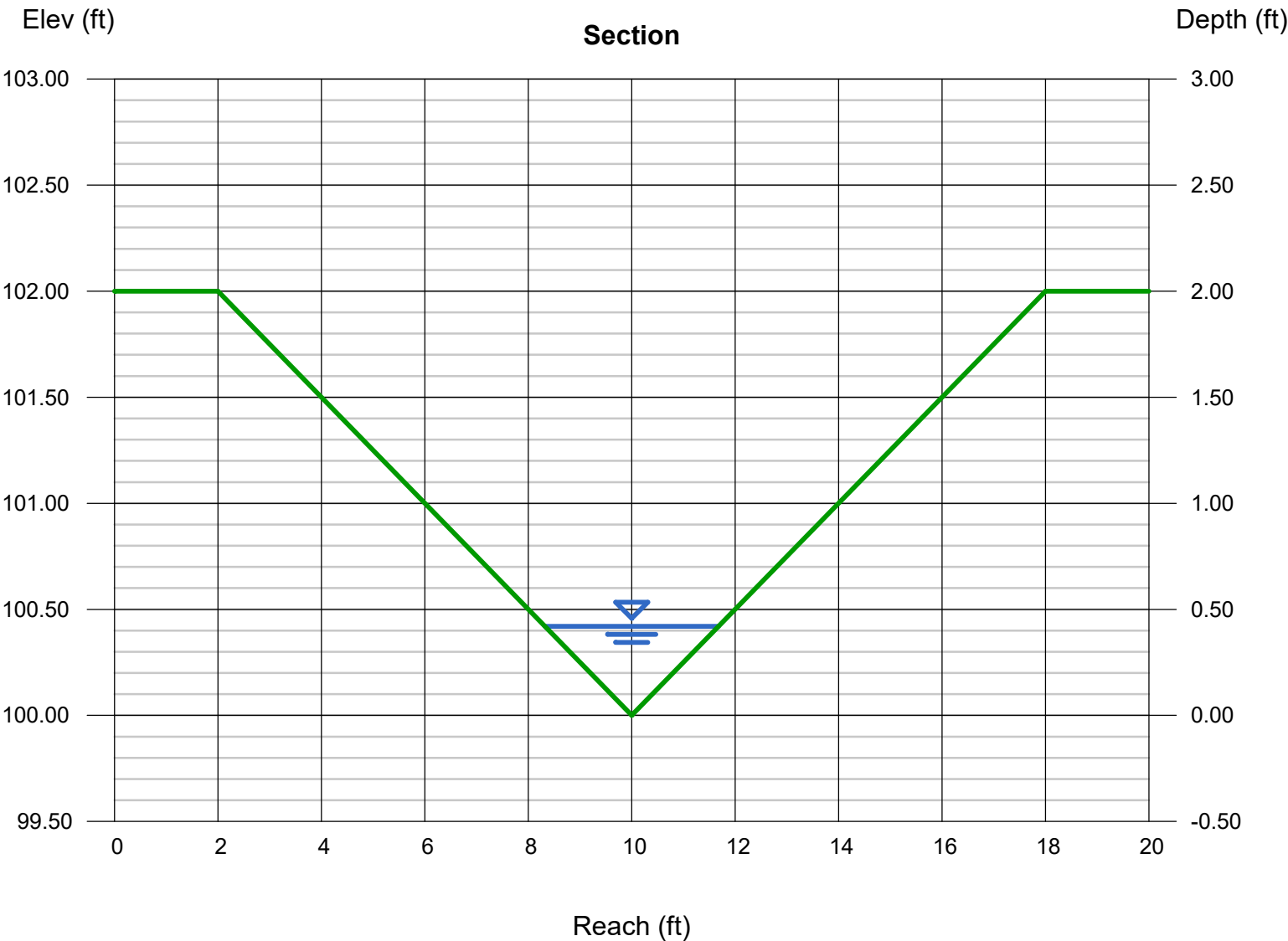
Invert Elev (ft) = 100.00
Slope (%) = 1.85
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 1.60

Highlighted

Depth (ft) = 0.42
Q (cfs) = 1.600
Area (sqft) = 0.71
Velocity (ft/s) = 2.27
Wetted Perim (ft) = 3.46
Crit Depth, Yc (ft) = 0.40
Top Width (ft) = 3.36
EGL (ft) = 0.50



Channel Report

SWALE B1.3 - 1.85% - 100 YR

Triangular

Side Slopes (z:1) = 4.00, 4.00
Total Depth (ft) = 2.00

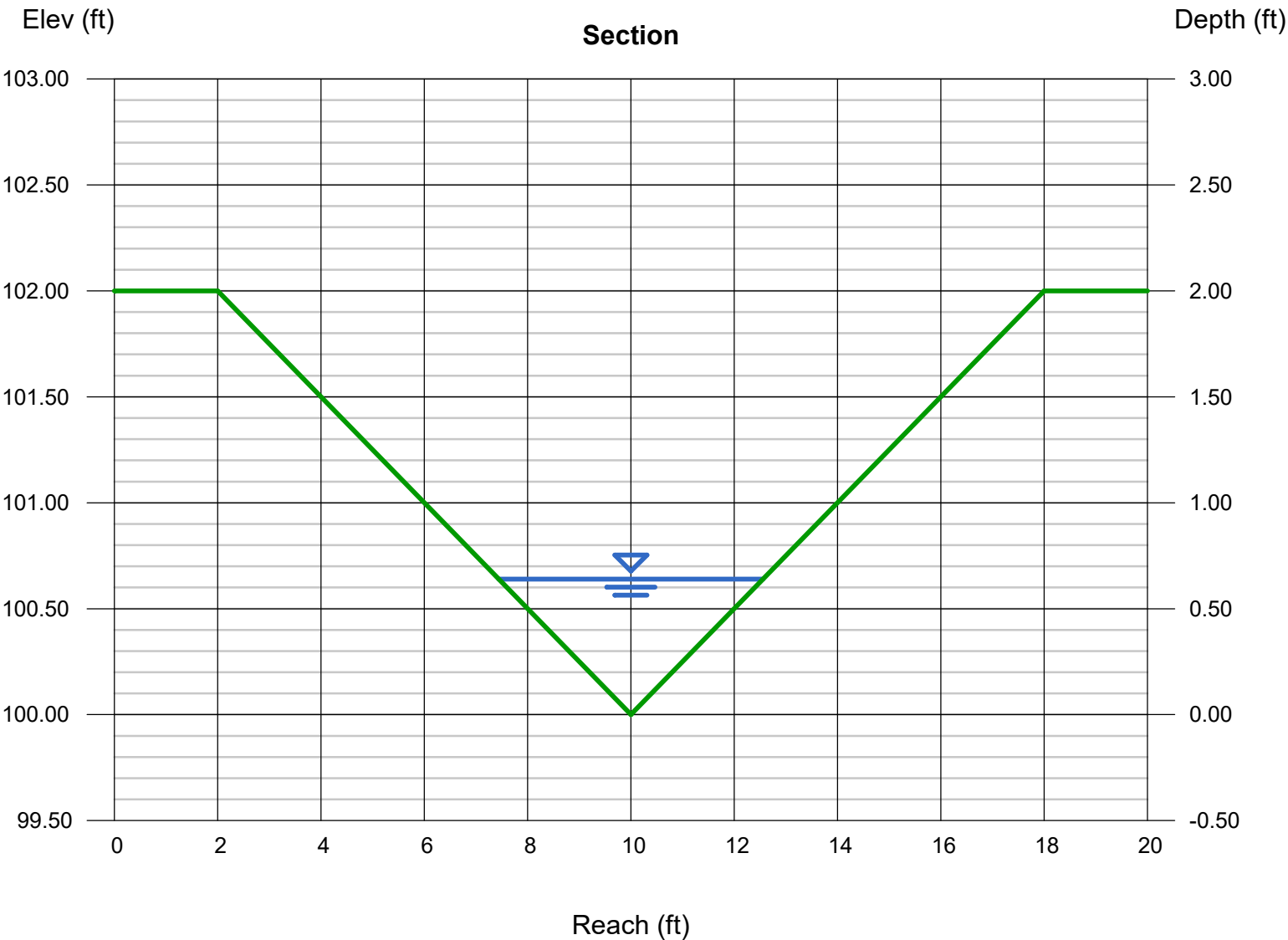
Invert Elev (ft) = 100.00
Slope (%) = 1.85
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 4.90

Highlighted

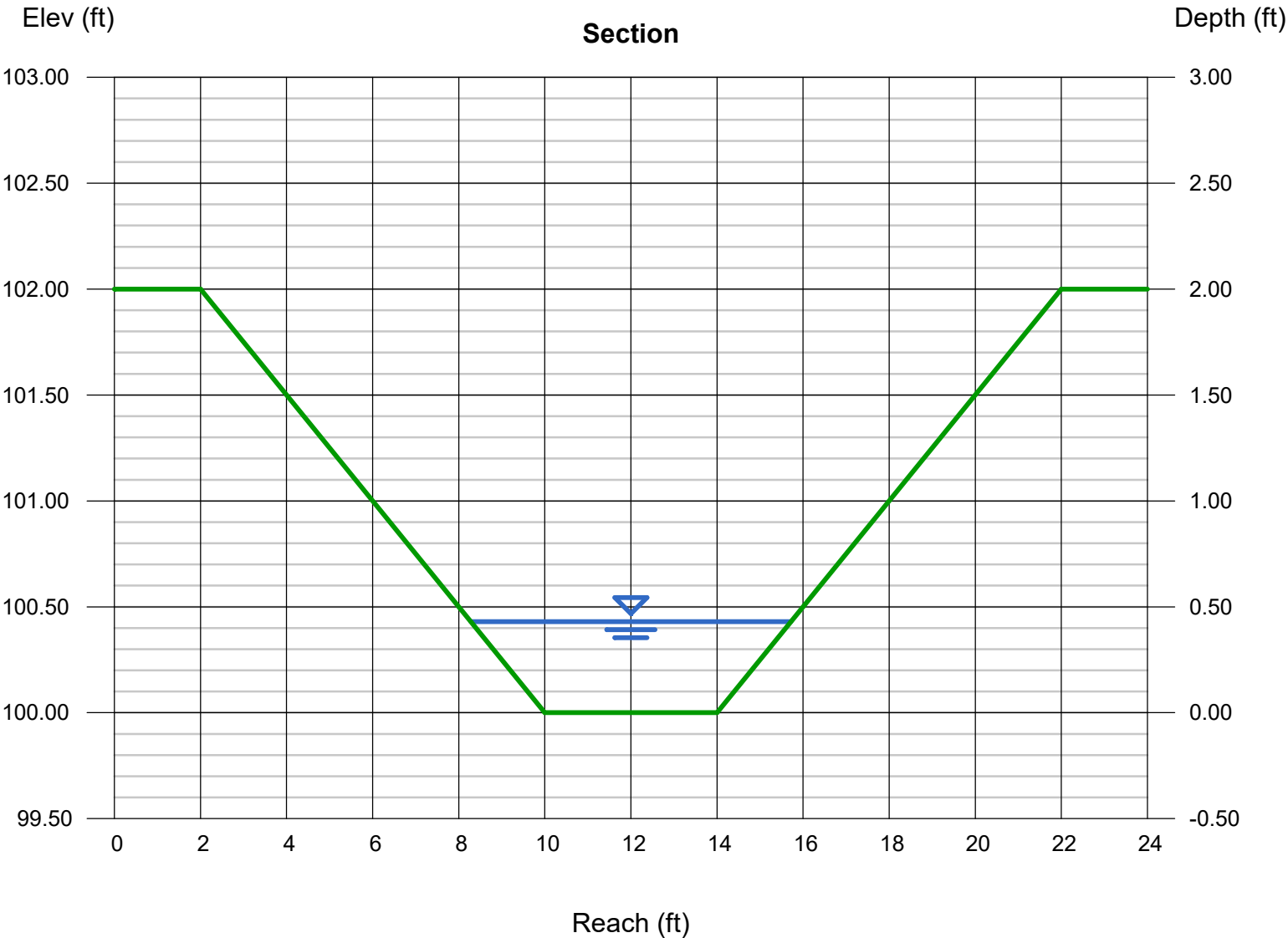
Depth (ft) = 0.64
Q (cfs) = 4.900
Area (sqft) = 1.64
Velocity (ft/s) = 2.99
Wetted Perim (ft) = 5.28
Crit Depth, Yc (ft) = 0.63
Top Width (ft) = 5.12
EGL (ft) = 0.78



Channel Report

SWALE B2.1 - 4.5% 4FT BOTTOM - 5 YR

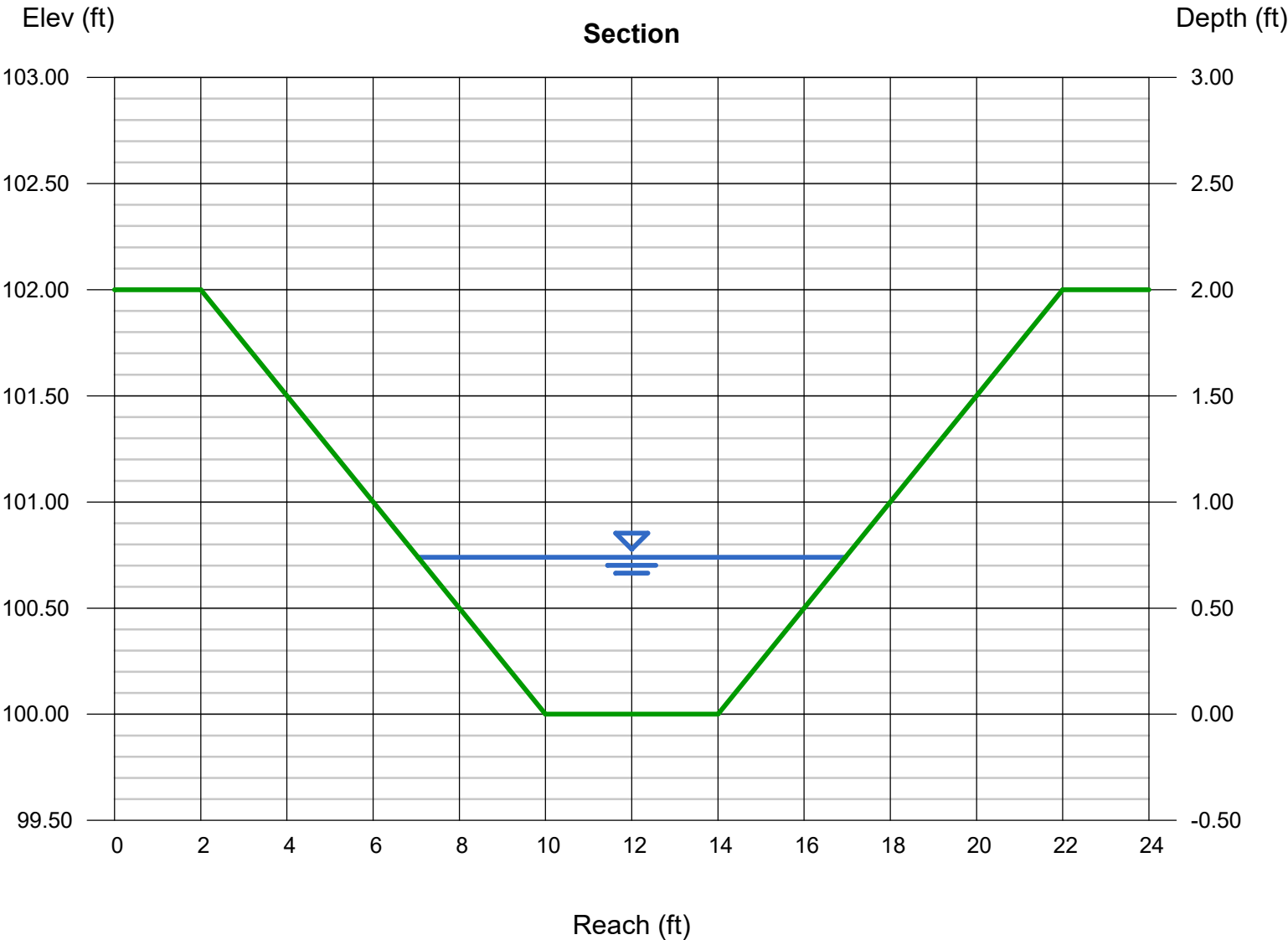
Trapezoidal		Highlighted	
Bottom Width (ft)	= 4.00	Depth (ft)	= 0.43
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 11.80
Total Depth (ft)	= 2.00	Area (sqft)	= 2.46
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 4.80
Slope (%)	= 4.50	Wetted Perim (ft)	= 7.55
N-Value	= 0.030	Crit Depth, Yc (ft)	= 0.54
Calculations		Top Width (ft)	= 7.44
Compute by:	Known Q	EGL (ft)	= 0.79
Known Q (cfs)	= 11.80		



Channel Report

SWALE B2.1 - 4.5% 4FT BOTTOM - 100 YR

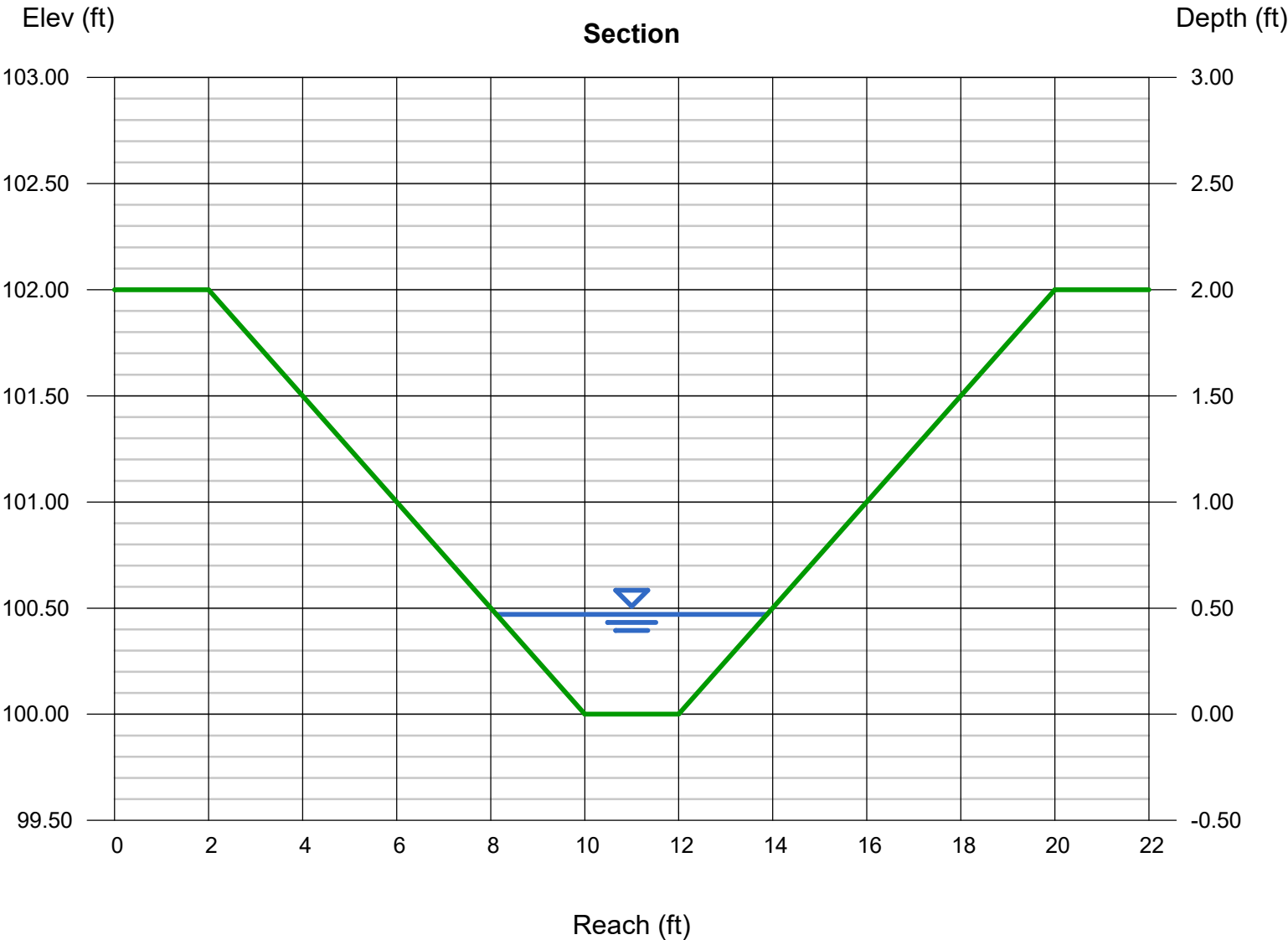
Trapezoidal		Highlighted	
Bottom Width (ft)	= 4.00	Depth (ft)	= 0.74
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 34.20
Total Depth (ft)	= 2.00	Area (sqft)	= 5.15
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 6.64
Slope (%)	= 4.50	Wetted Perim (ft)	= 10.10
N-Value	= 0.030	Crit Depth, Yc (ft)	= 0.96
Calculations		Top Width (ft)	= 9.92
Compute by:	Known Q	EGL (ft)	= 1.43
Known Q (cfs)	= 34.20		



Channel Report

SWALE B3.1 - 1% 2FT BOTTOM - 5 YR

Trapezoidal		Highlighted	
Bottom Width (ft)	= 2.00	Depth (ft)	= 0.47
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 4.100
Total Depth (ft)	= 2.00	Area (sqft)	= 1.82
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 2.25
Slope (%)	= 1.00	Wetted Perim (ft)	= 5.88
N-Value	= 0.030	Crit Depth, Yc (ft)	= 0.39
Calculations		Top Width (ft)	= 5.76
Compute by:	Known Q	EGL (ft)	= 0.55
Known Q (cfs)	= 4.10		



Channel Report

SWALE B3.1 - 1% 2FT BOTTOM - 100 YR

Trapezoidal

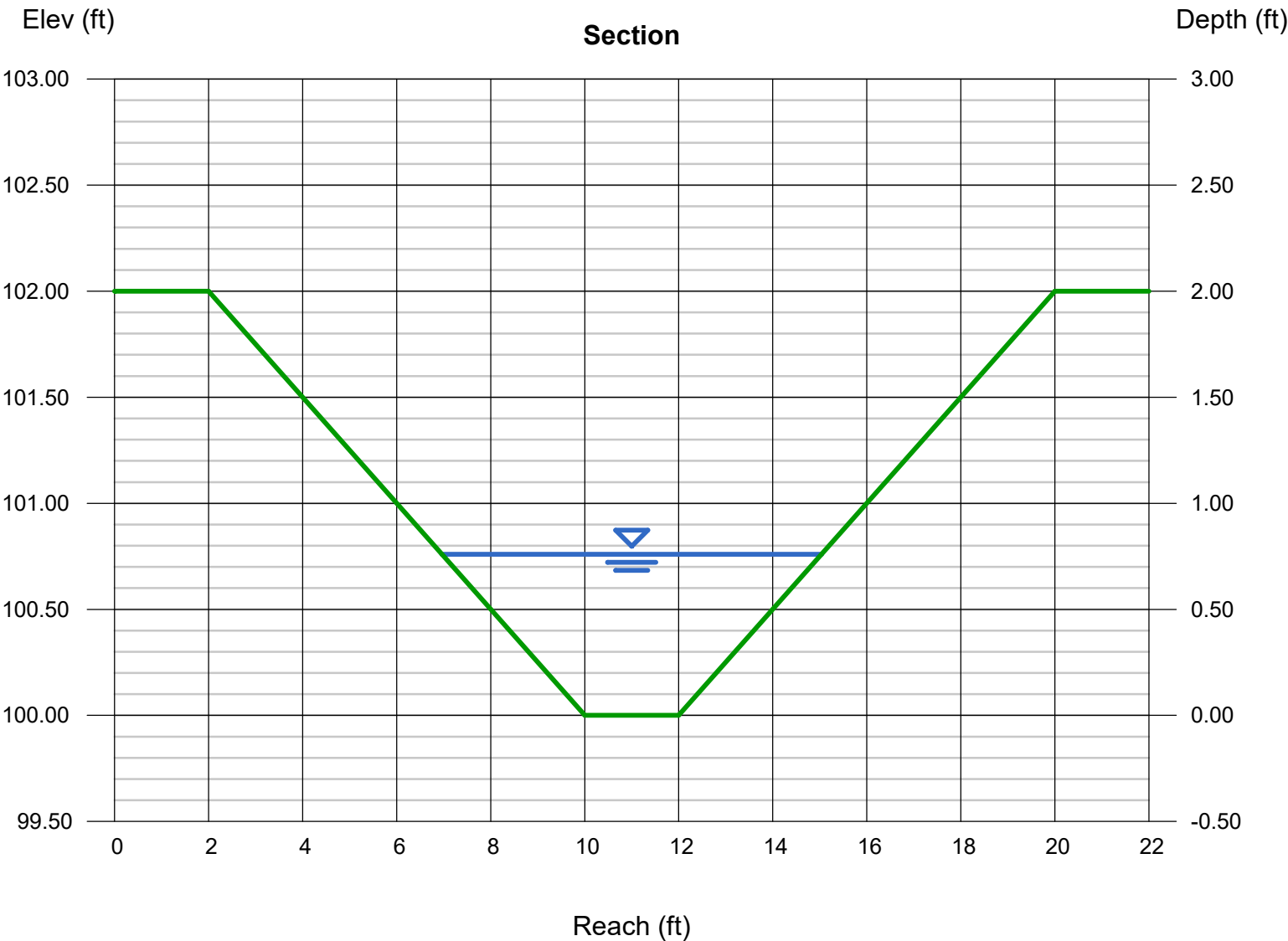
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.00
Invert Elev (ft)	= 100.00
Slope (%)	= 1.00
N-Value	= 0.030

Highlighted

Depth (ft)	= 0.76
Q (cfs)	= 11.20
Area (sqft)	= 3.83
Velocity (ft/s)	= 2.92
Wetted Perim (ft)	= 8.27
Crit Depth, Yc (ft)	= 0.66
Top Width (ft)	= 8.08
EGL (ft)	= 0.89

Calculations

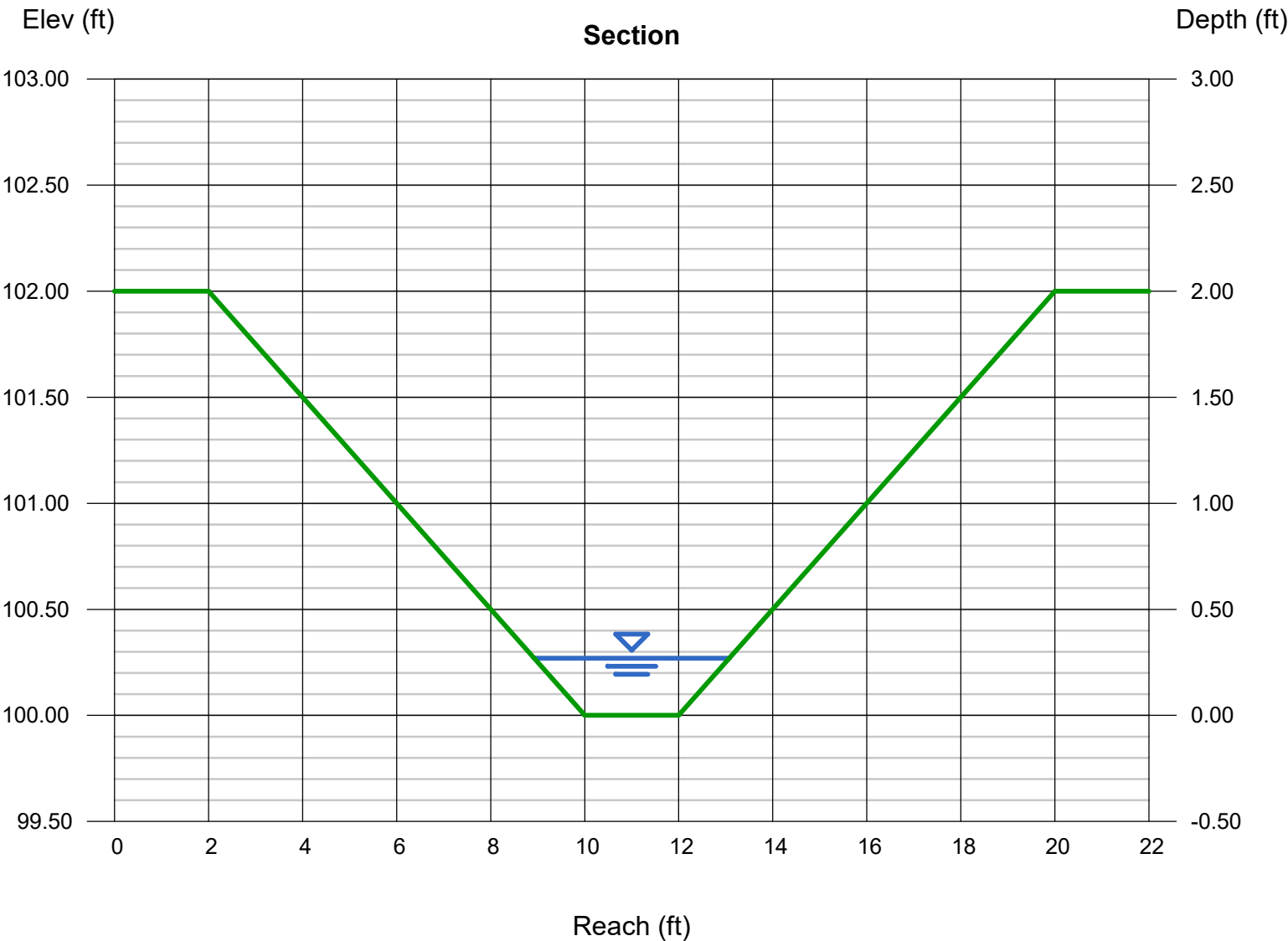
Compute by:	Known Q
Known Q (cfs)	= 11.20



Channel Report

SWALE B3.2 - 6.25% 2FT BOTTOM - 5 YR

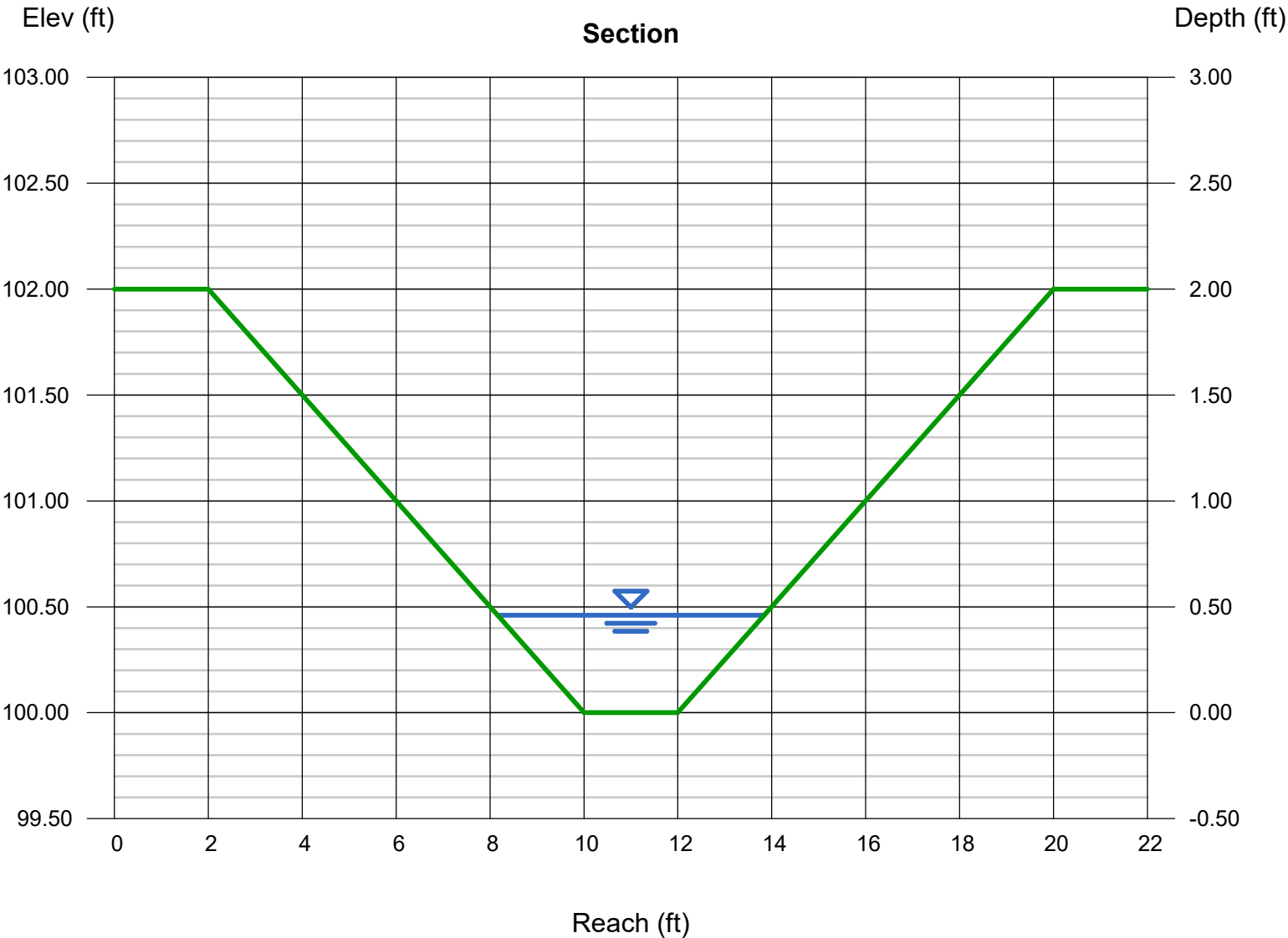
Trapezoidal		Highlighted	
Bottom Width (ft)	= 2.00	Depth (ft)	= 0.27
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 3.400
Total Depth (ft)	= 2.00	Area (sqft)	= 0.83
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 4.09
Slope (%)	= 6.25	Wetted Perim (ft)	= 4.23
N-Value	= 0.030	Crit Depth, Yc (ft)	= 0.36
Calculations		Top Width (ft)	= 4.16
Compute by:	Known Q	EGL (ft)	= 0.53
Known Q (cfs)	= 3.40		



Channel Report

SWALE B3.2 - 6.25% 2FT BOTTOM - 100YR

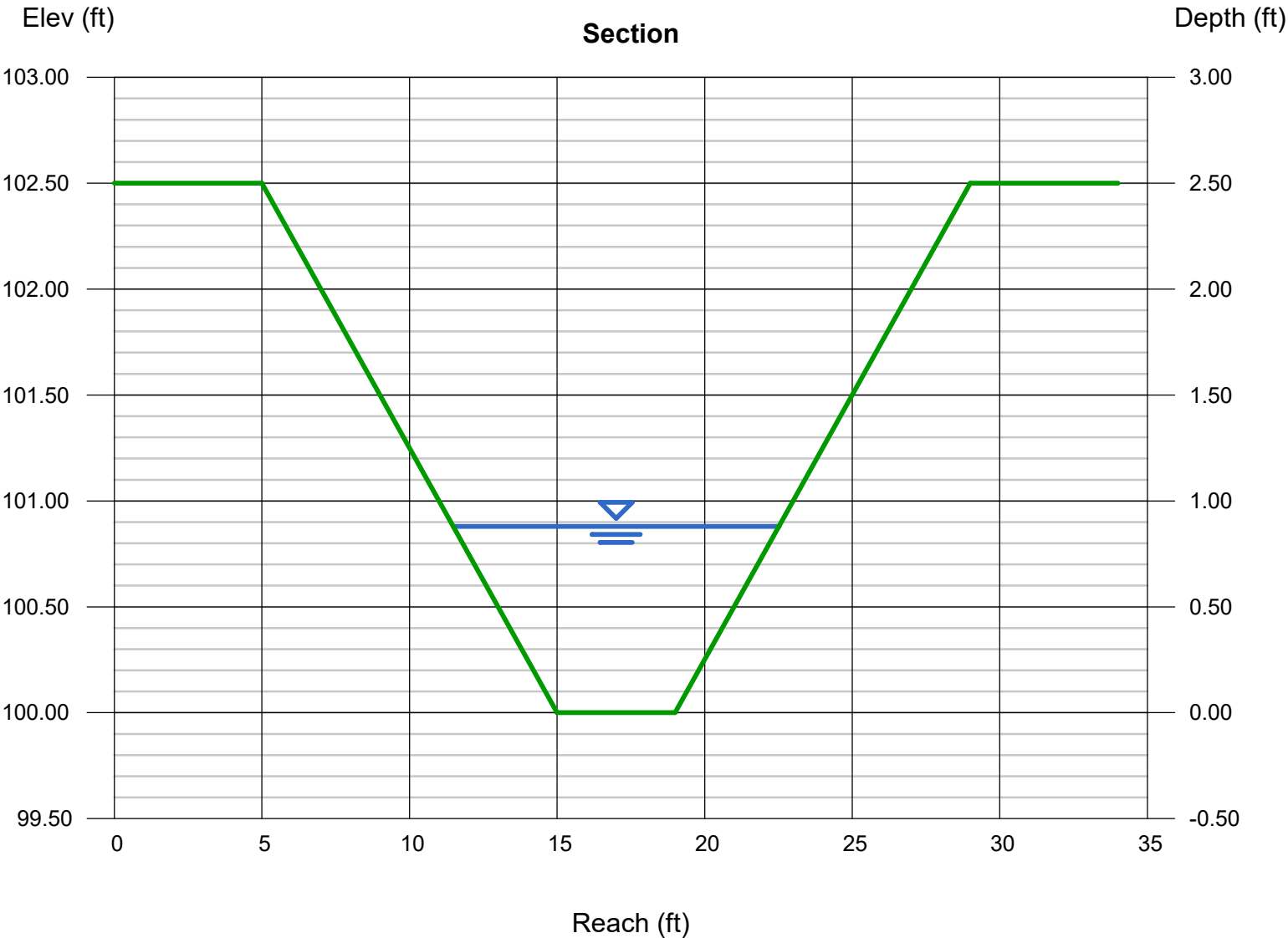
Trapezoidal		Highlighted	
Bottom Width (ft)	= 2.00	Depth (ft)	= 0.46
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 9.600
Total Depth (ft)	= 2.00	Area (sqft)	= 1.77
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 5.43
Slope (%)	= 6.25	Wetted Perim (ft)	= 5.79
N-Value	= 0.030	Crit Depth, Yc (ft)	= 0.61
Calculations		Top Width (ft)	= 5.68
Compute by:	Known Q	EGL (ft)	= 0.92
Known Q (cfs)	= 9.60		



Channel Report

SWALE B BEFORE B3 BASINS - 1.75% 4FT BOTTOM - 5 YR

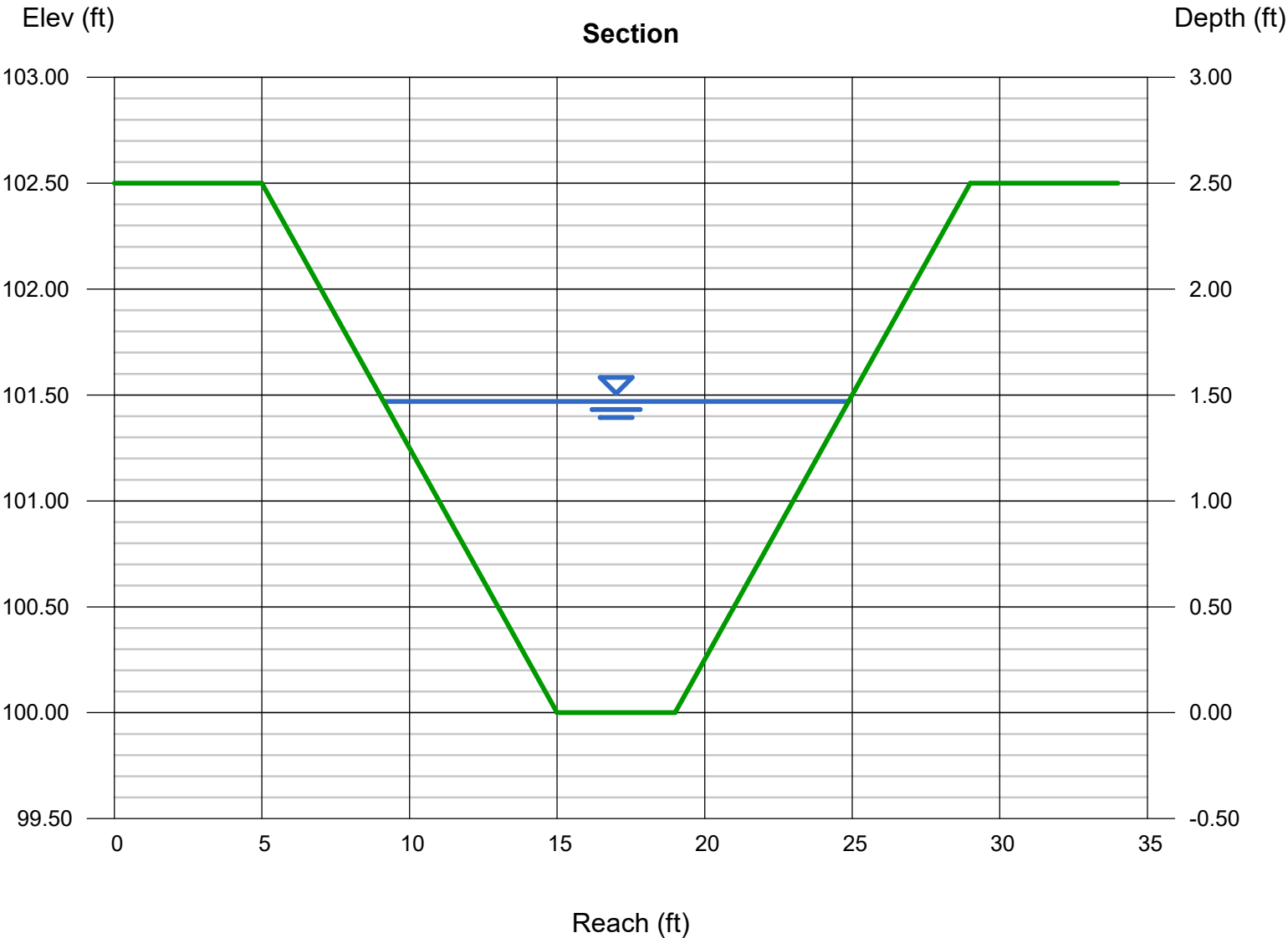
Trapezoidal		Highlighted	
Bottom Width (ft)	= 4.00	Depth (ft)	= 0.88
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 16.50
Total Depth (ft)	= 2.50	Area (sqft)	= 6.62
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 2.49
Slope (%)	= 1.75	Wetted Perim (ft)	= 11.26
N-Value	= 0.055	Crit Depth, Yc (ft)	= 0.65
Calculations		Top Width (ft)	= 11.04
Compute by:	Known Q	EGL (ft)	= 0.98
Known Q (cfs)	= 16.50		



Channel Report

SWALE B BEFORE B3 BASINS - 1.75% 4FT BOTTOM - 100 YR

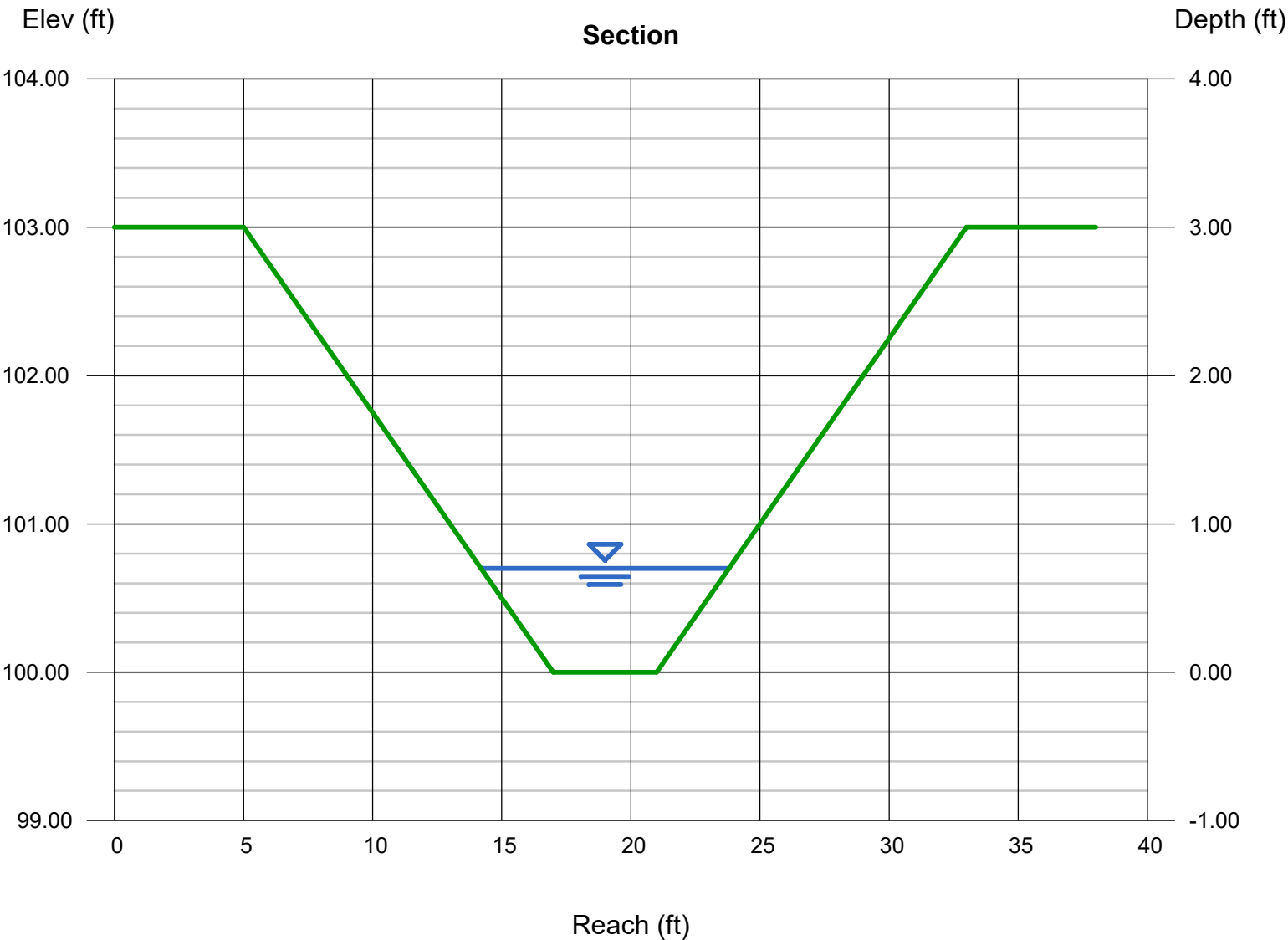
Trapezoidal		Highlighted	
Bottom Width (ft)	= 4.00	Depth (ft)	= 1.47
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 47.80
Total Depth (ft)	= 2.50	Area (sqft)	= 14.52
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 3.29
Slope (%)	= 1.75	Wetted Perim (ft)	= 16.12
N-Value	= 0.055	Crit Depth, Yc (ft)	= 1.15
Calculations		Top Width (ft)	= 15.76
Compute by:	Known Q	EGL (ft)	= 1.64
Known Q (cfs)	= 47.80		



Channel Report

SWALE B BEFORE B3 BASINS - 4.4% 4FT BOTTOM - 5 YR

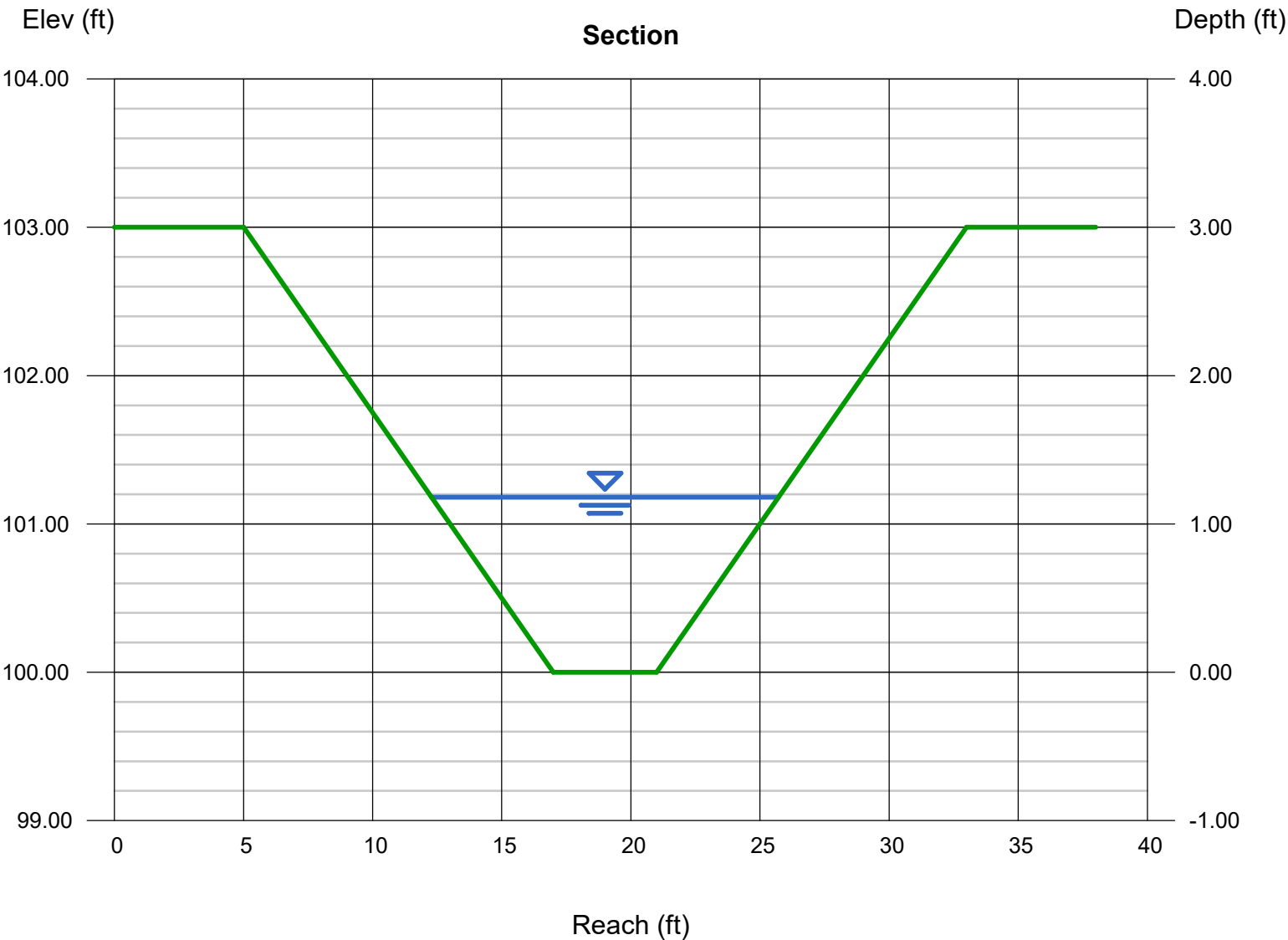
Trapezoidal		Highlighted	
Bottom Width (ft)	= 4.00	Depth (ft)	= 0.70
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 16.50
Total Depth (ft)	= 3.00	Area (sqft)	= 4.76
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 3.47
Slope (%)	= 4.40	Wetted Perim (ft)	= 9.77
N-Value	= 0.055	Crit Depth, Yc (ft)	= 0.65
Calculations		Top Width (ft)	= 9.60
Compute by:	Known Q	EGL (ft)	= 0.89
Known Q (cfs)	= 16.50		



Channel Report

SWALE B BEFORE B3 BASINS - 4.4% 4FT BOTTOM - 100 YR

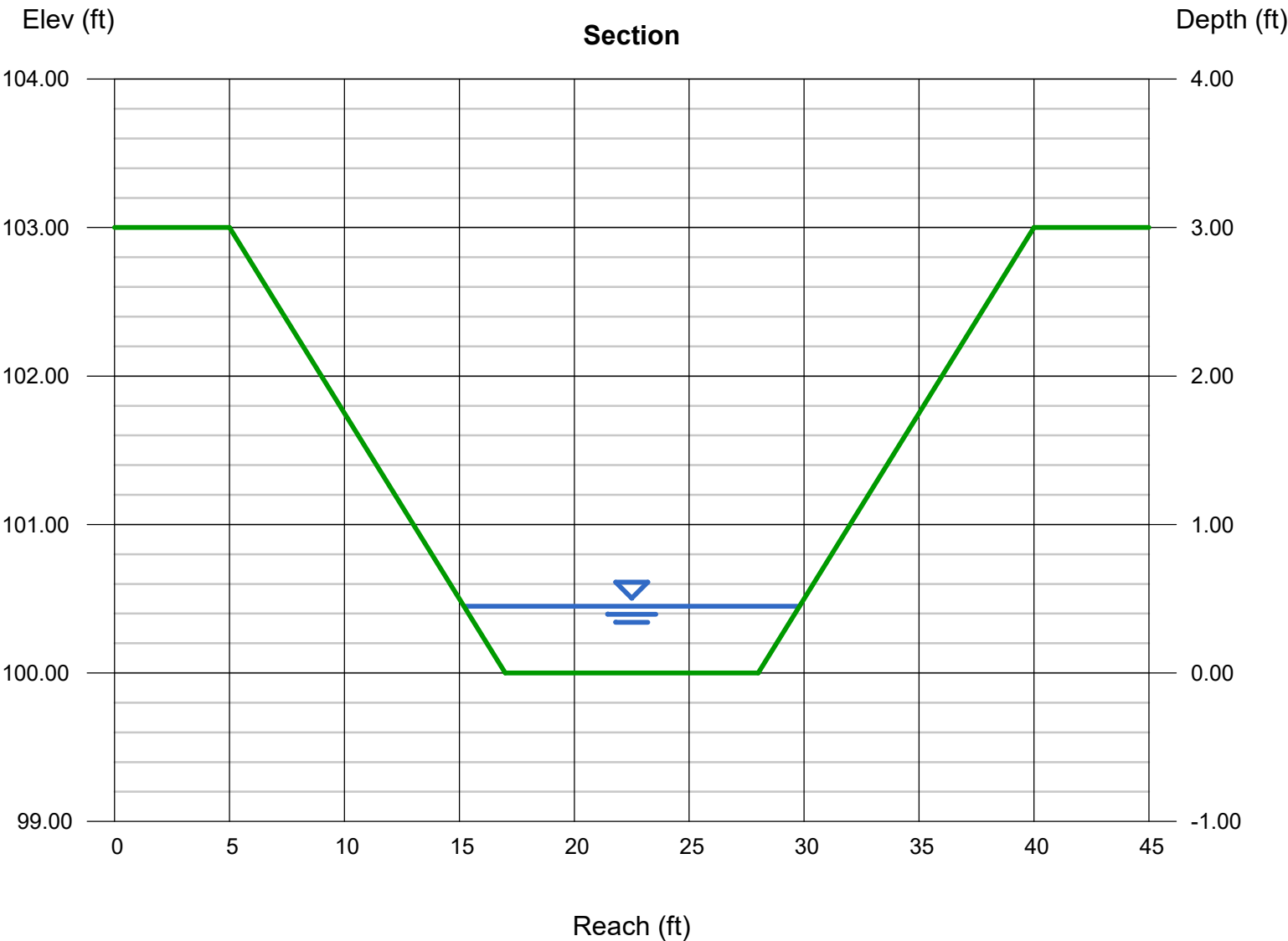
Trapezoidal		Highlighted	
Bottom Width (ft)	= 4.00	Depth (ft)	= 1.18
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 47.80
Total Depth (ft)	= 3.00	Area (sqft)	= 10.29
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 4.65
Slope (%)	= 4.40	Wetted Perim (ft)	= 13.73
N-Value	= 0.055	Crit Depth, Yc (ft)	= 1.15
Calculations		Top Width (ft)	= 13.44
Compute by:	Known Q	EGL (ft)	= 1.52
Known Q (cfs)	= 47.80		



Channel Report

SWALE B AFTER B3 BASINS - 10.75% 11FT BOTTOM - 5 YR

Trapezoidal		Highlighted	
Bottom Width (ft)	= 11.00	Depth (ft)	= 0.45
Side Slopes (z:1)	= 4.00, 4.00	Q (cfs)	= 26.50
Total Depth (ft)	= 3.00	Area (sqft)	= 5.76
Invert Elev (ft)	= 100.00	Velocity (ft/s)	= 4.60
Slope (%)	= 10.75	Wetted Perim (ft)	= 14.71
N-Value	= 0.055	Crit Depth, Yc (ft)	= 0.53
Calculations		Top Width (ft)	= 14.60
Compute by:	Known Q	EGL (ft)	= 0.78
Known Q (cfs)	= 26.50		



Channel Report

SWALE B AFTER B3 BASINS - 10.75% 11FT BOTTOM - 100 YR

Trapezoidal

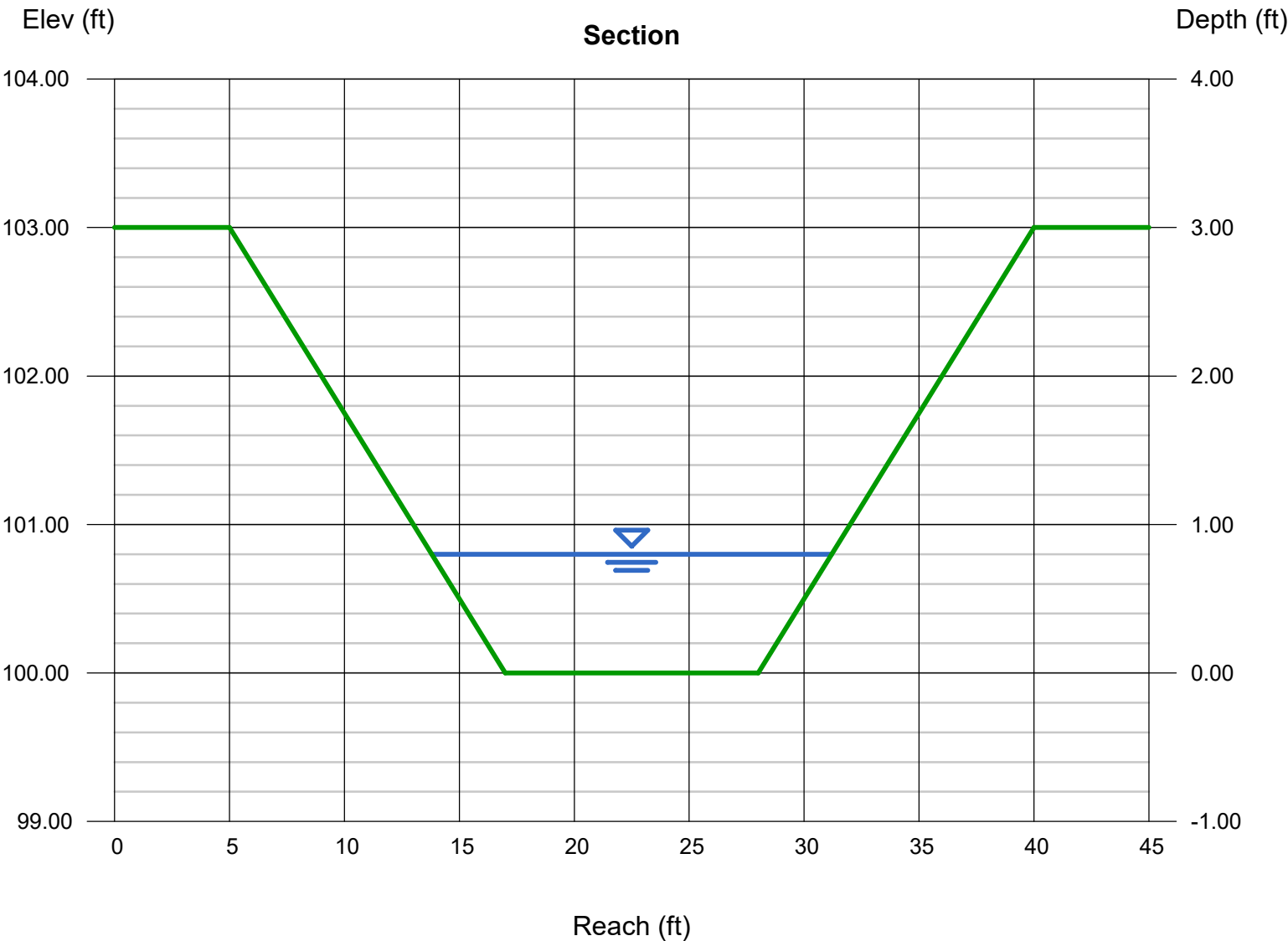
Bottom Width (ft) = 11.00
Side Slopes (z:1) = 4.00, 4.00
Total Depth (ft) = 3.00
Invert Elev (ft) = 100.00
Slope (%) = 10.75
N-Value = 0.055

Highlighted

Depth (ft) = 0.80
Q (cfs) = 74.80
Area (sqft) = 11.36
Velocity (ft/s) = 6.58
Wetted Perim (ft) = 17.60
Crit Depth, Yc (ft) = 1.00
Top Width (ft) = 17.40
EGL (ft) = 1.47

Calculations

Compute by: Known Q
Known Q (cfs) = 74.80



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc.

Friday, Jan 30 2026

Culvert B2.1

Invert Elev Dn (ft)	= 8841.35
Pipe Length (ft)	= 10.50
Slope (%)	= 5.52
Invert Elev Up (ft)	= 8841.93
Rise (in)	= 30.0
Shape	= Circular
Span (in)	= 30.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment

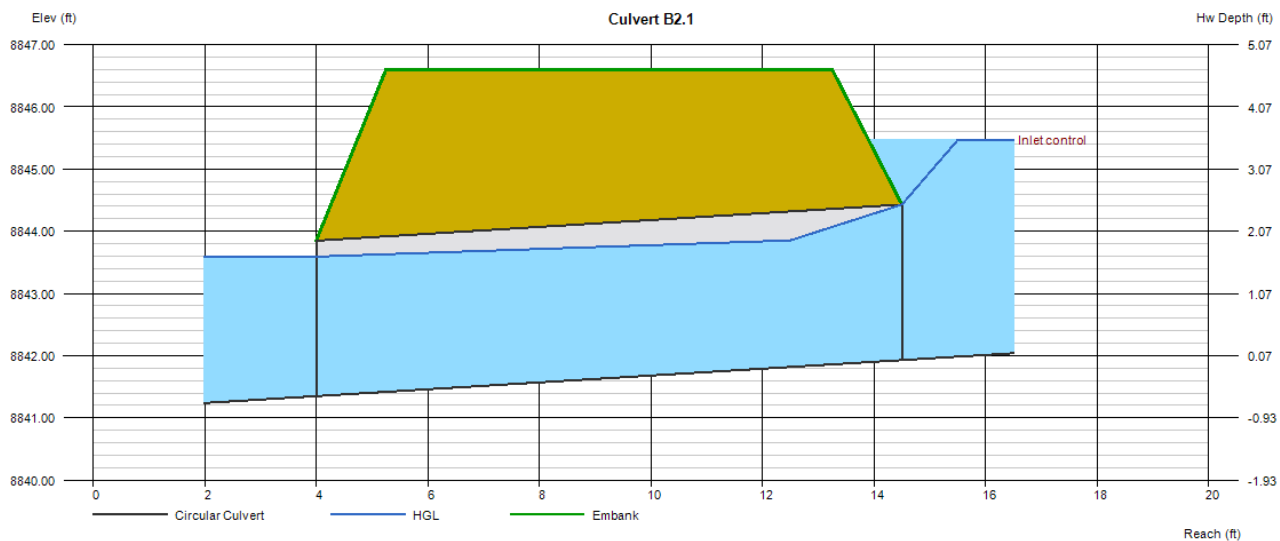
Top Elevation (ft)	= 8846.60
Top Width (ft)	= 8.00
Crest Width (ft)	= 20.00

Calculations

Qmin (cfs)	= 0.00
Qmax (cfs)	= 34.20
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 34.20
Qpipe (cfs)	= 34.20
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 7.37
Veloc Up (ft/s)	= 8.18
HGL Dn (ft)	= 8843.59
HGL Up (ft)	= 8843.92
Hw Elev (ft)	= 8845.47
Hw/D (ft)	= 1.42
Flow Regime	= Inlet Control



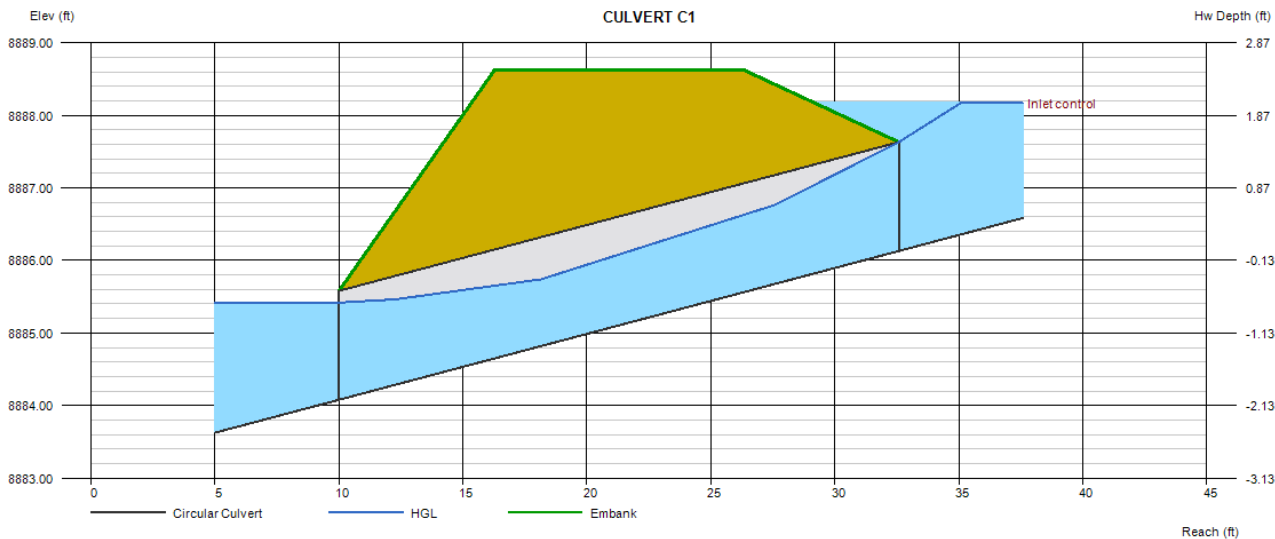
Culvert Report

CULVERT C1

Invert Elev Dn (ft)	= 8884.08
Pipe Length (ft)	= 22.58
Slope (%)	= 9.08
Invert Elev Up (ft)	= 8886.13
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment	
Top Elevation (ft)	= 8888.63
Top Width (ft)	= 10.00
Crest Width (ft)	= 10.00

Calculations	
Qmin (cfs)	= 0.00
Qmax (cfs)	= 9.30
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 9.30
Qpipe (cfs)	= 9.30
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.59
Veloc Up (ft/s)	= 6.25
HGL Dn (ft)	= 8885.42
HGL Up (ft)	= 8887.31
Hw Elev (ft)	= 8888.17
Hw/D (ft)	= 1.36
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc.

Monday, Jan 12 2026

CULVERT C2

Invert Elev Dn (ft) = 8877.37
Pipe Length (ft) = 18.02
Slope (%) = 1.66
Invert Elev Up (ft) = 8877.67
Rise (in) = 18.0
Shape = Circular
Span (in) = 18.0
No. Barrels = 1
n-Value = 0.013
Culvert Type = Circular Concrete
Culvert Entrance = Square edge w/headwall (C)
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

Embankment

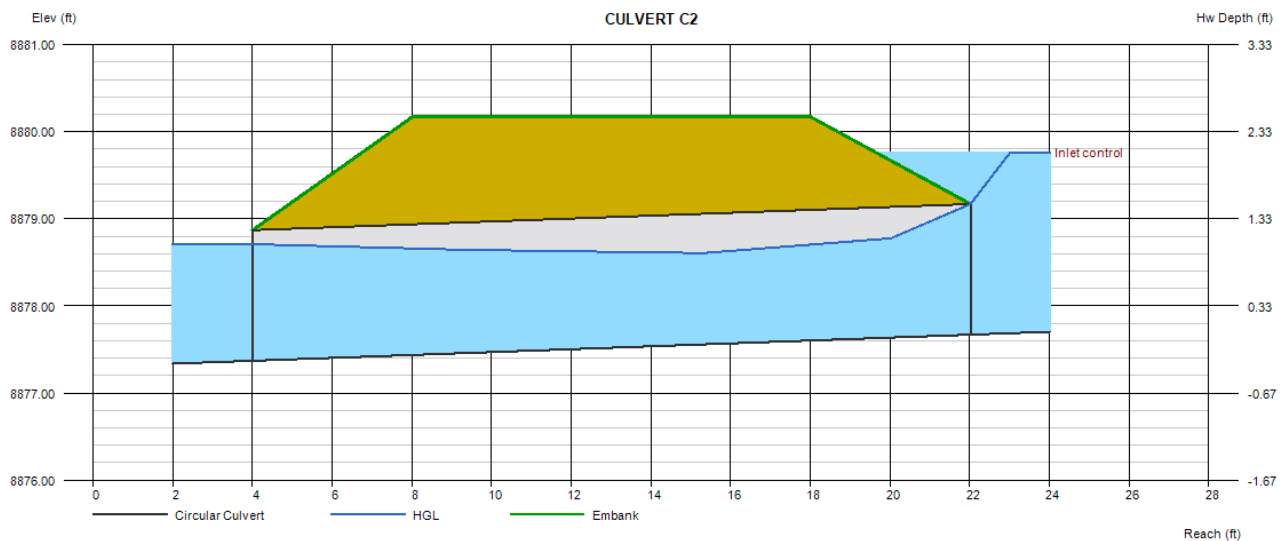
Top Elevation (ft) = 8880.17
Top Width (ft) = 10.00
Crest Width (ft) = 10.00

Calculations

Qmin (cfs) = 0.00
Qmax (cfs) = 9.30
Tailwater Elev (ft) = (dc+D)/2

Highlighted

Qtotal (cfs) = 9.30
Qpipe (cfs) = 9.30
Qovertop (cfs) = 0.00
Veloc Dn (ft/s) = 5.59
Veloc Up (ft/s) = 6.25
HGL Dn (ft) = 8878.71
HGL Up (ft) = 8878.85
Hw Elev (ft) = 8879.77
Hw/D (ft) = 1.40
Flow Regime = Inlet Control



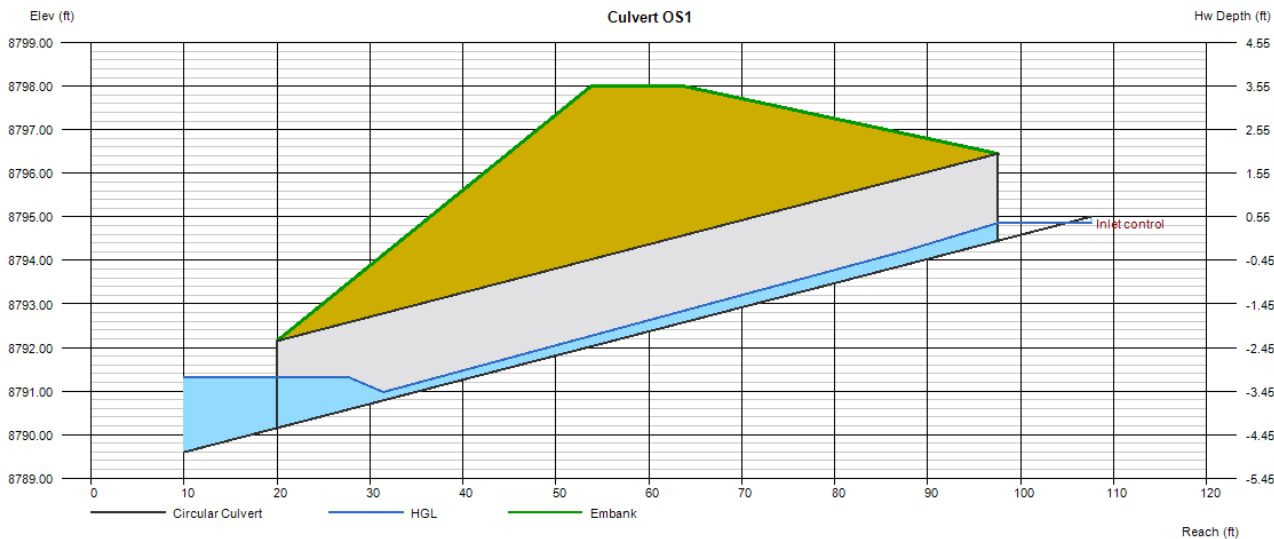
Culvert Report

Culvert OS1

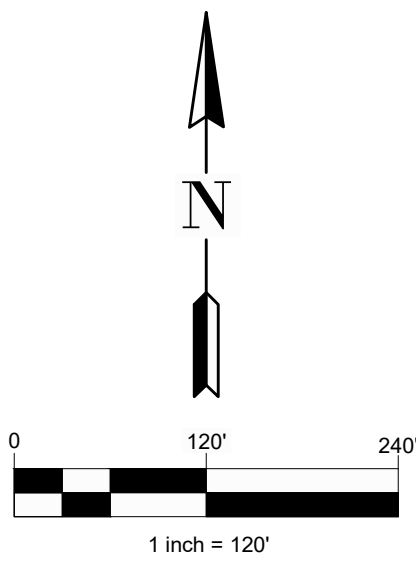
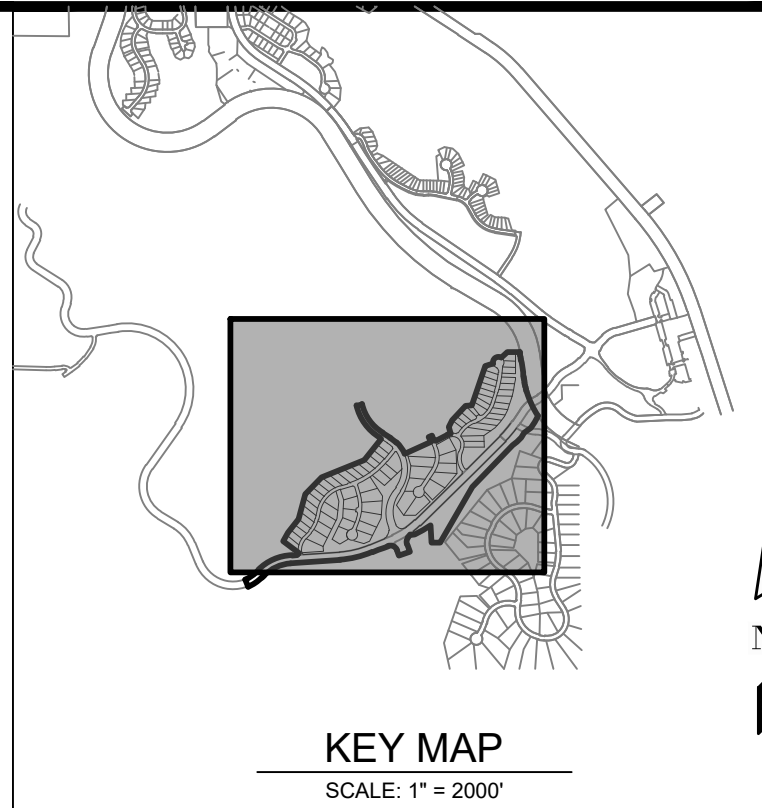
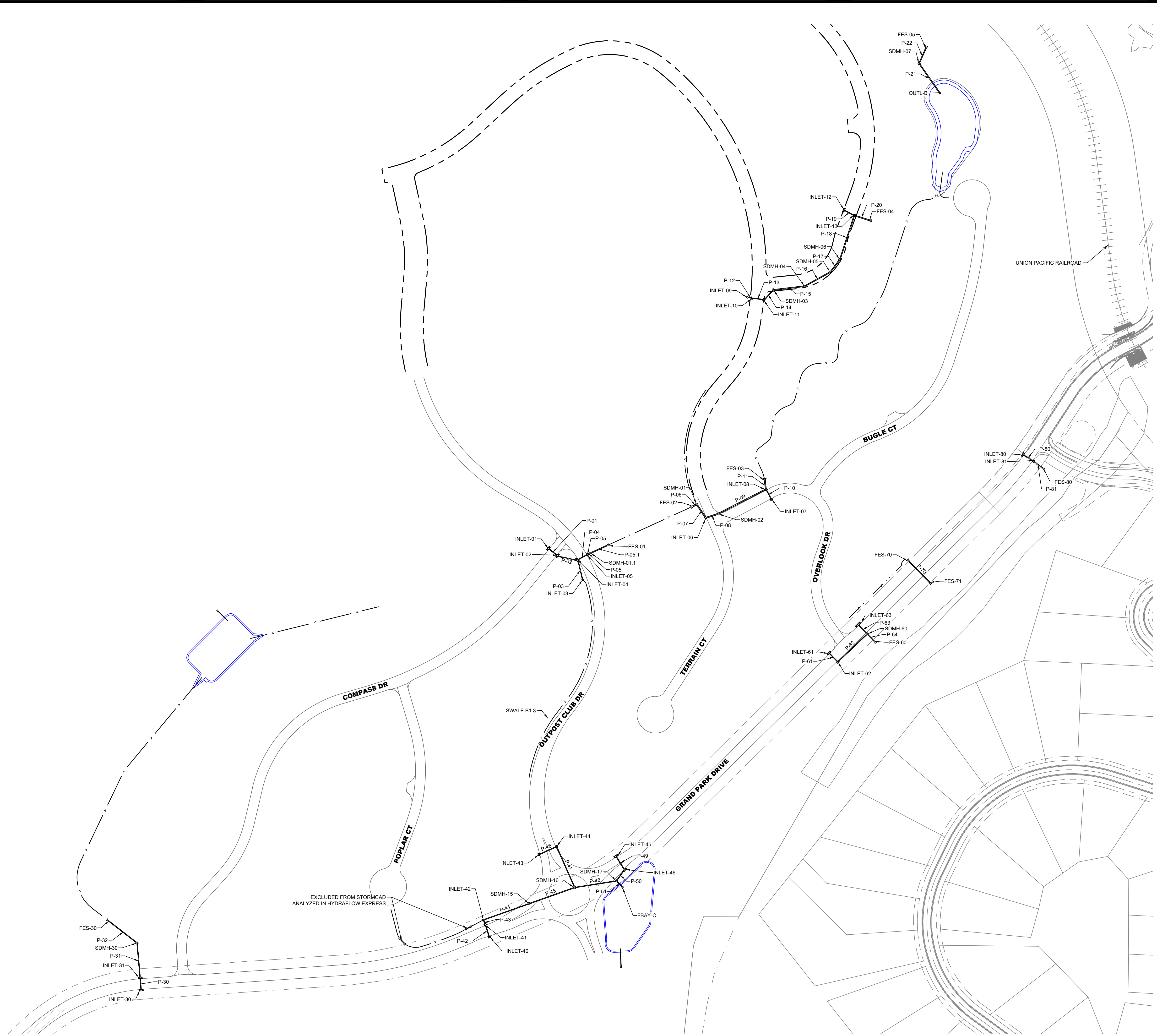
Invert Elev Dn (ft)	= 8790.15
Pipe Length (ft)	= 77.55
Slope (%)	= 5.54
Invert Elev Up (ft)	= 8794.45
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment	
Top Elevation (ft)	= 8798.00
Top Width (ft)	= 10.00
Crest Width (ft)	= 55.00

Calculations	
Qmin (cfs)	= 0.00
Qmax (cfs)	= 1.00
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 1.00
Qpipe (cfs)	= 1.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 0.52
Veloc Up (ft/s)	= 2.77
HGL Dn (ft)	= 8791.32
HGL Up (ft)	= 8794.79
Hw Elev (ft)	= 8794.86
Hw/D (ft)	= 0.20
Flow Regime	= Inlet Control



2/2/2026 8:54 AM X:\GRAND PARK\DOCUMENTS\REPORTS\DRAINAGE\16 - FILING 1 - 8WB 9W 10W 11\PHASE 3 - 10WC3 - STORM CAD STORMCAD KEYMAP.DWG 1



#	REVISION DESCRIPTION	DATE	BY
1	1ST SUBMITTAL	01/16/2026	MAJ

NOT FOR CONSTRUCTION

GRAND PARK - WEST MOUNTAIN - FILING 1 - 10W
TOWN OF FRASER, COLORADO
PHASE III DRAINAGE REPORT
STORMCAD KEYMAP



STORMCAD OUTPUT TABLES
West Mountain - 10W - 5-Year

STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

Catch Basin Table - Time: 0.00 hours

Label	Rim (ft)	Invert (ft)	Flow (cfs)	HGL (In) (ft)	HGL (Out) (ft)	Inlet Location	Notes
FES-02 (B2.1+B1)	8,846.29	8,843.79	11.80	8,843.08	8,843.08	In Sag	30" FES
FES-70 (OS1)	8,797.34	8,794.47	0.30	8,794.64	8,794.64	In Sag	30" FES
INLET-01 (B1.1)	8,869.47	8,862.10	2.60	8,862.69	8,862.69	In Sag	10' TYPE R INLET
INLET-02 (B1.2)	8,869.47	8,861.64	4.20	8,862.41	8,862.41	In Sag	10' TYPE R INLET
INLET-03 (B1.3)	8,865.53	8,861.58	1.60	8,862.04	8,862.04	In Sag	TYPE C INLET
INLET-04 (B1.4)	8,867.34	8,860.57	6.60	8,861.84	8,861.84	In Sag	10' TYPE R INLET
INLET-05 (B1.5)	8,867.68	8,860.11	7.90	8,861.09	8,861.09	In Sag	5' TYPE R INLET
INLET-06 (B2.2)	8,846.76	8,840.02	12.60	8,841.19	8,841.19	In Sag	5' TYPE R INLET
INLET-07 (B2.4)	8,840.75	8,836.18	0.40	8,836.92	8,836.92	In Sag	5' TYPE R INLET
INLET-08 (B2.3)	8,840.75	8,835.72	13.30	8,836.92	8,836.92	In Sag	5' TYPE R INLET
INLET-09 (B3.1+B3.2)	8,845.79	8,842.00	7.50	8,842.95	8,842.95	In Sag	TYPE C INLET
INLET-10 (B3.3)	8,847.66	8,840.70	8.10	8,841.69	8,841.69	In Sag	5' TYPE R INLET
INLET-11 (B3.4)	8,847.66	8,837.18	8.60	8,838.21	8,838.21	In Sag	5' TYPE R INLET
INLET-12 (B3.5)	8,827.46	8,823.96	1.20	8,824.35	8,824.35	In Sag	10' TYPE R INLET
INLET-13 (B3.6)	8,827.70	8,821.03	10.00	8,822.15	8,822.15	In Sag	5' TYPE R INLET
INLET-30 (A4.1)	8,923.30	8,918.84	0.80	8,919.16	8,919.16	In Sag	10' TYPE R INLET
INLET-31 (A4.2)	8,923.30	8,918.36	1.70	8,918.84	8,918.84	In Sag	10' TYPE R INLET
INLET-40 (C2.2)	8,877.77	8,871.03	0.60	8,871.30	8,871.30	In Sag	5' TYPE R INLET
INLET-41 (C2.1)	8,877.68	8,870.53	1.30	8,870.94	8,870.94	In Sag	5' TYPE R INLET
INLET-42 (C1+C2.3)	8,875.28	8,869.88	4.20	8,870.65	8,870.65	In Sag	TYPE C INLET
INLET-43 (C2.4)	8,875.29	8,869.26	0.40	8,869.47	8,869.47	In Sag	5' TYPE R INLET
INLET-44 (C2.5)	8,875.38	8,868.59	0.50	8,868.83	8,868.83	In Sag	5' TYPE R INLET
INLET-45 (C2.6)	8,869.00	8,864.80	0.50	8,864.97	8,864.97	In Sag	10' TYPE R INLET
INLET-46 (C2.7)	8,870.93	8,864.21	1.00	8,864.50	8,864.50	In Sag	10' TYPE R INLET
INLET-61 (D1.1)	8,817.83	8,810.43	2.20	8,810.97	8,810.97	In Sag	10' TYPE R INLET
INLET-62 (D2)	8,817.83	8,807.49	2.60	8,808.08	8,808.08	In Sag	5' TYPE R INLET
INLET-63 (D1.2)	8,812.47	8,806.04	1.10	8,806.42	8,806.42	In Sag	15' TYPE R INLET
INLET-80 (E1.1)	8,764.09	8,760.11	0.90	8,760.44	8,760.44	In Sag	10' TYPE R INLET
INLET-81 (E1.2)	8,763.87	8,759.63	1.30	8,760.03	8,760.03	In Sag	5' TYPE R INLET
OUTL-B	8,792.00	8,784.75	1.30	8,785.14	8,785.14	In Sag	OUTLET STRUCTURE

Manhole Table - Time: 0.00 hours

Label	Flow (cfs)	Headloss (ft)	Elevation (Rim) (ft)	HGL (In) (ft)	HGL (Out) (ft)	Notes	Headloss Method	AASHTO Shaping Method
SDMH-01	11.80	0.35	8,847.40	8,842.38	8,842.03	6' DIA MH FLAT TOP	AASHTO	Full
SDMH-02	12.60	0.17	8,846.49	8,840.63	8,840.46	6' DIA MH	AASHTO	Full
SDMH-03	8.60	0.00	8,846.98	8,834.97	8,834.97	5' DIA MH	AASHTO	Full
SDMH-04	8.60	0.00	8,843.79	8,831.33	8,831.33	5' DIA MH	AASHTO	Full
SDMH-05	8.60	0.00	8,838.80	8,827.79	8,827.79	5' DIA MH	AASHTO	Full
SDMH-06	8.60	0.00	8,836.26	8,824.97	8,824.97	5' DIA MH	AASHTO	Full
SDMH-07	1.30	0.13	8,786.91	8,779.83	8,779.70	5' DIA MH	AASHTO	Full
SDMH-15	4.20	0.11	8,875.64	8,869.29	8,869.18	5' DIA MH	AASHTO	Full
SDMH-16	4.70	0.12	8,873.61	8,867.89	8,867.76	6' DIA MH	AASHTO	Full
SDMH-17	5.70	0.31	8,869.97	8,864.42	8,864.10	6' DIA MH	AASHTO	Full
SDMH-30	1.70	0.13	8,922.22	8,917.83	8,917.70	5' DIA MH	AASHTO	Full
SDMH-60	3.70	0.08	8,812.65	8,805.22	8,805.13	5' DIA MH	AASHTO	Full

STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

Conduit Table - Time: 0.00 hours

Label	Start Node	Stop Node	Invert (Start) (ft)	Invert (Stop) (ft)	Length (ft)	Slope (%)	Dia. (in)	Mann.	Flow (cfs)	Velo. (ft/s)	Depth (ft)	Capacity (cfs)	Froude Number	HGL (In) (ft)	HGL (Out) (ft)
P-01	INLET-01 (B1.1)	INLET-02 (B1.2)	8,862.08	8,861.82	26.0	1.00	18.0	0.013	2.60	4.93	0.61	10.50	1.425	8,862.69	8,862.33
P-02	INLET-02 (B1.2)	INLET-04 (B1.4)	8,861.62	8,861.05	57.0	1.00	18.0	0.013	4.20	5.61	0.79	10.50	1.395	8,862.41	8,861.84
P-03	INLET-03 (B1.3)	INLET-04 (B1.4)	8,861.56	8,861.05	51.0	1.00	18.0	0.013	1.60	4.29	0.48	10.50	1.426	8,862.04	8,861.84
P-04	INLET-04 (B1.4)	INLET-05 (B1.5)	8,860.85	8,860.59	26.0	1.00	18.0	0.013	6.60	6.28	0.99	10.50	1.315	8,861.84	8,861.47
P-05	INLET-05 (B1.5)	SDMH-01.1	8,860.09	8,859.98	10.8	1.00	24.0	0.013	7.90	6.55	1.00	22.58	1.474	8,861.09	8,860.86
P-06	FES-02 (B2.1+ B1)	SDMH-01	8,841.93	8,841.35	10.5	5.50	30.0	0.013	11.80	13.30	1.15	96.21	3.627	8,843.08	8,842.13
P-07	SDMH-01	INLET-06 (B2.2)	8,840.88	8,840.20	41.0	1.65	30.0	0.013	11.80	8.65	1.15	52.66	1.995	8,842.03	8,841.05
P-08	INLET-06 (B2.2)	SDMH-02	8,840.00	8,839.47	32.1	1.65	30.0	0.013	12.60	8.82	1.19	52.73	1.996	8,841.19	8,840.37
P-09	SDMH-02	INLET-08 (B2.3)	8,839.27	8,835.90	142.2	2.37	30.0	0.013	12.60	10.04	1.19	63.15	2.394	8,840.46	8,836.66
P-10	INLET-07 (B2.4)	INLET-08 (B2.3)	8,836.16	8,835.90	26.0	1.00	18.0	0.013	0.40	2.86	0.23	10.50	1.359	8,836.92	8,836.92
P-11	INLET-08 (B2.3)	FES-03	8,835.70	8,835.46	23.8	1.00	30.0	0.013	13.30	7.46	1.23	40.98	1.537	8,836.92	8,836.50
P-12	INLET-09 (B3.1+ B3.2)	INLET-10 (B3.3)	8,841.98	8,841.68	15.0	2.00	24.0	0.013	7.50	8.32	0.97	31.99	2.117	8,842.95	8,842.43
P-13	INLET-10 (B3.3)	INLET-11 (B3.4)	8,840.68	8,840.16	26.0	2.00	24.0	0.013	8.10	8.49	1.01	31.99	2.113	8,841.69	8,840.91
P-14	INLET-11 (B3.4)	SDMH-03	8,837.16	8,836.43	36.9	2.00	24.0	0.013	8.60	8.64	1.05	32.01	2.112	8,838.21	8,837.17
P-15	SDMH-03	SDMH-04	8,833.93	8,832.28	82.3	2.00	24.0	0.013	8.60	8.64	1.05	31.99	2.111	8,834.97	8,832.99
P-16	SDMH-04	SDMH-05	8,830.28	8,828.74	76.8	2.00	24.0	0.013	8.60	8.64	1.05	32.02	2.113	8,831.33	8,829.45
P-17	SDMH-05	SDMH-06	8,826.74	8,825.92	41.1	2.00	24.0	0.013	8.60	8.63	1.05	31.97	2.109	8,827.79	8,826.66
P-18	SDMH-06	INLET-13 (B3.6)	8,823.92	8,821.52	120.2	2.00	24.0	0.013	8.60	8.63	1.05	31.97	2.109	8,824.97	8,822.23
P-19	INLET-12 (B3.5)	INLET-13 (B3.6)	8,823.94	8,823.68	26.3	1.00	18.0	0.013	1.20	3.95	0.41	10.50	1.418	8,824.35	8,824.02

STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

Conduit Table - Time: 0.00 hours

Label	Start Node	Stop Node	Invert (Start) (ft)	Invert (Stop) (ft)	Length (ft)	Slope (%)	Dia. (in)	Mann.	Flow (cfs)	Velo. (ft/s)	Depth (ft)	Capacity (cfs)	Froude Number	HGL (In) (ft)	HGL (Out) (ft)
P-20	INLET-13 (B3.6)	FES-04	8,821.02	8,820.58	43.7	1.00	24.0	0.013	10.00	6.97	1.13	22.59	1.450	8,822.15	8,821.53
P-21	OUTL-B	SDMH-07	8,784.75	8,779.51	92.9	5.63	24.0	0.013	1.30	7.16	0.39	53.69	3.300	8,785.14	8,779.72
P-22	SDMH-07	FES-05	8,779.31	8,778.88	43.3	1.00	24.0	0.013	1.30	3.91	0.39	22.65	1.455	8,779.70	8,779.20
P-30	INLET-30 (A4.1)	INLET-31 (A4.2)	8,918.83	8,918.55	28.0	1.00	18.0	0.013	0.80	3.51	0.33	10.50	1.403	8,919.16	8,918.83
P-31	INLET-31 (A4.2)	SDMH-30	8,918.35	8,917.41	93.5	1.00	18.0	0.013	1.70	4.38	0.49	10.53	1.431	8,918.84	8,917.82
P-32	SDMH-30	FES-30	8,917.21	8,916.27	94.0	1.00	18.0	0.013	1.70	4.37	0.49	10.50	1.427	8,917.70	8,916.68
P-42	INLET-40 (C2.2)	INLET-41 (C2.1)	8,871.01	8,870.71	29.6	1.00	18.0	0.013	0.60	3.22	0.29	10.50	1.384	8,871.30	8,870.96
P-43	INLET-41 (C2.1)	INLET-42 (C1 +C2.3)	8,870.51	8,870.36	15.4	1.00	18.0	0.013	1.30	4.04	0.43	10.49	1.418	8,870.94	8,870.72
P-44	INLET-42 (C1 +C2.3)	SDMH-15	8,869.86	8,868.59	126.6	1.00	18.0	0.013	4.20	5.62	0.79	10.52	1.397	8,870.65	8,869.25
P-45	SDMH-15	SDMH-16	8,868.39	8,867.13	126.6	1.00	18.0	0.013	4.20	5.60	0.79	10.48	1.392	8,869.18	8,867.79
P-46	INLET-43 (C2.4)	INLET-44 (C2.5)	8,869.24	8,868.77	46.4	1.00	18.0	0.013	0.40	2.86	0.23	10.51	1.360	8,869.47	8,868.97
P-47	INLET-44 (C2.5)	SDMH-16	8,868.57	8,867.38	119.4	1.00	18.0	0.013	0.50	3.05	0.26	10.49	1.371	8,868.83	8,867.89
P-48	SDMH-16	SDMH-17	8,866.93	8,863.76	110.5	2.87	18.0	0.013	4.70	8.50	0.83	17.79	2.410	8,867.76	8,864.29
P-49	INLET-45 (C2.6)	INLET-46 (C2.7)	8,864.71	8,864.33	38.2	1.00	18.0	0.013	0.50	3.05	0.26	10.50	1.373	8,864.97	8,864.55
P-50	INLET-46 (C2.7)	SDMH-17	8,864.13	8,863.76	36.5	1.00	18.0	0.013	1.00	3.74	0.37	10.50	1.410	8,864.50	8,864.42
P-51	SDMH-17	FBAY-C	8,863.26	8,863.06	19.7	1.00	24.0	0.013	5.70	6.01	0.84	22.66	1.497	8,864.10	8,863.77
P-61	INLET-61 (D1.1)	INLET-62 (D2)	8,810.41	8,810.13	28.0	1.00	18.0	0.013	2.20	4.70	0.56	10.50	1.428	8,810.97	8,810.60
P-62	INLET-62 (D2)	SDMH-60	8,807.47	8,806.40	106.9	1.00	18.0	0.013	2.60	4.93	0.61	10.51	1.426	8,808.08	8,806.91
P-63	INLET-63 (D1.2)	SDMH-60	8,806.02	8,804.90	32.1	3.50	18.0	0.013	1.10	5.99	0.39	19.66	2.589	8,806.42	8,805.14
P-64	SDMH-60	FES-60	8,804.40	8,803.48	26.2	3.50	18.0	0.013	3.70	8.53	0.73	19.65	2.671	8,805.13	8,803.95
P-70	FES-70 (OS1)	FES-71	8,794.45	8,790.15	77.6	5.55	24.0	0.013	0.30	4.56	0.19	53.30	2.983	8,794.64	8,790.25

STORMCAD OUTPUT TABLES

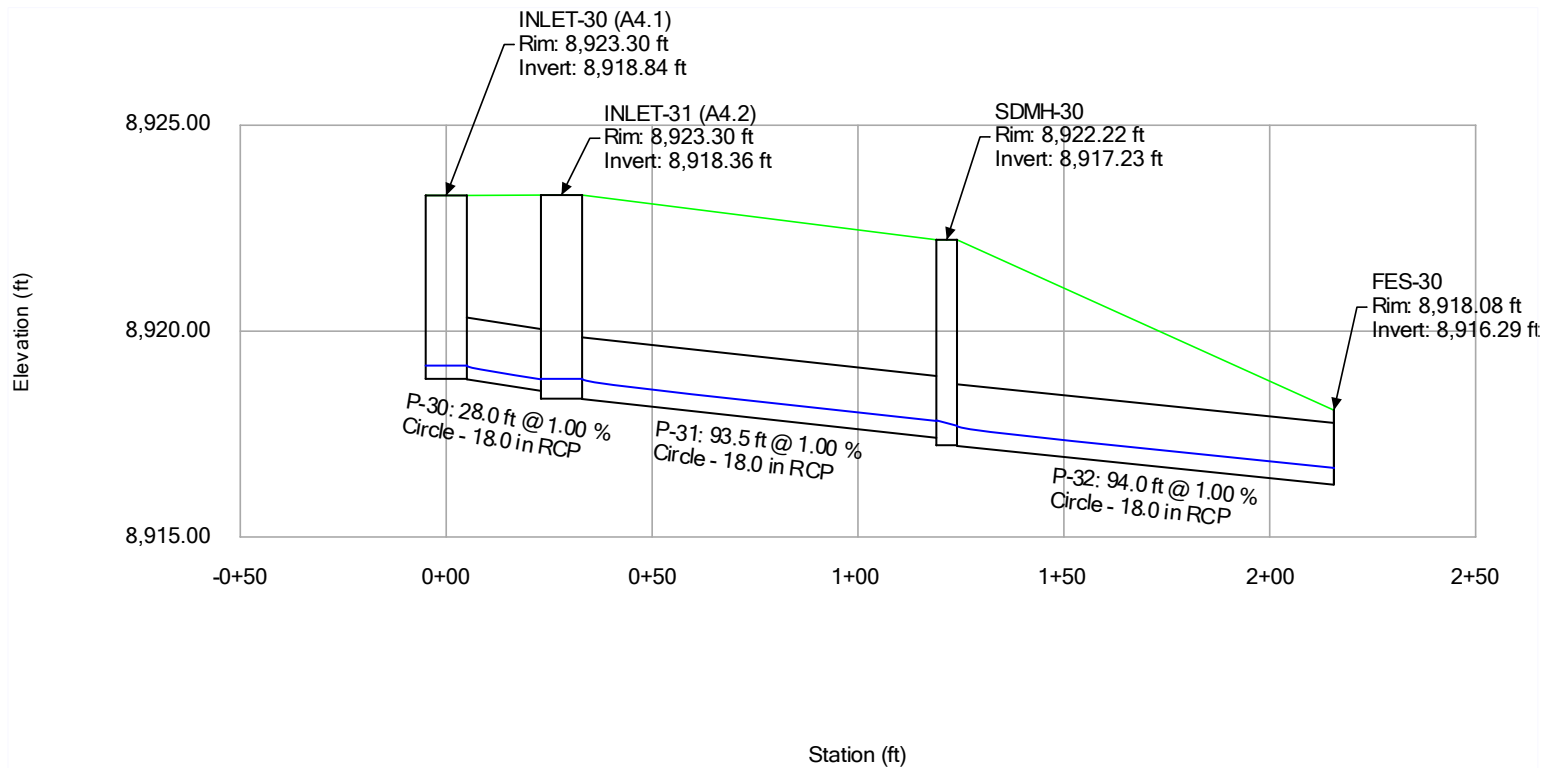
West Mountain - 10W - 5-Year

Conduit Table - Time: 0.00 hours

Label	Start Node	Stop Node	Invert (Start) (ft)	Invert (Stop) (ft)	Length (ft)	Slope (%)	Dia. (in)	Mann.	Flow (cfs)	Velo. (ft/s)	Depth (ft)	Capacity (cfs)	Froude Number	HGL (In) (ft)	HGL (Out) (ft)
P-80	INLET-80 (E1.1)	INLET-81 (E1.2)	8,760.09	8,759.81	28.1	1.00	18.0	0.013	0.90	3.63	0.35	10.48	1.404	8,760.44	8,760.11
P-81	INLET-81 (E1.2)	FES-80	8,759.61	8,759.29	31.5	1.00	18.0	0.013	1.30	4.04	0.43	10.50	1.419	8,760.03	8,759.65

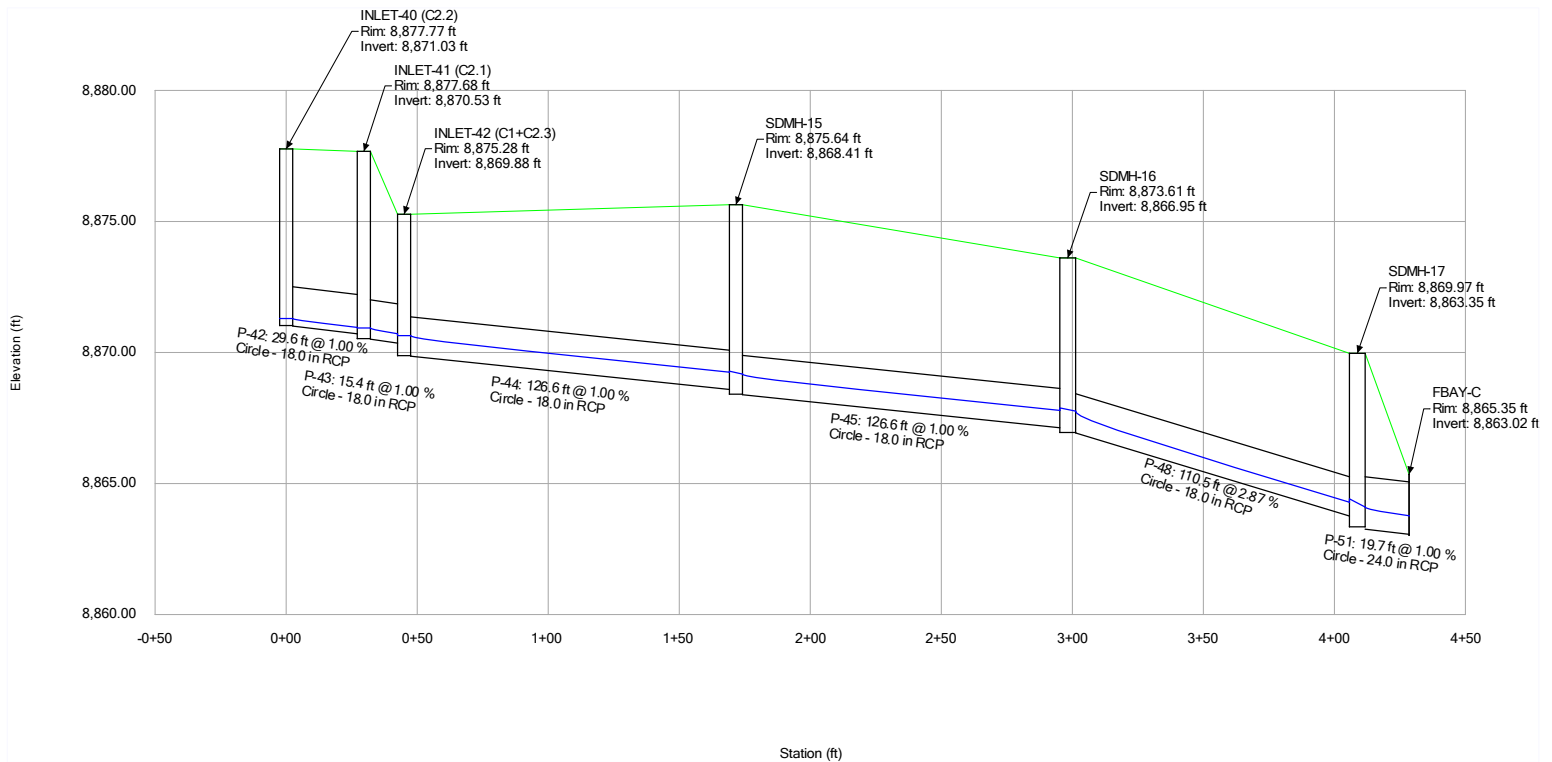
STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year



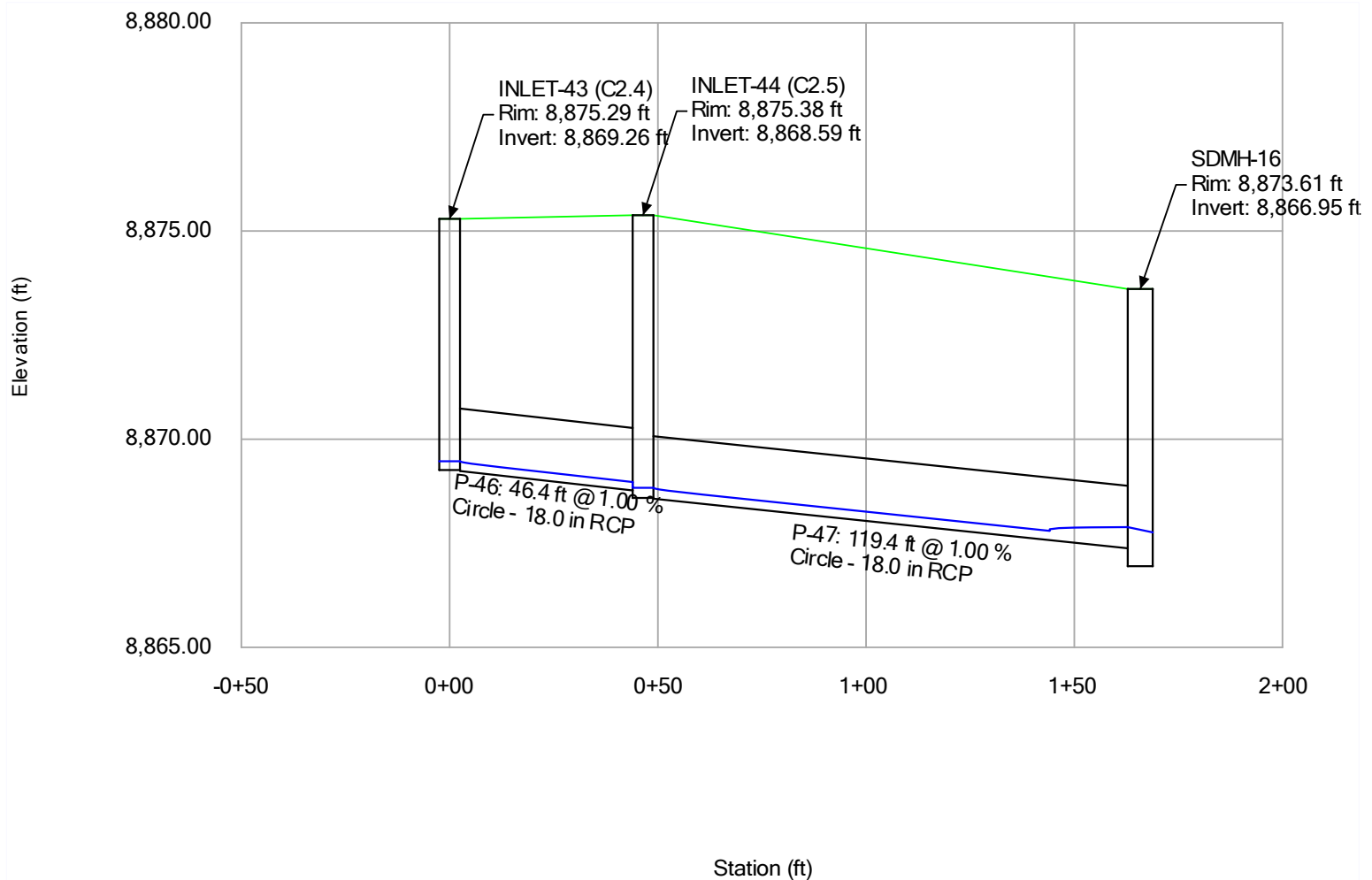
STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

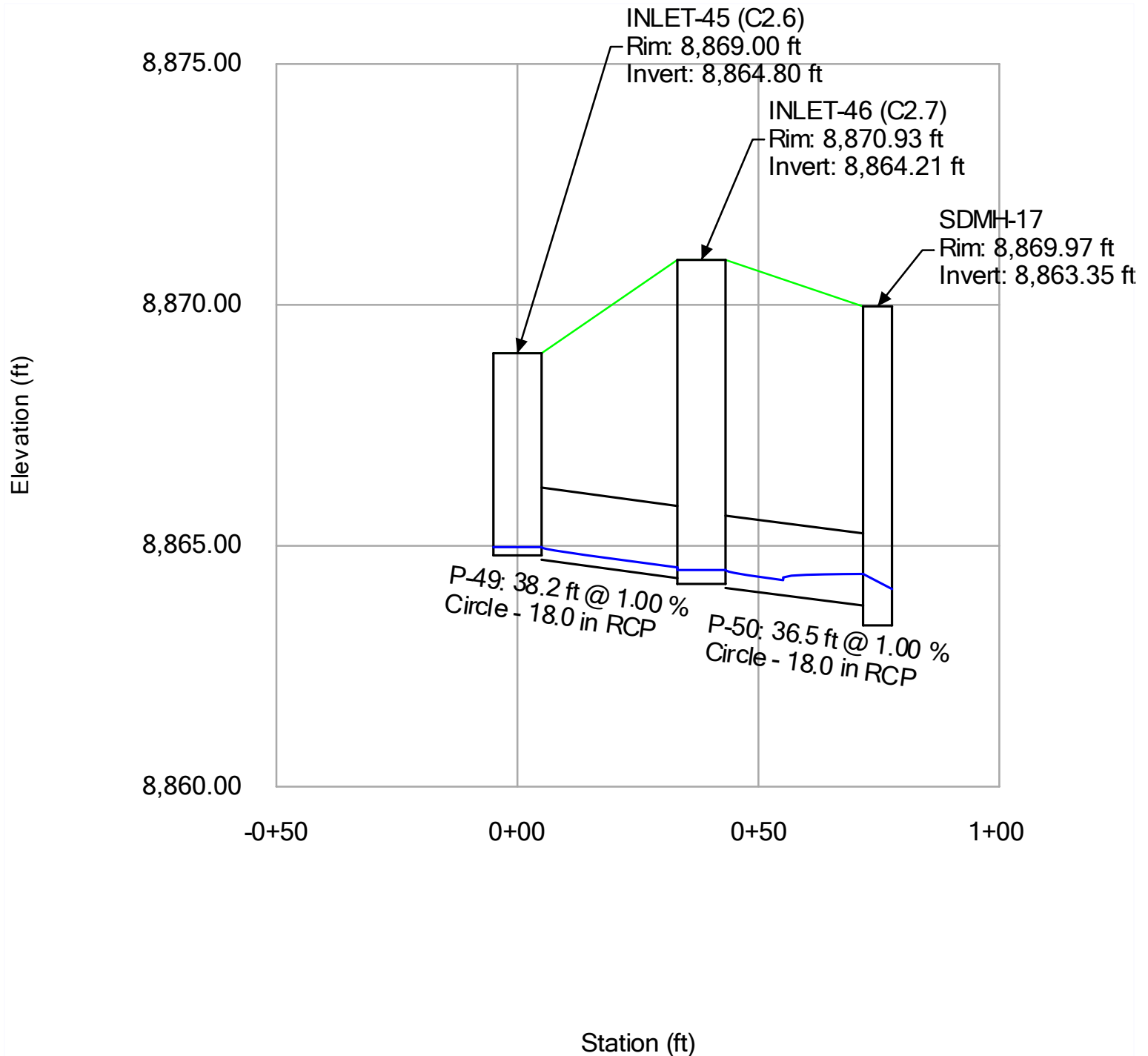


STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

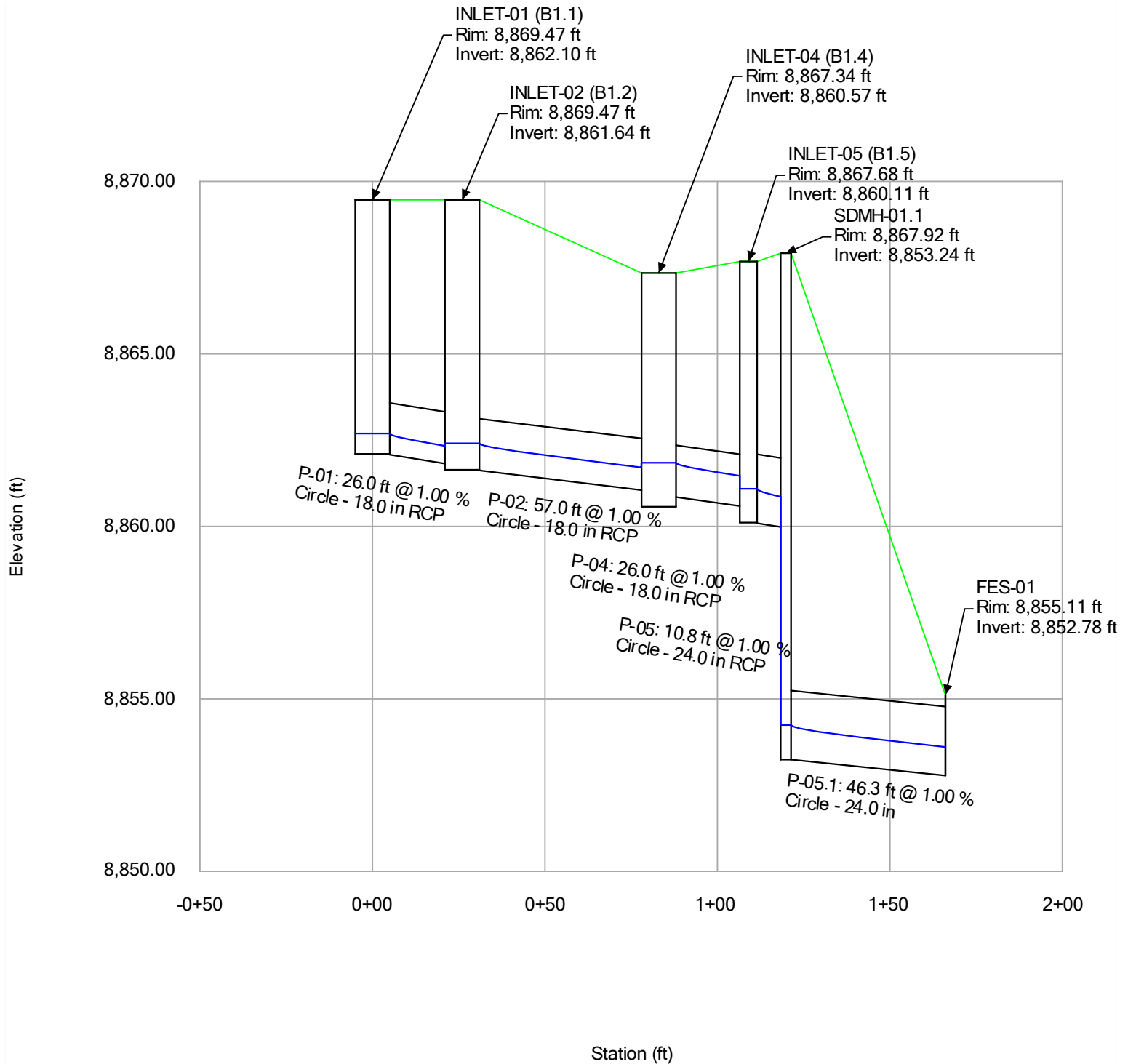


STORMCAD OUTPUT TABLES **West Mountain - 10W - 5-Year**

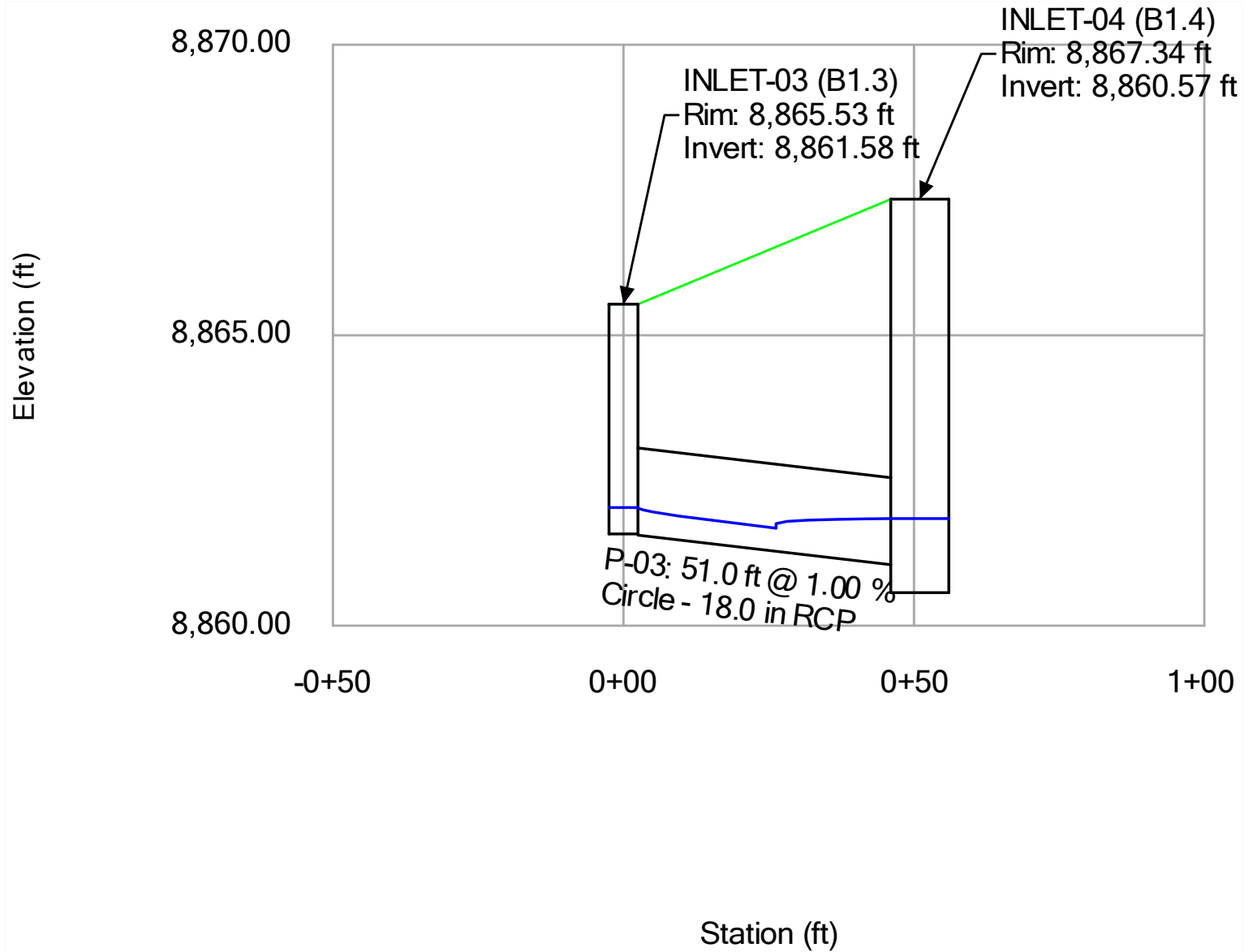


STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

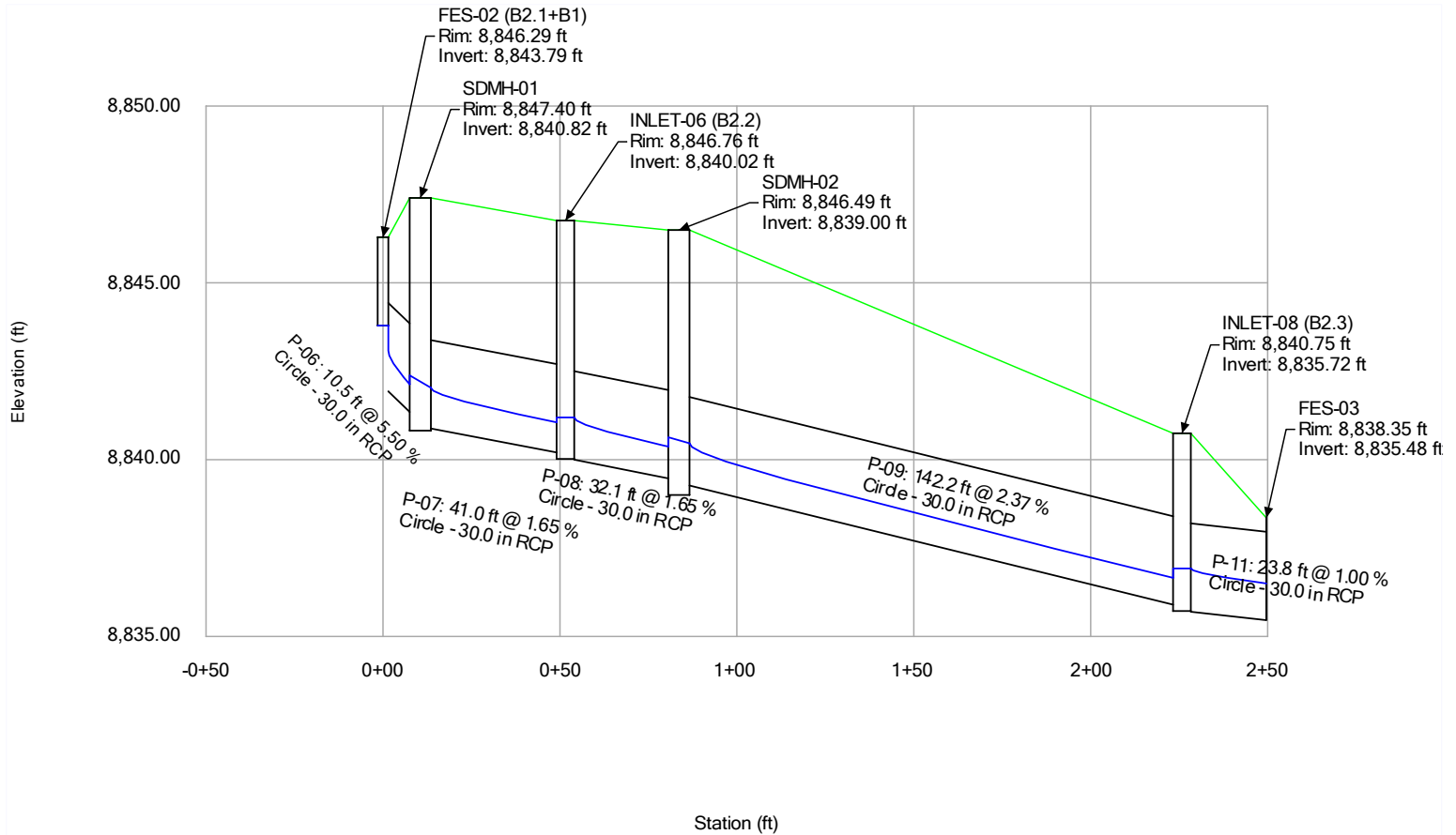


STORMCAD OUTPUT TABLES
West Mountain - 10W - 5-Year



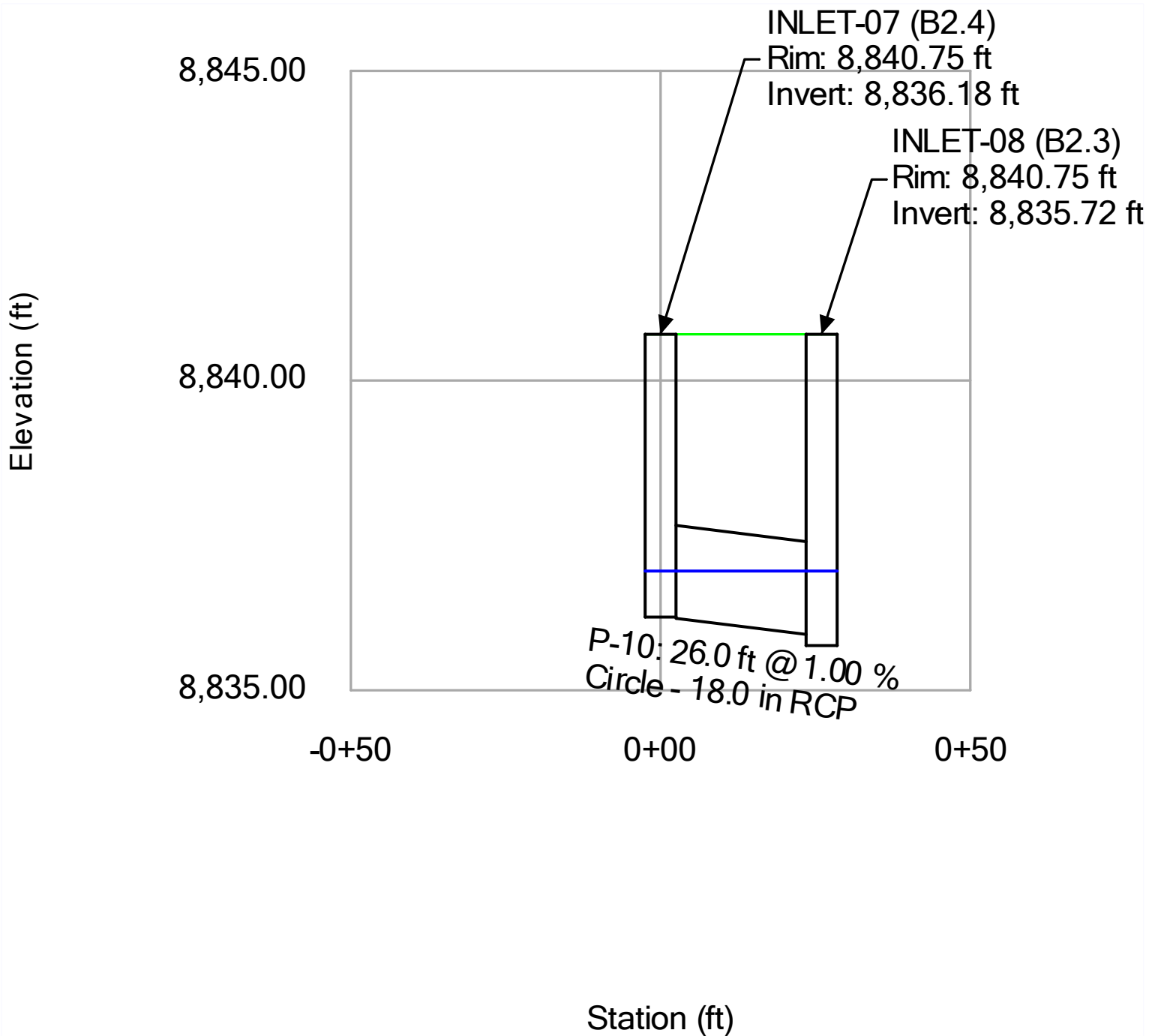
STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year



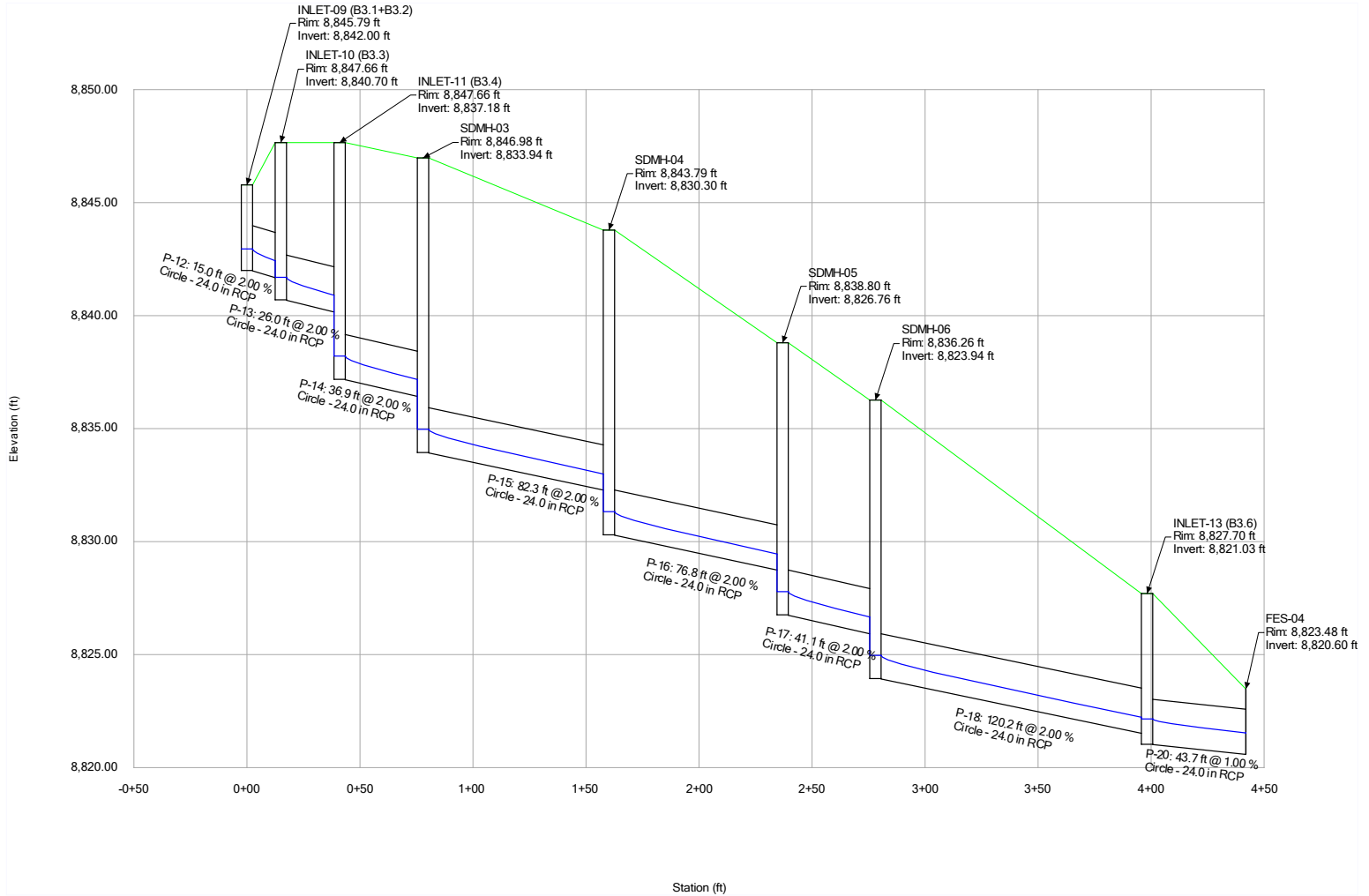
STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

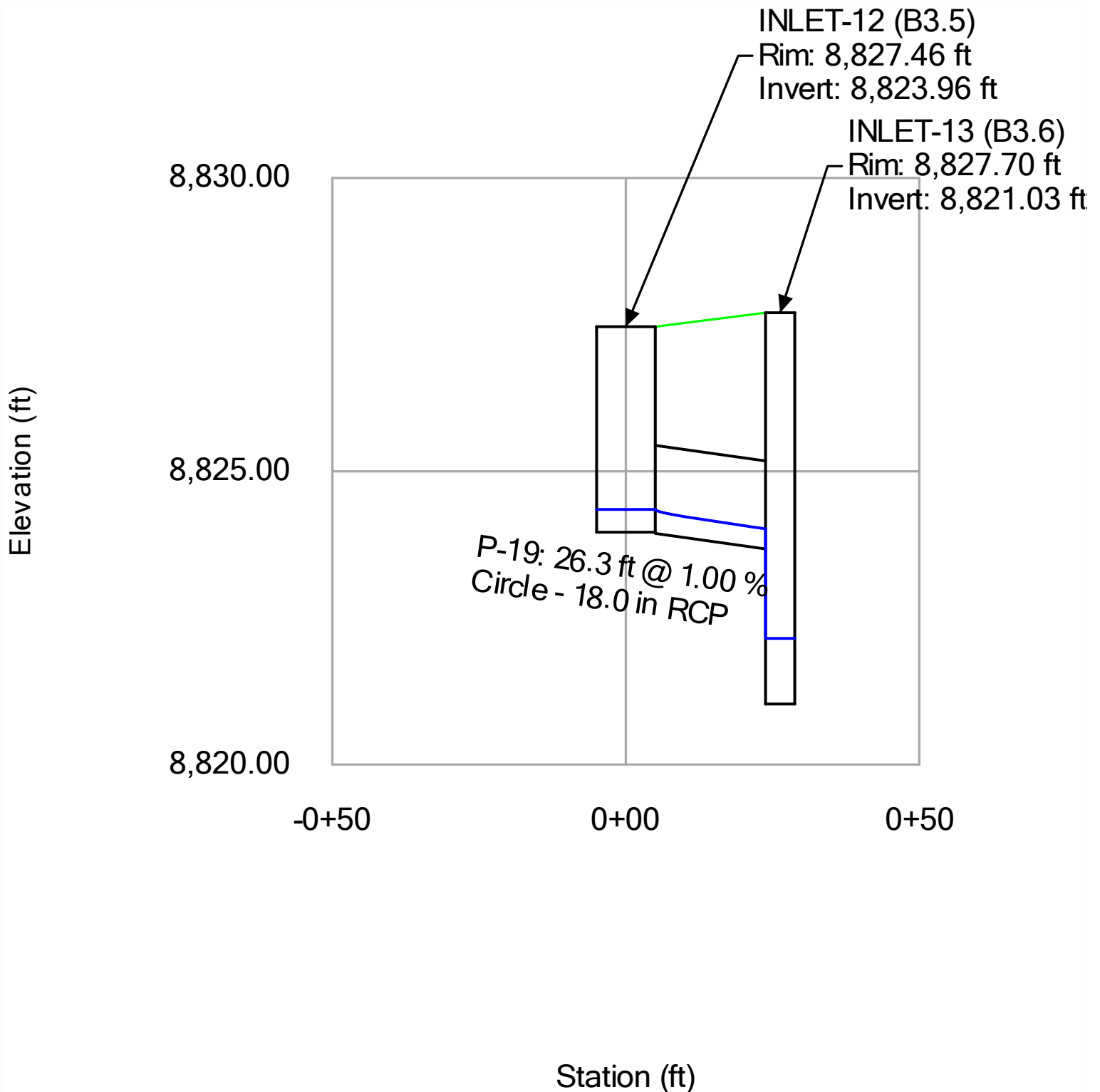


STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

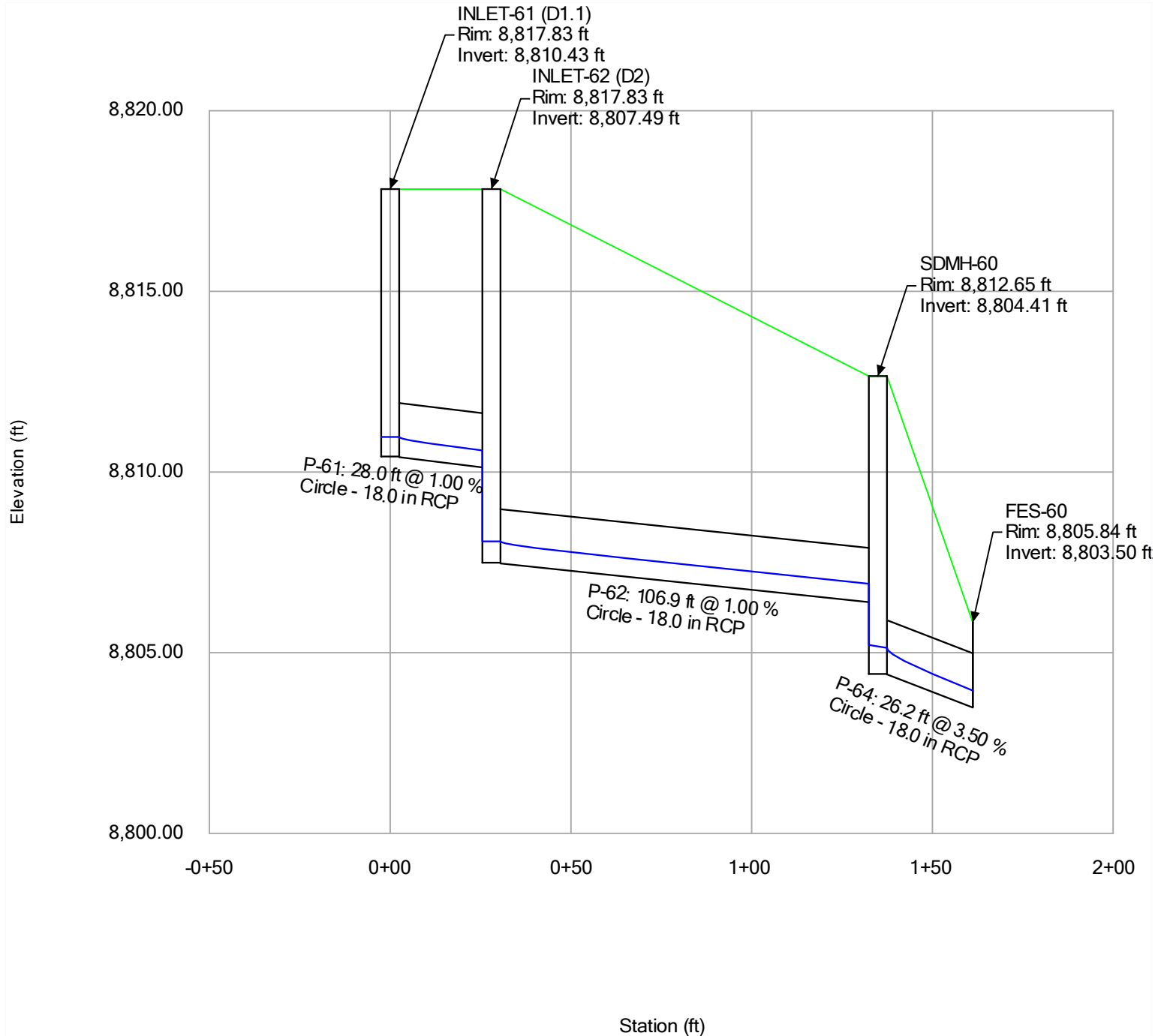


STORMCAD OUTPUT TABLES
West Mountain - 10W - 5-Year



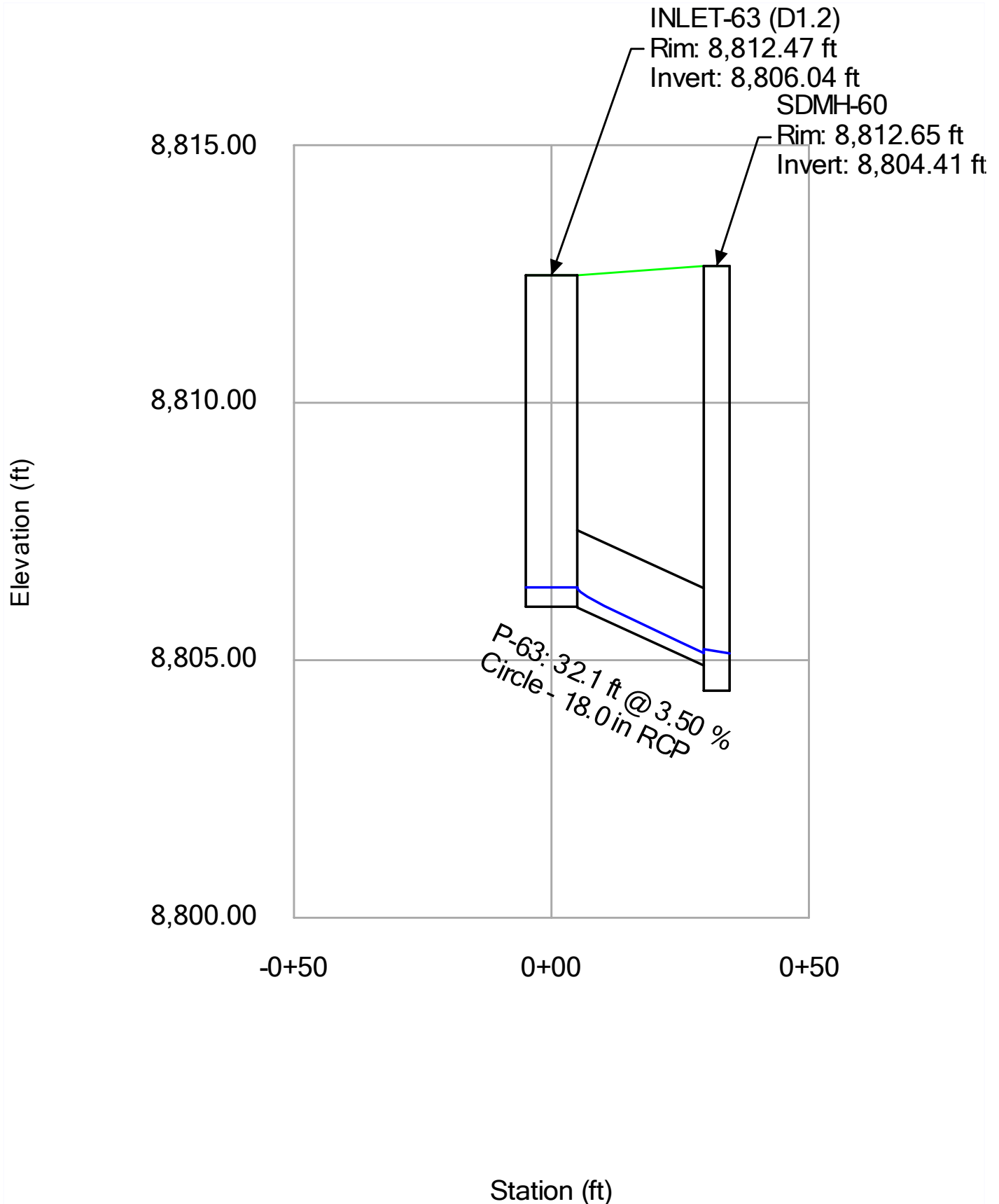
STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

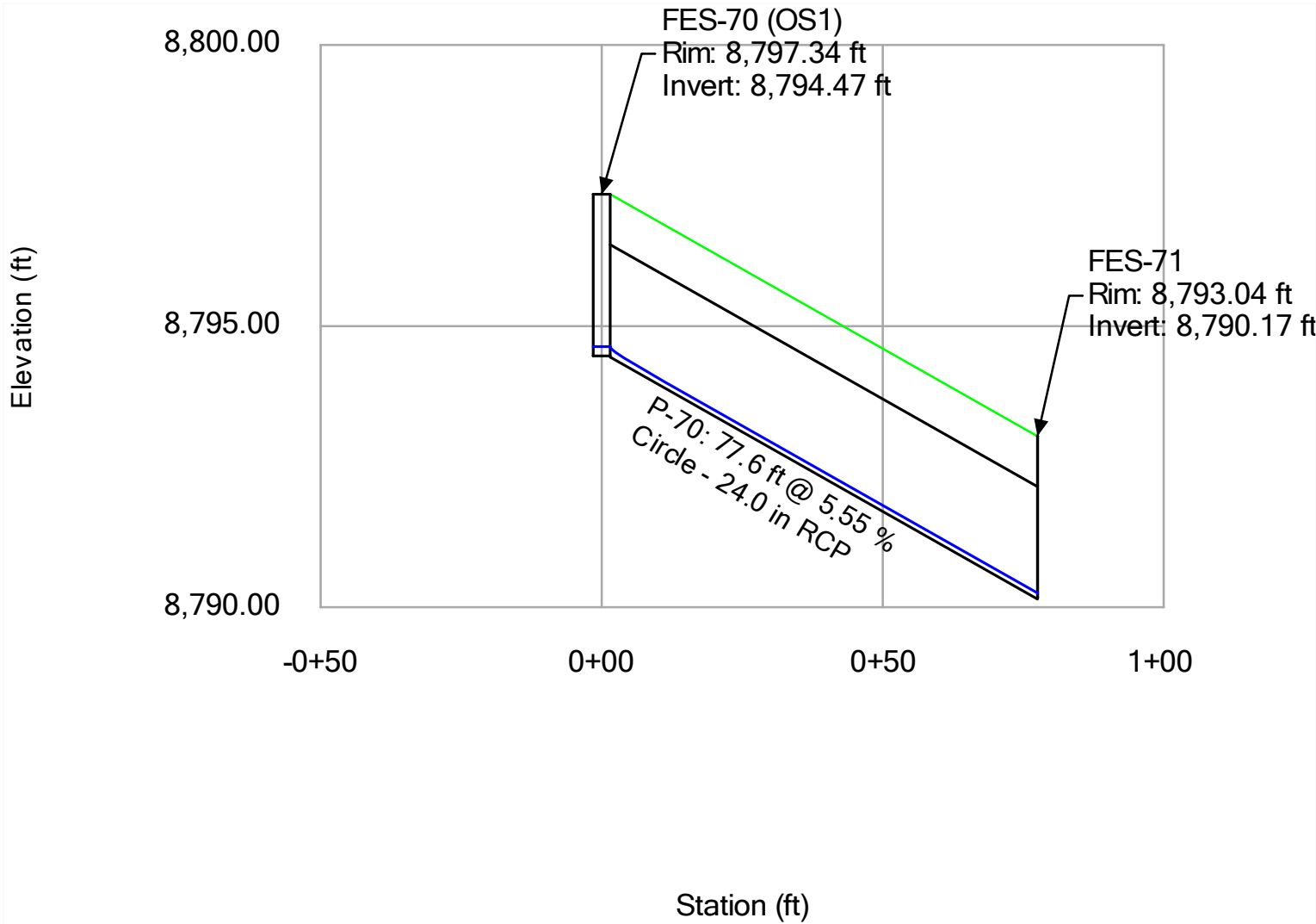


STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year

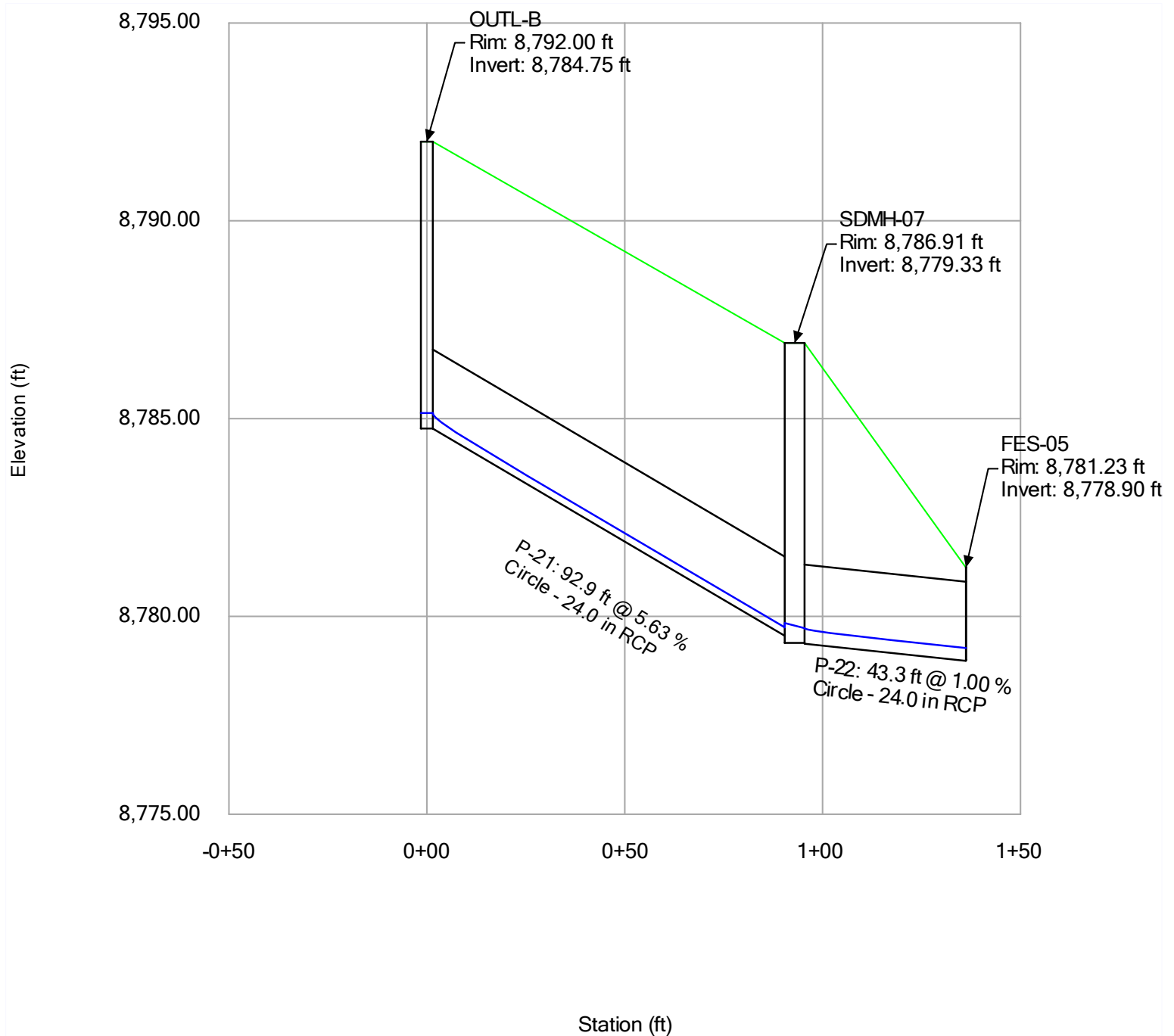


STORMCAD OUTPUT TABLES
West Mountain - 10W - 5-Year



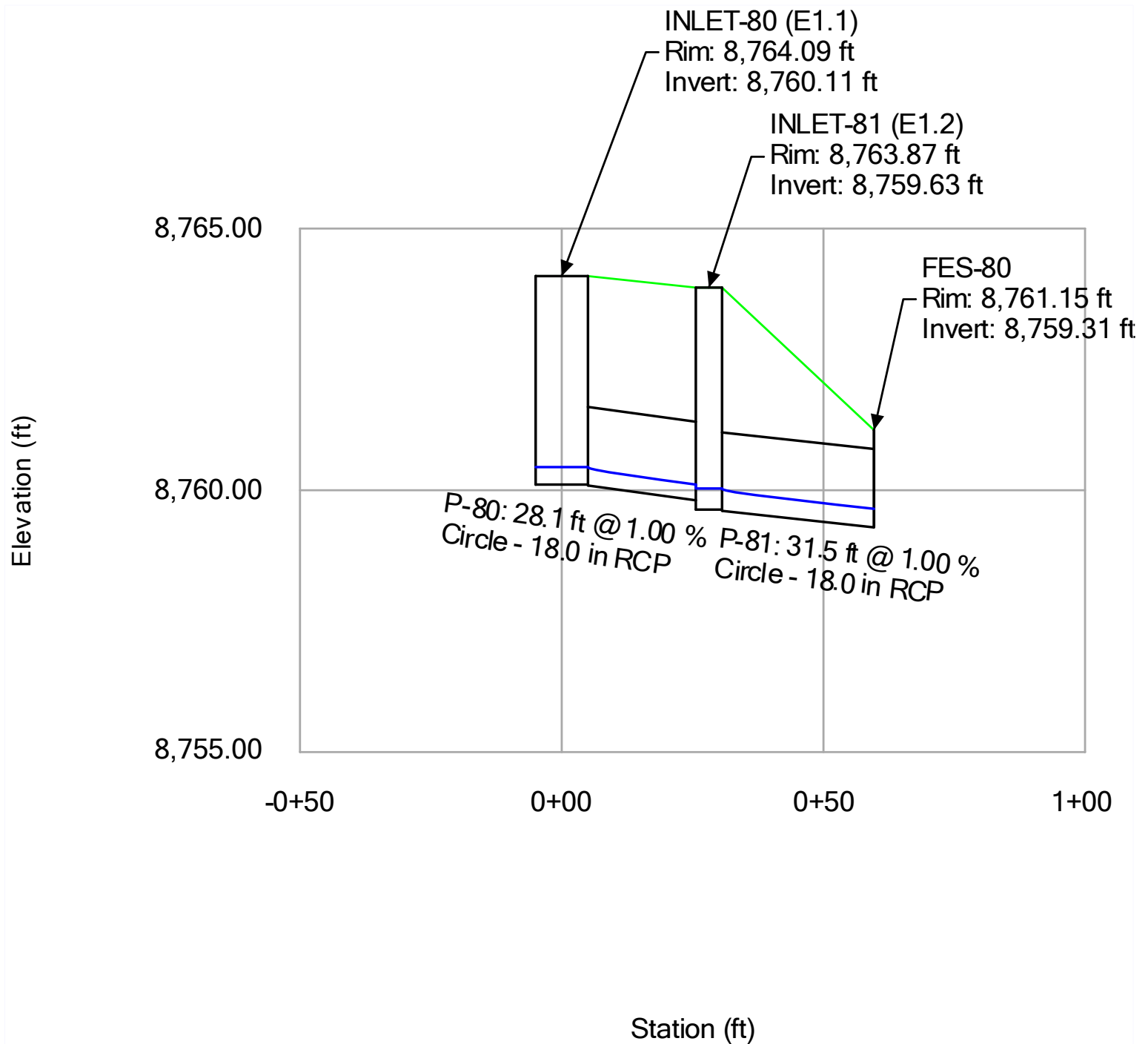
STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year



STORMCAD OUTPUT TABLES

West Mountain - 10W - 5-Year



STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year

STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year

Catch Basin Table - Time: 0.00 hours

Label	Rim (ft)	Invert (ft)	Flow (cfs)	HGL (In) (ft)	HGL (Out) (ft)	Inlet Location	Notes
FES-02 (B2.1+B1)	8,846.29	8,843.79	34.20	8,843.92	8,843.92	In Sag	30" FES
FES-70 (OS1)	8,797.34	8,794.47	1.00	8,794.79	8,794.79	In Sag	30" FES
INLET-01 (B1.1)	8,869.47	8,862.10	7.50	8,863.94	8,863.94	In Sag	10' TYPE R INLET
INLET-02 (B1.2)	8,869.47	8,861.64	12.40	8,863.81	8,863.81	In Sag	10' TYPE R INLET
INLET-03 (B1.3)	8,865.53	8,861.58	4.90	8,863.12	8,863.12	In Sag	TYPE C INLET
INLET-04 (B1.4)	8,867.34	8,860.57	19.90	8,863.01	8,863.01	In Sag	10' TYPE R INLET
INLET-05 (B1.5)	8,867.68	8,860.11	23.60	8,861.83	8,861.83	In Sag	5' TYPE R INLET
INLET-06 (B2.2)	8,846.76	8,840.02	36.10	8,842.04	8,842.04	In Sag	5' TYPE R INLET
INLET-07 (B2.4)	8,840.75	8,836.18	1.20	8,837.79	8,837.79	In Sag	5' TYPE R INLET
INLET-08 (B2.3)	8,840.75	8,835.72	38.00	8,837.78	8,837.78	In Sag	5' TYPE R INLET
INLET-09 (B3.1+B3.2)	8,845.79	8,842.00	20.80	8,843.62	8,843.62	In Sag	TYPE C INLET
INLET-10 (B3.3)	8,847.66	8,840.70	22.10	8,842.36	8,842.36	In Sag	5' TYPE R INLET
INLET-11 (B3.4)	8,847.66	8,837.18	23.10	8,838.87	8,838.87	In Sag	5' TYPE R INLET
INLET-12 (B3.5)	8,827.46	8,823.96	3.40	8,824.64	8,824.64	In Sag	10' TYPE R INLET
INLET-13 (B3.6)	8,827.70	8,821.03	27.00	8,823.10	8,823.10	In Sag	5' TYPE R INLET
INLET-30 (A4.1)	8,923.30	8,918.84	2.70	8,919.45	8,919.45	In Sag	10' TYPE R INLET
INLET-31 (A4.2)	8,923.30	8,918.36	4.70	8,919.18	8,919.18	In Sag	10' TYPE R INLET
INLET-40 (C2.2)	8,877.77	8,871.03	1.40	8,872.68	8,872.68	In Sag	5' TYPE R INLET
INLET-41 (C2.1)	8,877.68	8,870.53	3.50	8,872.68	8,872.68	In Sag	5' TYPE R INLET
INLET-42 (C1+C2.3)	8,875.28	8,869.88	12.80	8,872.66	8,872.66	In Sag	TYPE C INLET
INLET-43 (C2.4)	8,875.29	8,869.26	1.20	8,869.64	8,869.64	In Sag	5' TYPE R INLET
INLET-44 (C2.5)	8,875.38	8,868.59	1.60	8,869.04	8,869.04	In Sag	5' TYPE R INLET
INLET-45 (C2.6)	8,869.00	8,864.80	1.50	8,865.29	8,865.29	In Sag	10' TYPE R INLET
INLET-46 (C2.7)	8,870.93	8,864.21	3.00	8,865.32	8,865.32	In Sag	10' TYPE R INLET
INLET-61 (D1.1)	8,817.83	8,810.43	8.10	8,811.51	8,811.51	In Sag	10' TYPE R INLET
INLET-62 (D2)	8,817.83	8,807.49	9.20	8,808.64	8,808.64	In Sag	5' TYPE R INLET
INLET-63 (D1.2)	8,812.47	8,806.04	3.70	8,806.76	8,806.76	In Sag	15' TYPE R INLET
INLET-80 (E1.1)	8,764.09	8,760.11	3.20	8,760.77	8,760.77	In Sag	10' TYPE R INLET
INLET-81 (E1.2)	8,763.87	8,759.63	4.30	8,760.40	8,760.40	In Sag	5' TYPE R INLET
OUTL-B	8,792.00	8,784.75	26.20	8,786.54	8,786.54	In Sag	OUTLET STRUCTURE

Manhole Table - Time: 0.00 hours

Label	Flow (cfs)	Headloss (ft)	Elevation (Rim) (ft)	HGL (In) (ft)	HGL (Out) (ft)	Notes	Headloss Method	AASHTO Shaping Method
SDMH-01	34.20	0.60	8,847.40	8,843.46	8,842.87	6' DIA MH FLAT TOP	AASHTO	Full
SDMH-02	36.10	0.36	8,846.49	8,841.67	8,841.31	6' DIA MH	AASHTO	Full
SDMH-03	23.10	0.00	8,846.98	8,835.63	8,835.63	5' DIA MH	AASHTO	Full
SDMH-04	23.10	0.00	8,843.79	8,831.99	8,831.99	5' DIA MH	AASHTO	Full
SDMH-05	23.10	0.00	8,838.80	8,828.45	8,828.45	5' DIA MH	AASHTO	Full
SDMH-06	23.10	0.00	8,836.26	8,825.63	8,825.63	5' DIA MH	AASHTO	Full
SDMH-07	26.20	0.61	8,786.91	8,781.94	8,781.32	5' DIA MH	AASHTO	Full
SDMH-15	12.80	0.24	8,875.64	8,870.78	8,870.54	5' DIA MH	AASHTO	Full
SDMH-16	14.40	0.34	8,873.61	8,868.66	8,868.32	6' DIA MH	AASHTO	Full
SDMH-17	17.40	0.54	8,869.97	8,865.31	8,864.76	6' DIA MH	AASHTO	Full
SDMH-30	4.70	0.19	8,922.22	8,918.23	8,918.04	5' DIA MH	AASHTO	Full
SDMH-60	12.90	0.14	8,812.65	8,805.89	8,805.75	5' DIA MH	AASHTO	Full

STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year
Conduit Table - Time: 0.00 hours

Label	Start Node	Stop Node	Invert (Start) (ft)	Invert (Stop) (ft)	Length (ft)	Slope (%)	Dia. (in)	Mann.	Flow (cfs)	Velo. (ft/s)	Depth (ft)	Capacity (cfs)	Froude Number	HGL (In) (ft)	HGL (Out) (ft)
P-01	INLET-01 (B1.1)	INLET-02 (B1.2)	8,862.08	8,861.82	26.0	1.00	18.0	0.013	7.50	4.24	1.06	10.50	1.273	8,863.94	8,863.81
P-02	INLET-02 (B1.2)	INLET-04 (B1.4)	8,861.62	8,861.05	57.0	1.00	18.0	0.013	12.40	7.02	1.33	10.50	1.010	8,863.81	8,863.01
P-03	INLET-03 (B1.3)	INLET-04 (B1.4)	8,861.56	8,861.05	51.0	1.00	18.0	0.013	4.90	2.77	0.85	10.50	1.377	8,863.12	8,863.01
P-04	INLET-04 (B1.4)	INLET-05 (B1.5)	8,860.85	8,860.59	26.0	1.00	18.0	0.013	19.90	11.26	1.47	10.50	1.621	8,863.01	8,862.06
P-05	INLET-05 (B1.5)	SDMH-01.1	8,860.09	8,859.98	10.8	1.00	24.0	0.013	23.60	8.15	1.72	22.58	0.984	8,861.83	8,861.71
P-06	FES-02 (B2.1+ B1)	SDMH-01	8,841.93	8,841.35	10.5	5.50	30.0	0.013	34.20	17.94	1.99	96.21	3.593	8,843.92	8,843.46
P-07	SDMH-01	INLET-06 (B2.2)	8,840.88	8,840.20	41.0	1.65	30.0	0.013	34.20	11.42	1.99	52.66	1.825	8,842.87	8,841.80
P-08	INLET-06 (B2.2)	SDMH-02	8,840.00	8,839.47	32.1	1.65	30.0	0.013	36.10	11.57	2.04	52.73	1.804	8,842.04	8,841.67
P-09	SDMH-02	INLET-08 (B2.3)	8,839.27	8,835.90	142.2	2.37	30.0	0.013	36.10	13.29	2.04	63.15	2.245	8,841.31	8,837.28
P-10	INLET-07 (B2.4)	INLET-08 (B2.3)	8,836.16	8,835.90	26.0	1.00	18.0	0.013	1.20	0.68	0.41	10.50	1.418	8,837.79	8,837.78
P-11	INLET-08 (B2.3)	FES-03	8,835.70	8,835.46	23.8	1.00	30.0	0.013	38.00	9.48	2.08	40.98	1.219	8,837.78	8,837.41
P-12	INLET-09 (B3.1+ B3.2)	INLET-10 (B3.3)	8,841.98	8,841.68	15.0	2.00	24.0	0.013	20.80	10.84	1.63	31.99	1.936	8,843.62	8,843.04
P-13	INLET-10 (B3.3)	INLET-11 (B3.4)	8,840.68	8,840.16	26.0	2.00	24.0	0.013	22.10	10.99	1.68	31.99	1.907	8,842.36	8,841.52
P-14	INLET-11 (B3.4)	SDMH-03	8,837.16	8,836.43	36.9	2.00	24.0	0.013	23.10	11.10	1.71	32.01	1.885	8,838.87	8,837.79
P-15	SDMH-03	SDMH-04	8,833.93	8,832.28	82.3	2.00	24.0	0.013	23.10	11.09	1.71	31.99	1.883	8,835.63	8,833.58
P-16	SDMH-04	SDMH-05	8,830.28	8,828.74	76.8	2.00	24.0	0.013	23.10	11.10	1.71	32.02	1.886	8,831.99	8,830.04
P-17	SDMH-05	SDMH-06	8,826.74	8,825.92	41.1	2.00	24.0	0.013	23.10	11.09	1.71	31.97	1.882	8,828.45	8,827.27
P-18	SDMH-06	INLET-13 (B3.6)	8,823.92	8,821.52	120.2	2.00	24.0	0.013	23.10	11.08	1.71	31.97	1.881	8,825.63	8,822.79
P-19	INLET-12 (B3.5)	INLET-13 (B3.6)	8,823.94	8,823.68	26.3	1.00	18.0	0.013	3.40	5.30	0.70	10.50	1.413	8,824.64	8,824.27

STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year
Conduit Table - Time: 0.00 hours

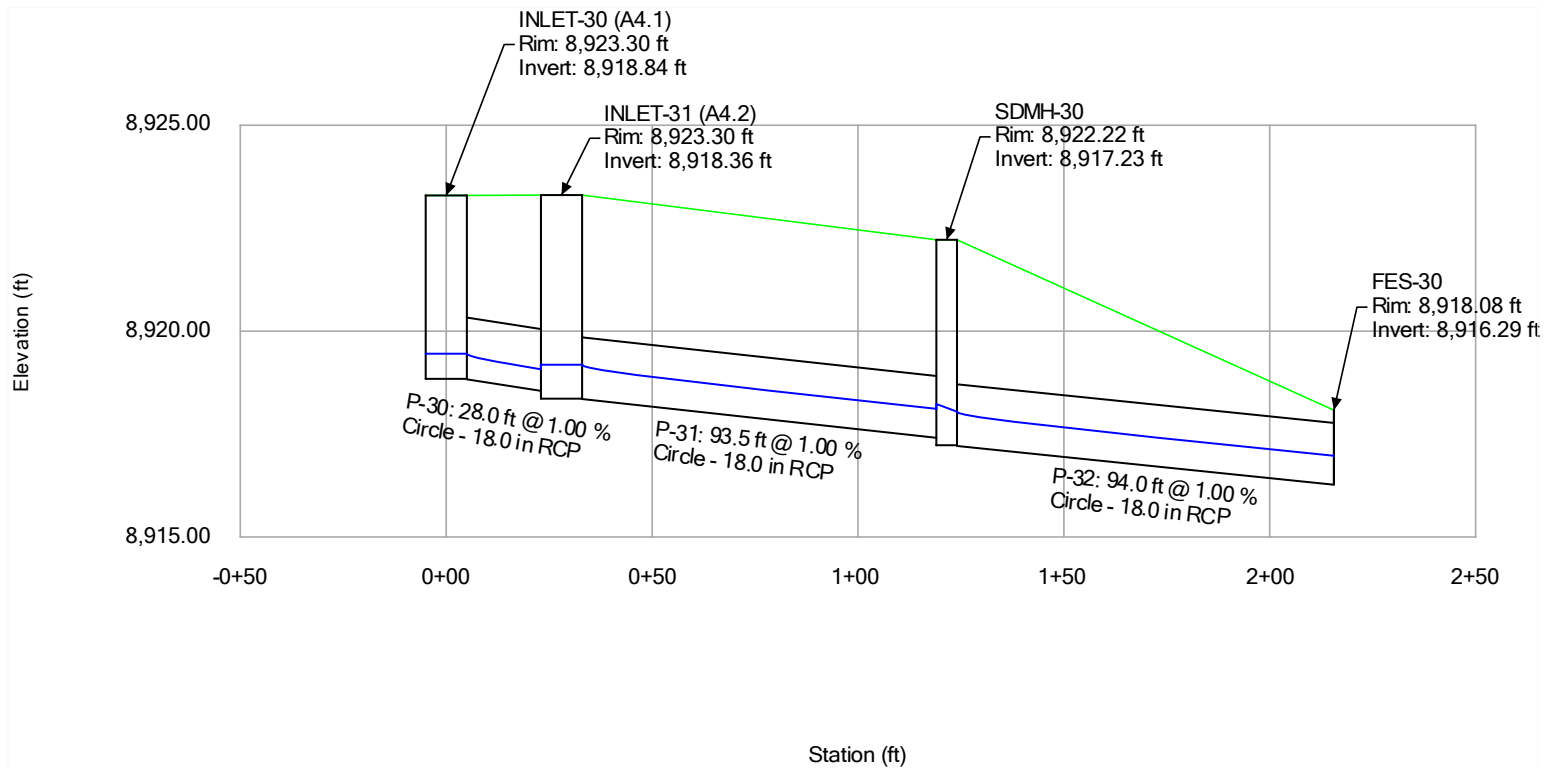
Label	Start Node	Stop Node	Invert (Start) (ft)	Invert (Stop) (ft)	Length (ft)	Slope (%)	Dia. (in)	Mann.	Flow (cfs)	Velo. (ft/s)	Depth (ft)	Capacity (cfs)	Froude Number	HGL (In) (ft)	HGL (Out) (ft)
P-20	INLET-13 (B3.6)	FES-04	8,821.02	8,820.58	43.7	1.00	24.0	0.013	27.00	8.59	1.81	22.59	1.071	8,823.10	8,822.39
P-21	OUTL-B	SDMH-07	8,784.75	8,779.51	92.9	5.63	24.0	0.013	26.20	16.98	1.79	53.69	3.408	8,786.54	8,781.94
P-22	SDMH-07	FES-05	8,779.31	8,778.88	43.3	1.00	24.0	0.013	26.20	8.34	1.79	22.65	1.040	8,781.32	8,780.67
P-30	INLET-30 (A4.1)	INLET-31 (A4.2)	8,918.83	8,918.55	28.0	1.00	18.0	0.013	2.70	4.98	0.62	10.50	1.424	8,919.45	8,919.18
P-31	INLET-31 (A4.2)	SDMH-30	8,918.35	8,917.41	93.5	1.00	18.0	0.013	4.70	5.79	0.83	10.53	1.386	8,919.18	8,918.11
P-32	SDMH-30	FES-30	8,917.21	8,916.27	94.0	1.00	18.0	0.013	4.70	5.78	0.83	10.50	1.383	8,918.04	8,916.97
P-42	INLET-40 (C2.2)	INLET-41 (C2.1)	8,871.01	8,870.71	29.6	1.00	18.0	0.013	1.40	0.79	0.44	10.50	1.422	8,872.68	8,872.68
P-43	INLET-41 (C2.1)	INLET-42 (C1 +C2.3)	8,870.51	8,870.36	15.4	1.00	18.0	0.013	3.50	1.98	0.71	10.49	1.409	8,872.68	8,872.66
P-44	INLET-42 (C1 +C2.3)	SDMH-15	8,869.86	8,868.59	126.6	1.00	18.0	0.013	12.80	7.24	1.34	10.52	1.043	8,872.66	8,870.78
P-45	SDMH-15	SDMH-16	8,868.39	8,867.13	126.6	1.00	18.0	0.013	12.80	7.24	1.34	10.48	1.043	8,870.54	8,868.66
P-46	INLET-43 (C2.4)	INLET-44 (C2.5)	8,869.24	8,868.77	46.4	1.00	18.0	0.013	1.20	3.95	0.41	10.51	1.419	8,869.64	8,869.11
P-47	INLET-44 (C2.5)	SDMH-16	8,868.57	8,867.38	119.4	1.00	18.0	0.013	1.60	4.29	0.48	10.49	1.424	8,869.04	8,868.66
P-48	SDMH-16	SDMH-17	8,866.93	8,863.76	110.5	2.87	18.0	0.013	14.40	11.21	1.39	17.79	2.060	8,868.32	8,865.31
P-49	INLET-45 (C2.6)	INLET-46 (C2.7)	8,864.71	8,864.33	38.2	1.00	18.0	0.013	1.50	4.22	0.46	10.50	1.425	8,865.29	8,865.32
P-50	INLET-46 (C2.7)	SDMH-17	8,864.13	8,863.76	36.5	1.00	18.0	0.013	3.00	5.12	0.66	10.50	1.419	8,865.32	8,865.31
P-51	SDMH-17	FBAY-C	8,863.26	8,863.06	19.7	1.00	24.0	0.013	17.40	7.95	1.50	22.66	1.306	8,864.76	8,864.42
P-61	INLET-61 (D1.1)	INLET-62 (D2)	8,810.41	8,810.13	28.0	1.00	18.0	0.013	8.10	6.56	1.10	10.50	1.241	8,811.51	8,811.13
P-62	INLET-62 (D2)	SDMH-60	8,807.47	8,806.40	106.9	1.00	18.0	0.013	9.20	6.70	1.17	10.51	1.168	8,808.64	8,807.49
P-63	INLET-63 (D1.2)	SDMH-60	8,806.02	8,804.90	32.1	3.50	18.0	0.013	3.70	8.54	0.73	19.66	2.673	8,806.76	8,805.89
P-64	SDMH-60	FES-60	8,804.40	8,803.48	26.2	3.50	18.0	0.013	12.90	11.86	1.35	19.65	2.435	8,805.75	8,804.48
P-70	FES-70 (OS1)	FES-71	8,794.45	8,790.15	77.6	5.55	24.0	0.013	1.00	6.59	0.34	53.30	3.230	8,794.79	8,790.33

STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year
Conduit Table - Time: 0.00 hours

Label	Start Node	Stop Node	Invert (Start) (ft)	Invert (Stop) (ft)	Length (ft)	Slope (%)	Dia. (in)	Mann.	Flow (cfs)	Velo. (ft/s)	Depth (ft)	Capacity (cfs)	Froude Number	HGL (In) (ft)	HGL (Out) (ft)
P-80	INLET-80 (E1.1)	INLET-81 (E1.2)	8,760.09	8,759.81	28.1	1.00	18.0	0.013	3.20	5.21	0.68	10.48	1.415	8,760.77	8,760.38
P-81	INLET-81 (E1.2)	FES-80	8,759.61	8,759.29	31.5	1.00	18.0	0.013	4.30	5.64	0.80	10.50	1.392	8,760.40	8,759.97

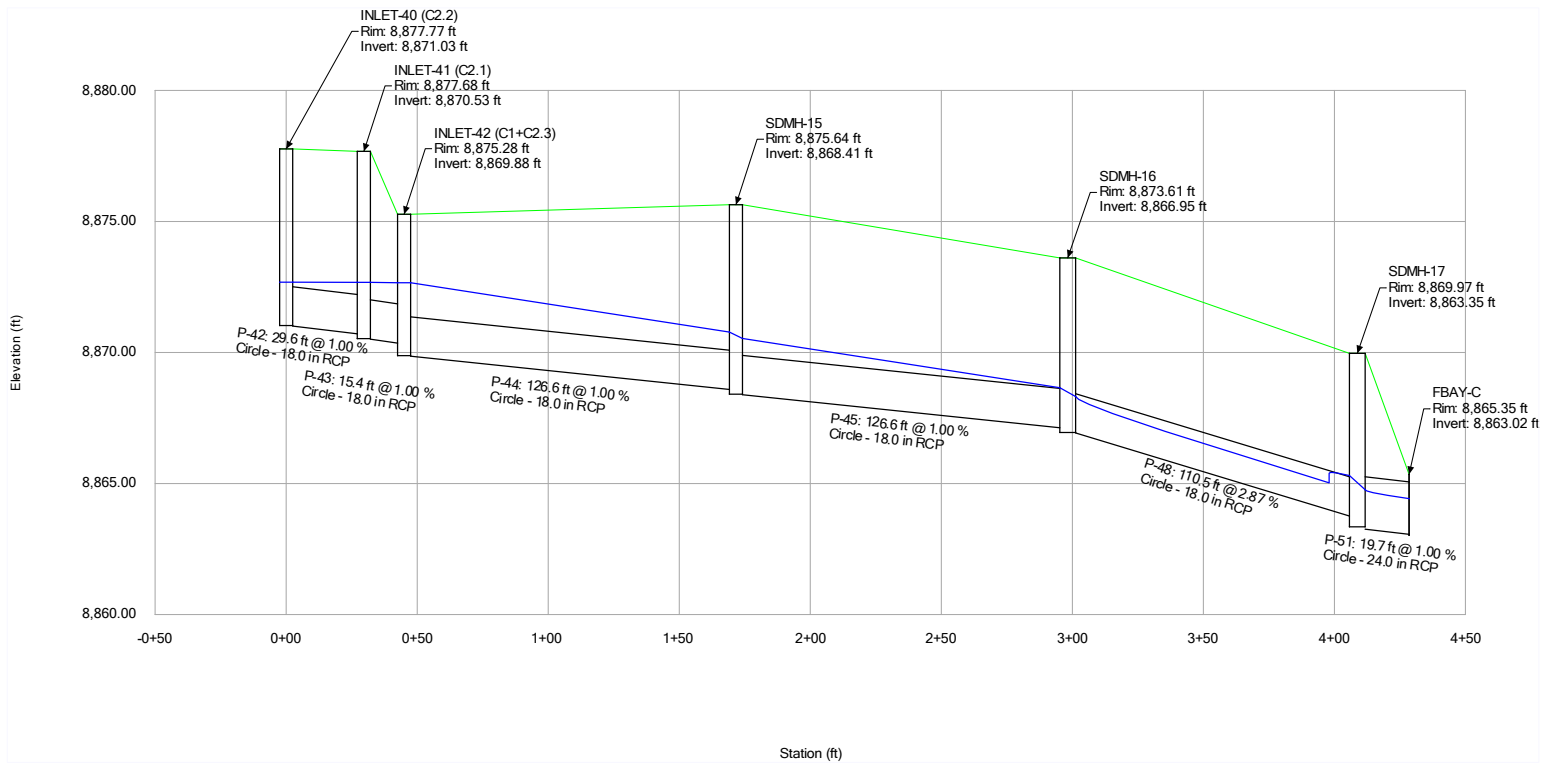
STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year



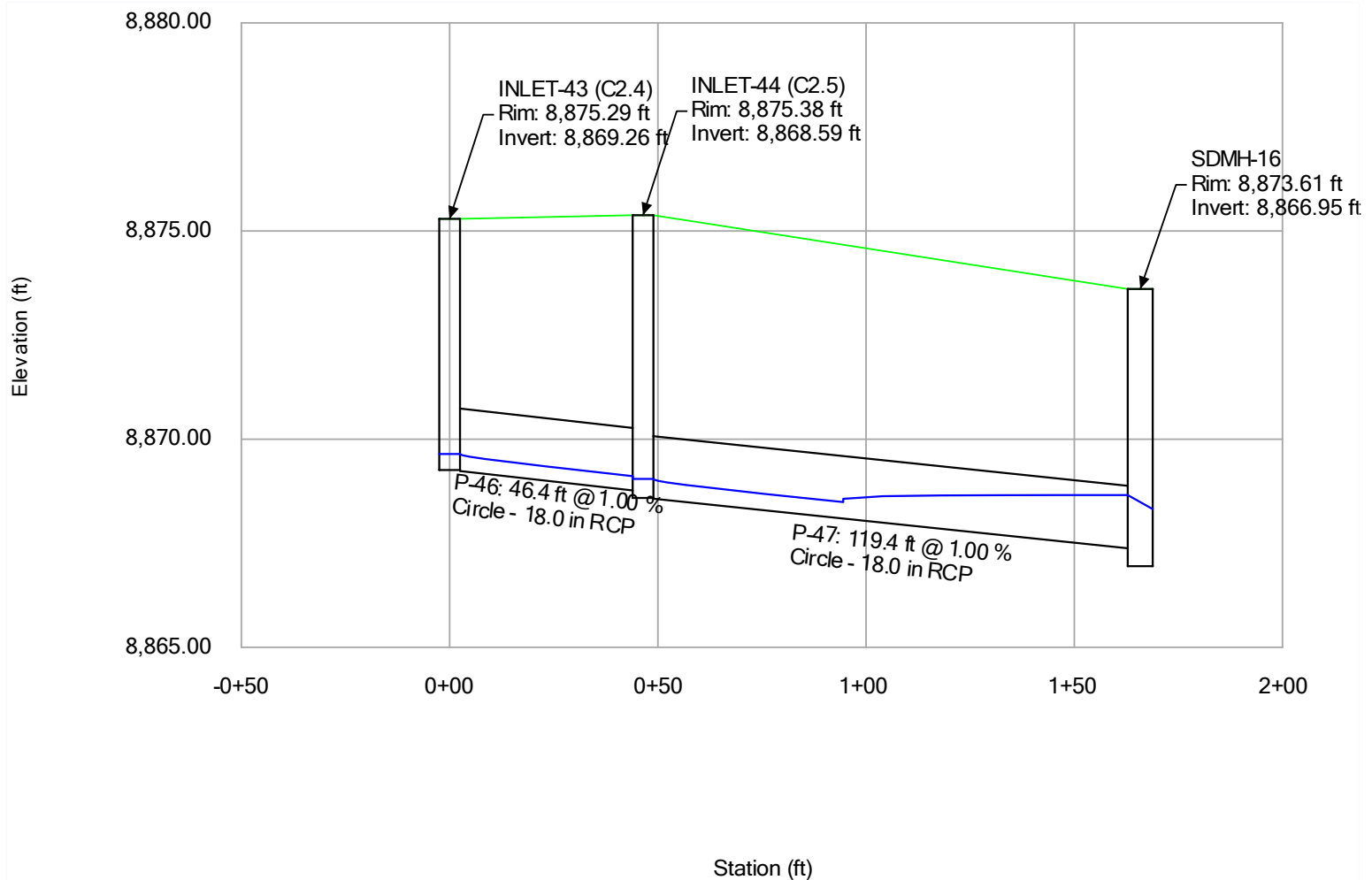
STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year

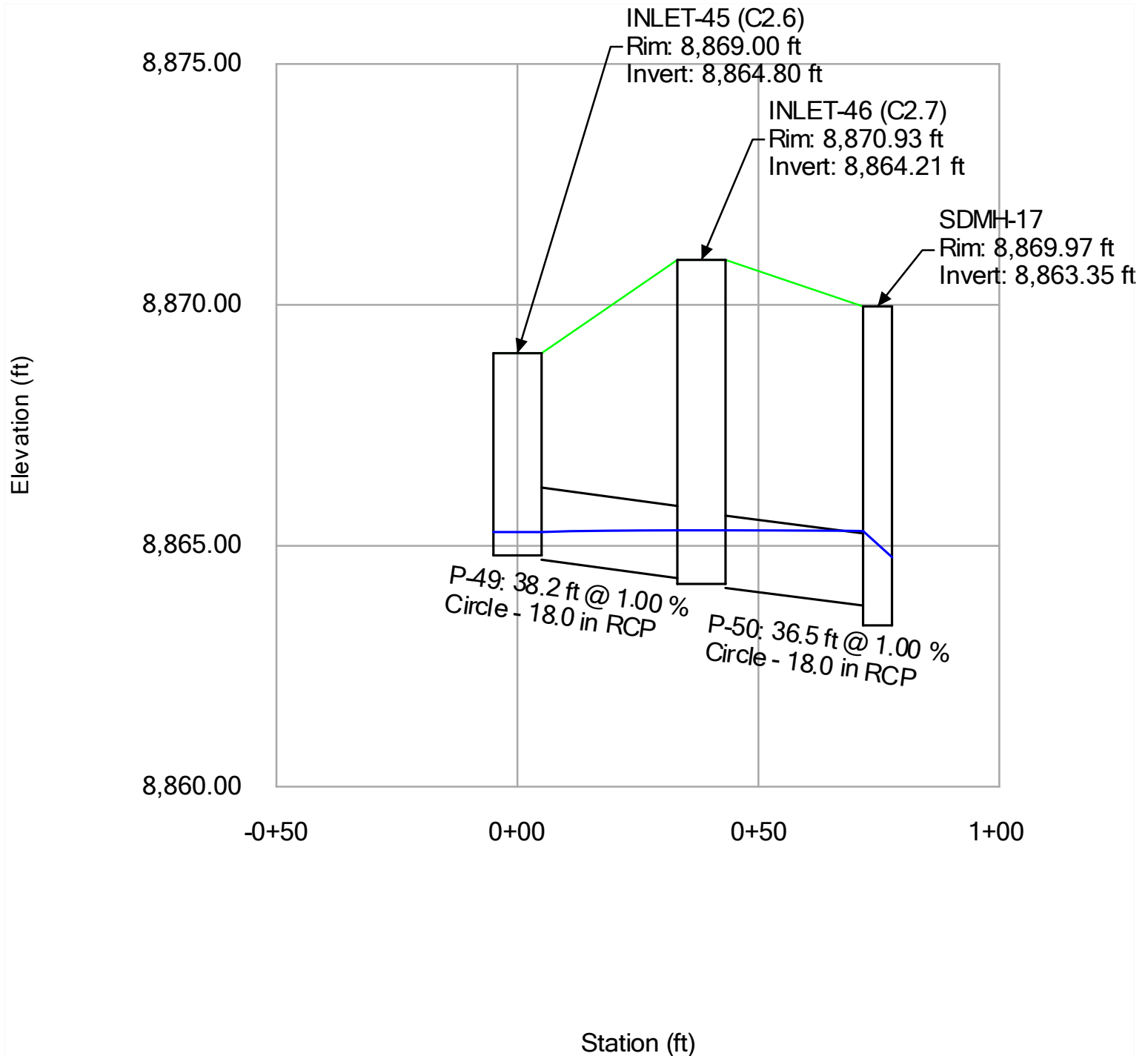


STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year

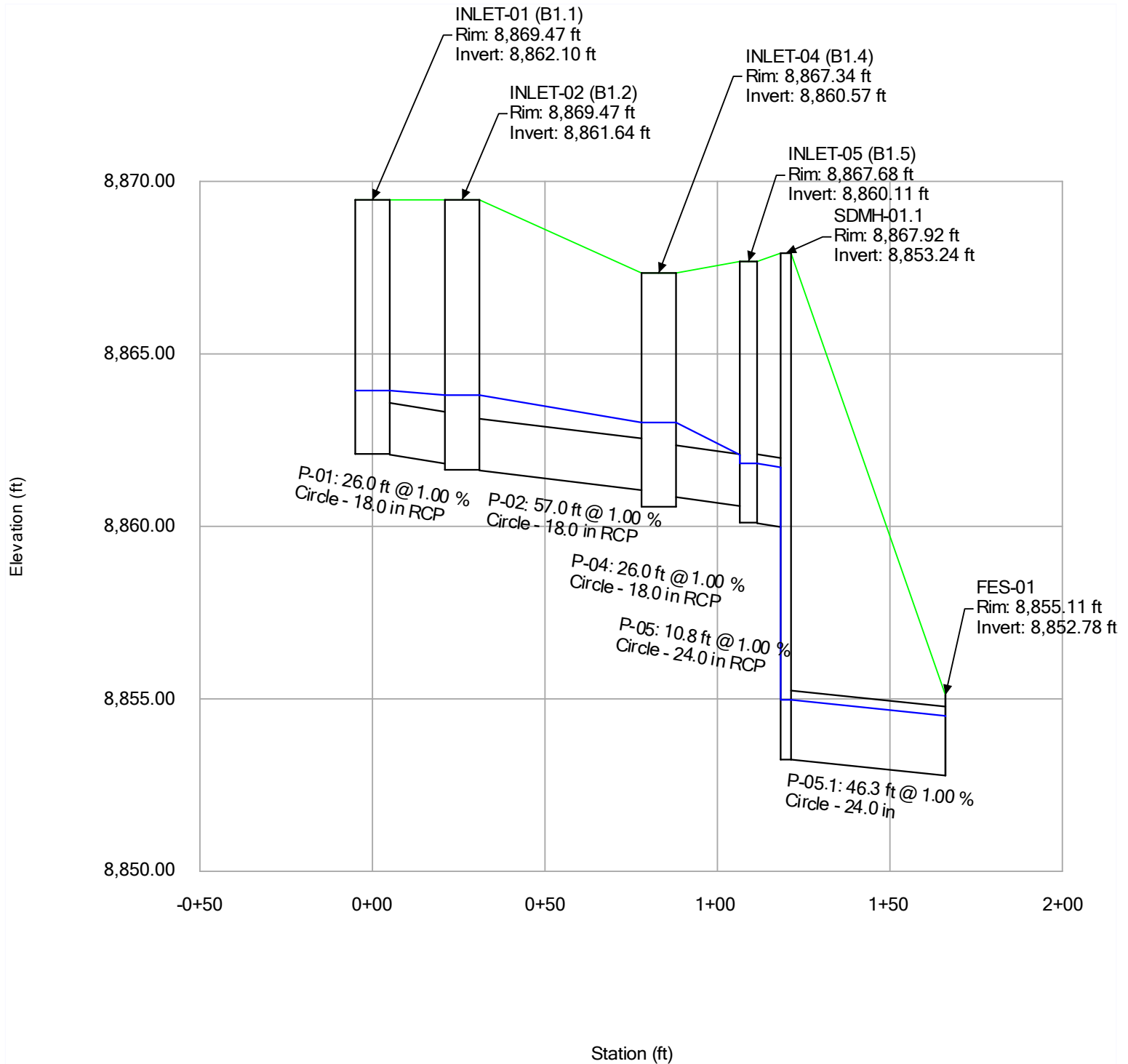


STORMCAD OUTPUT TABLES **West Mountain - 10W - 100-Year**

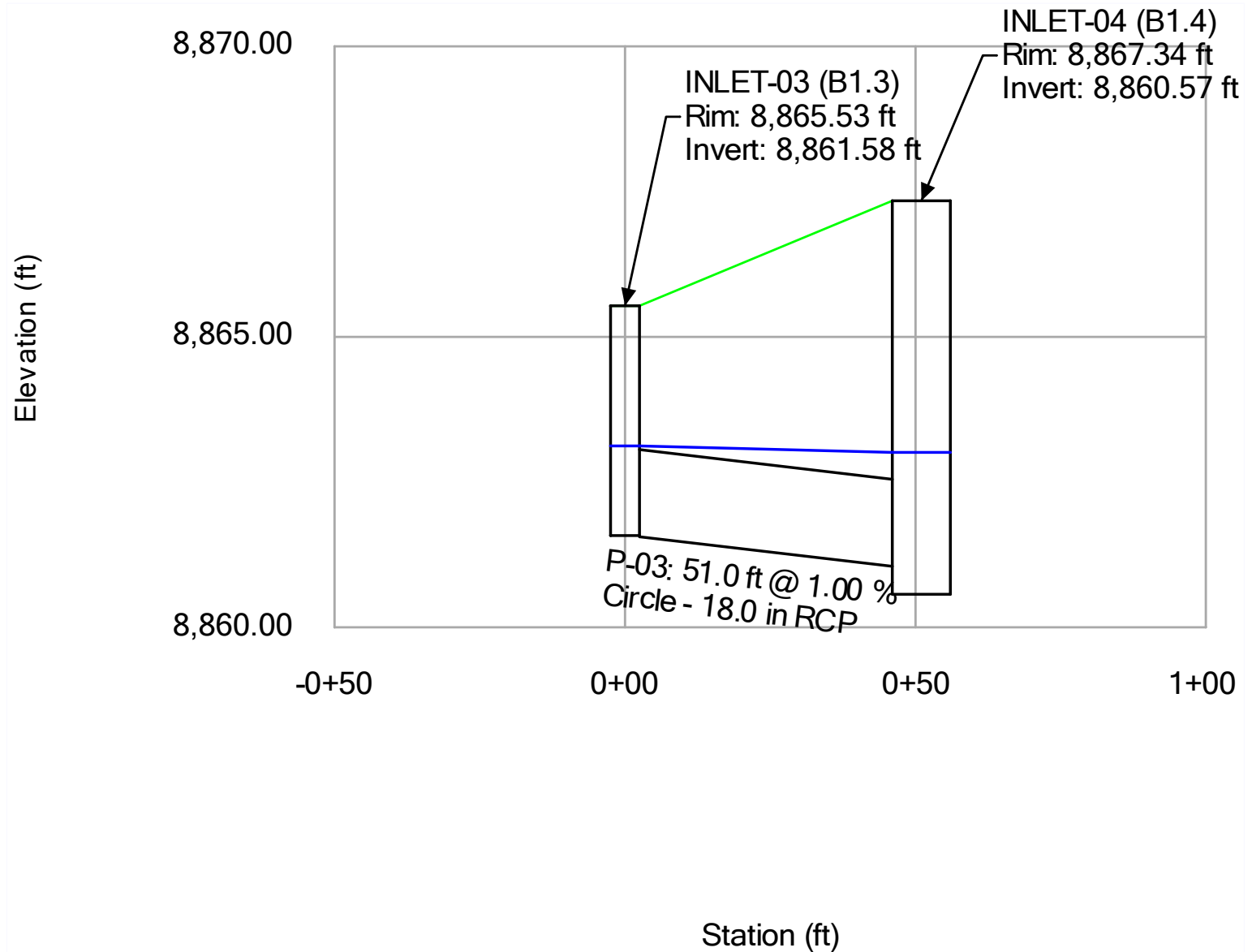


STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year

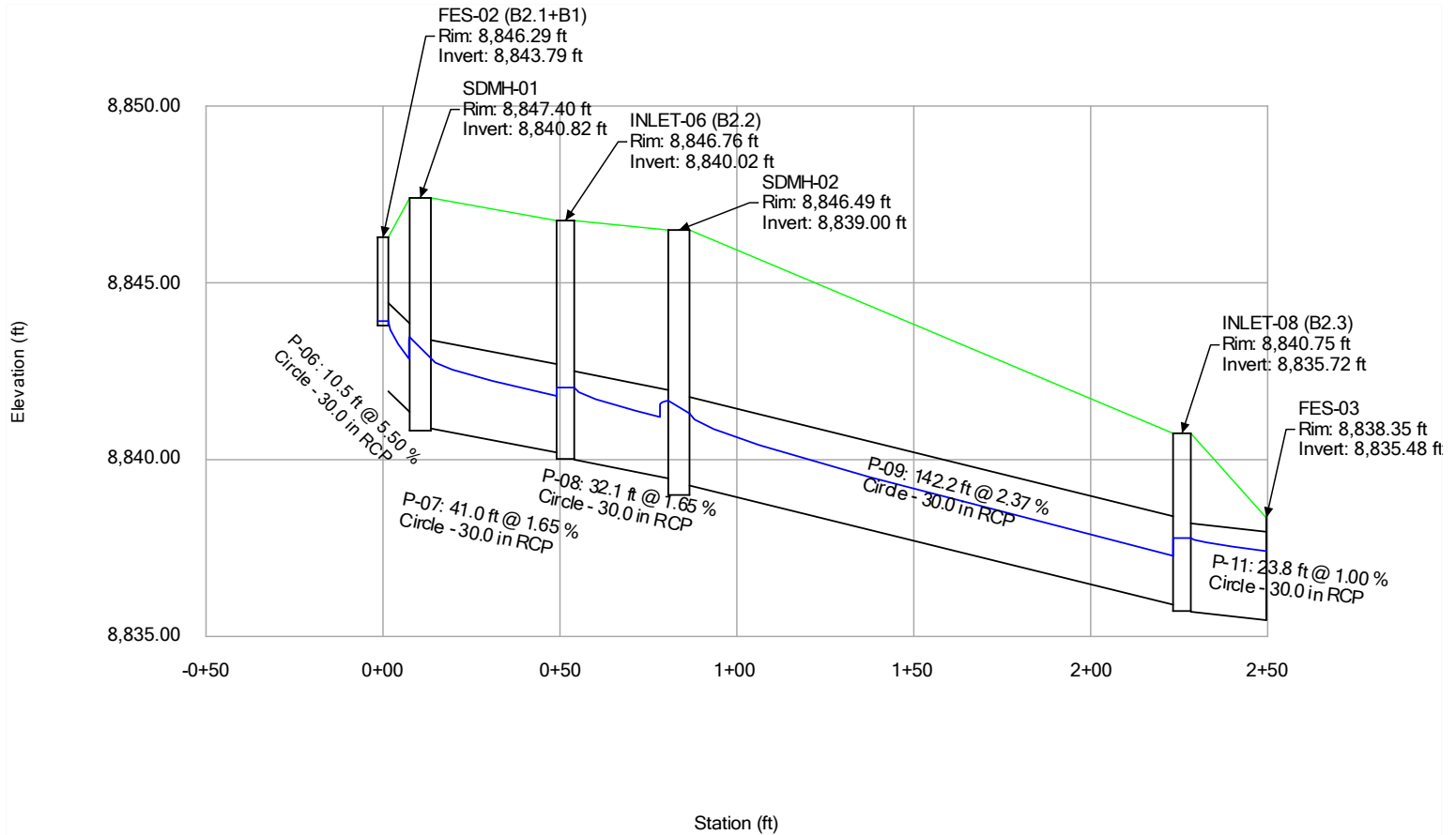


STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year

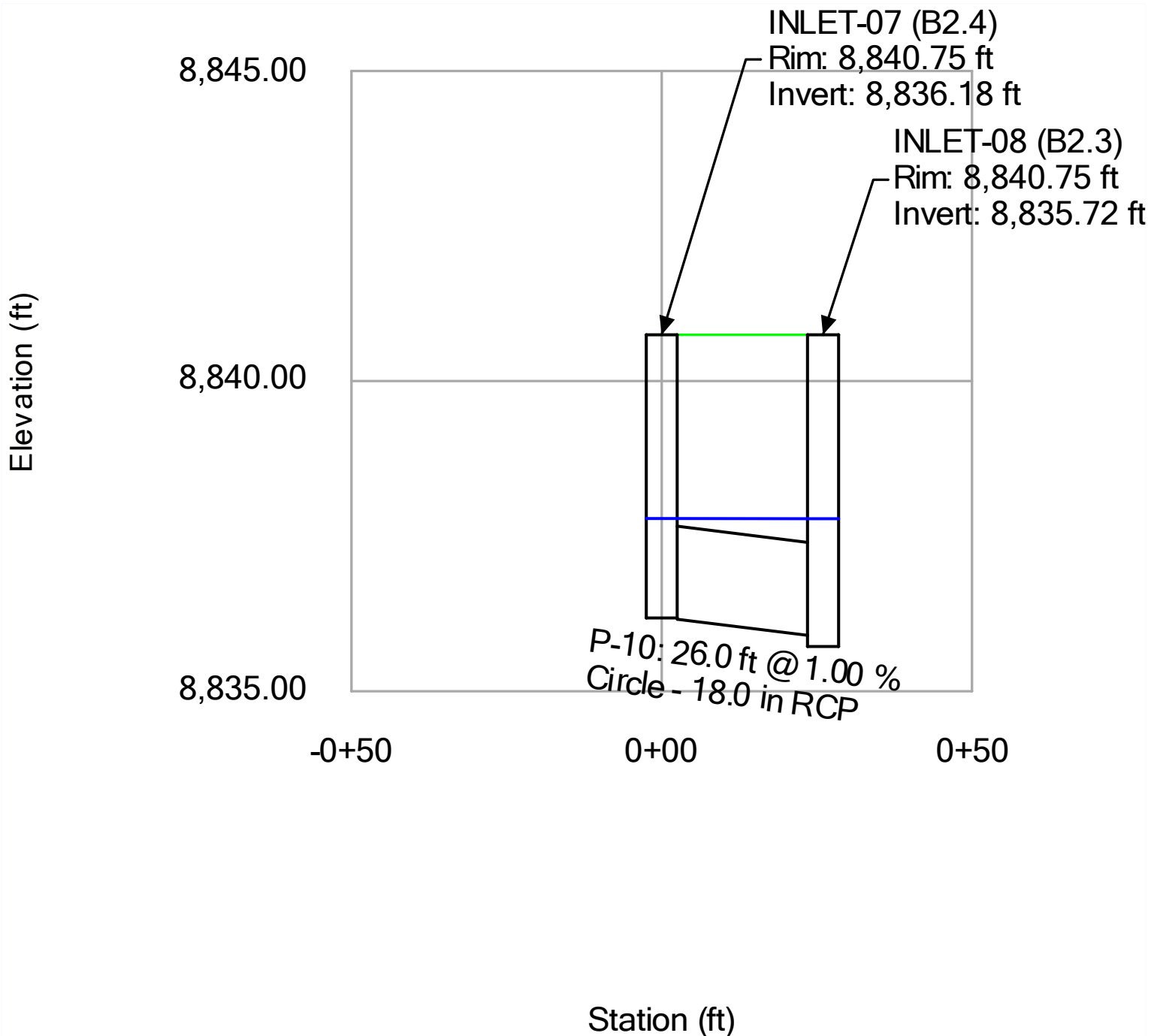


STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year

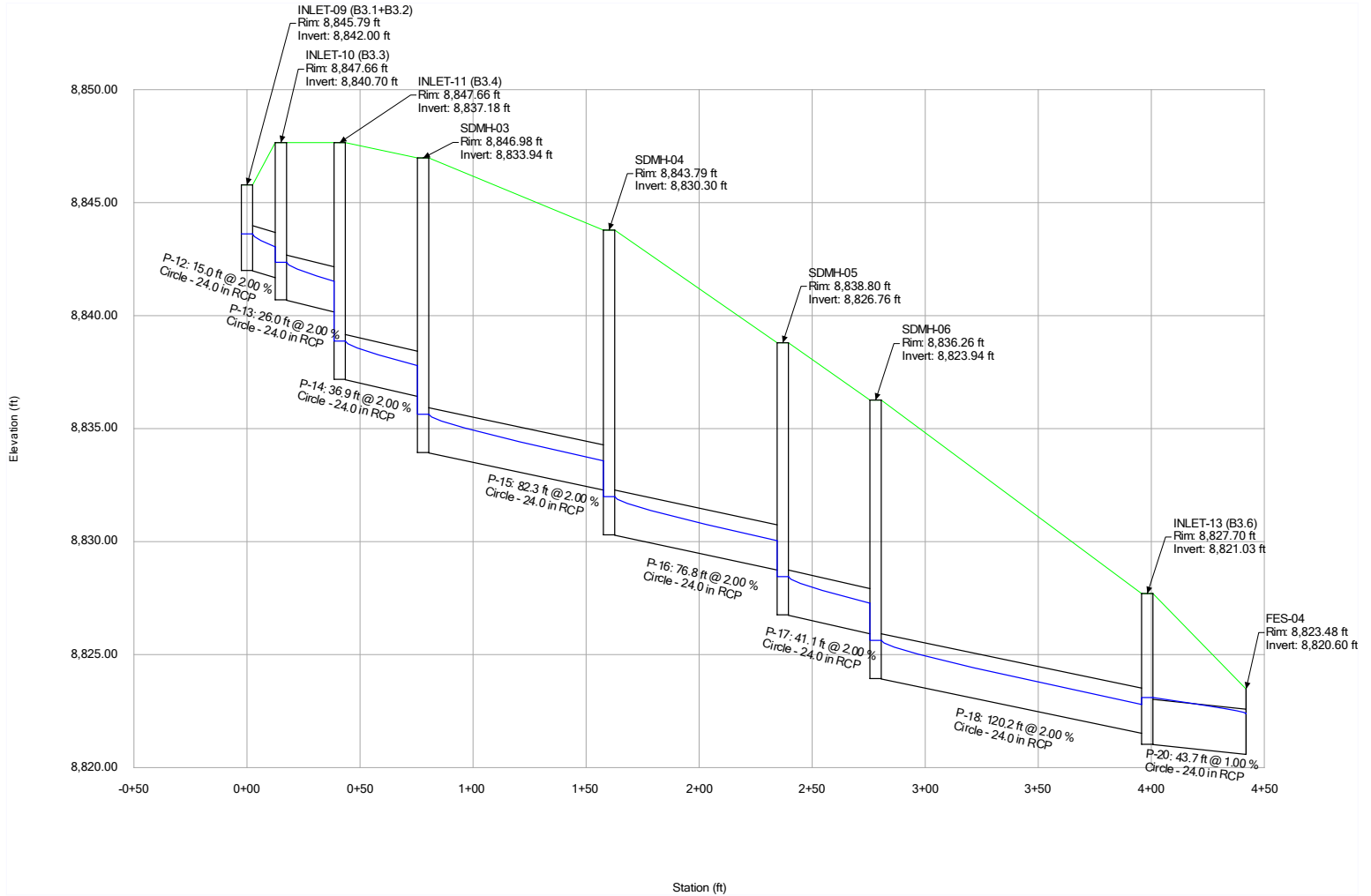


STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year

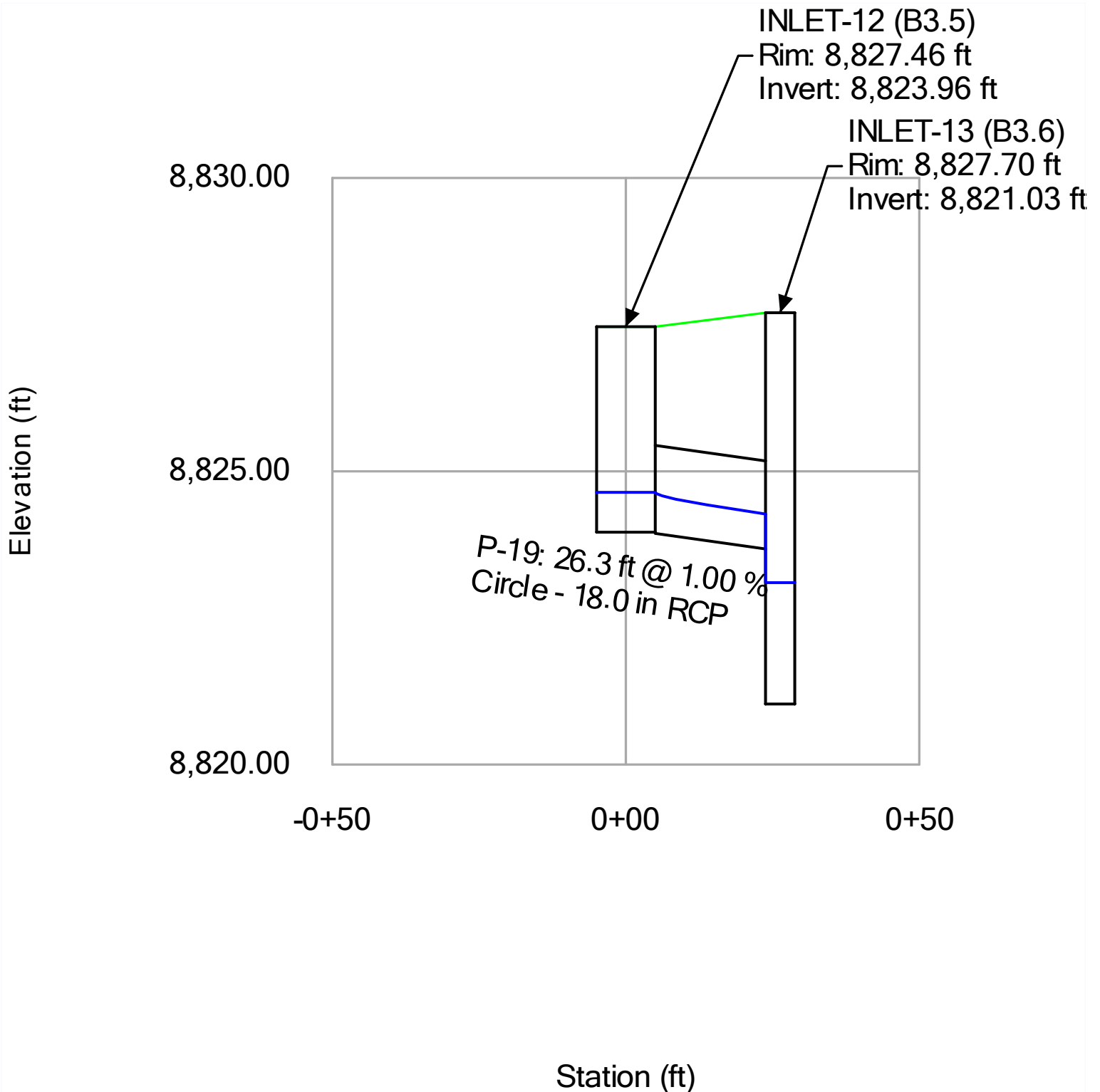


STORMCAD OUTPUT TABLES

West Mountain - 10W - 100-Year

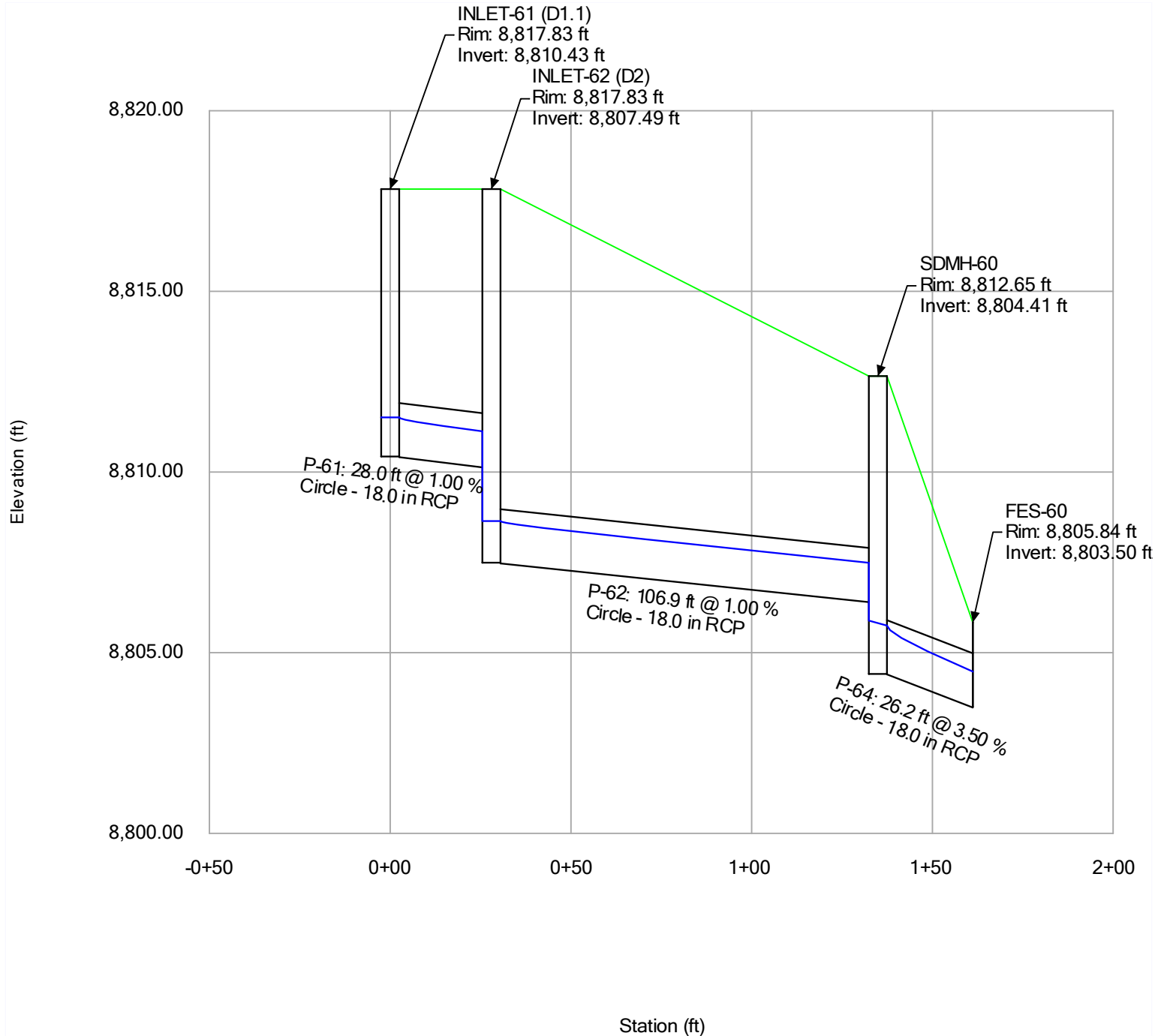


STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year

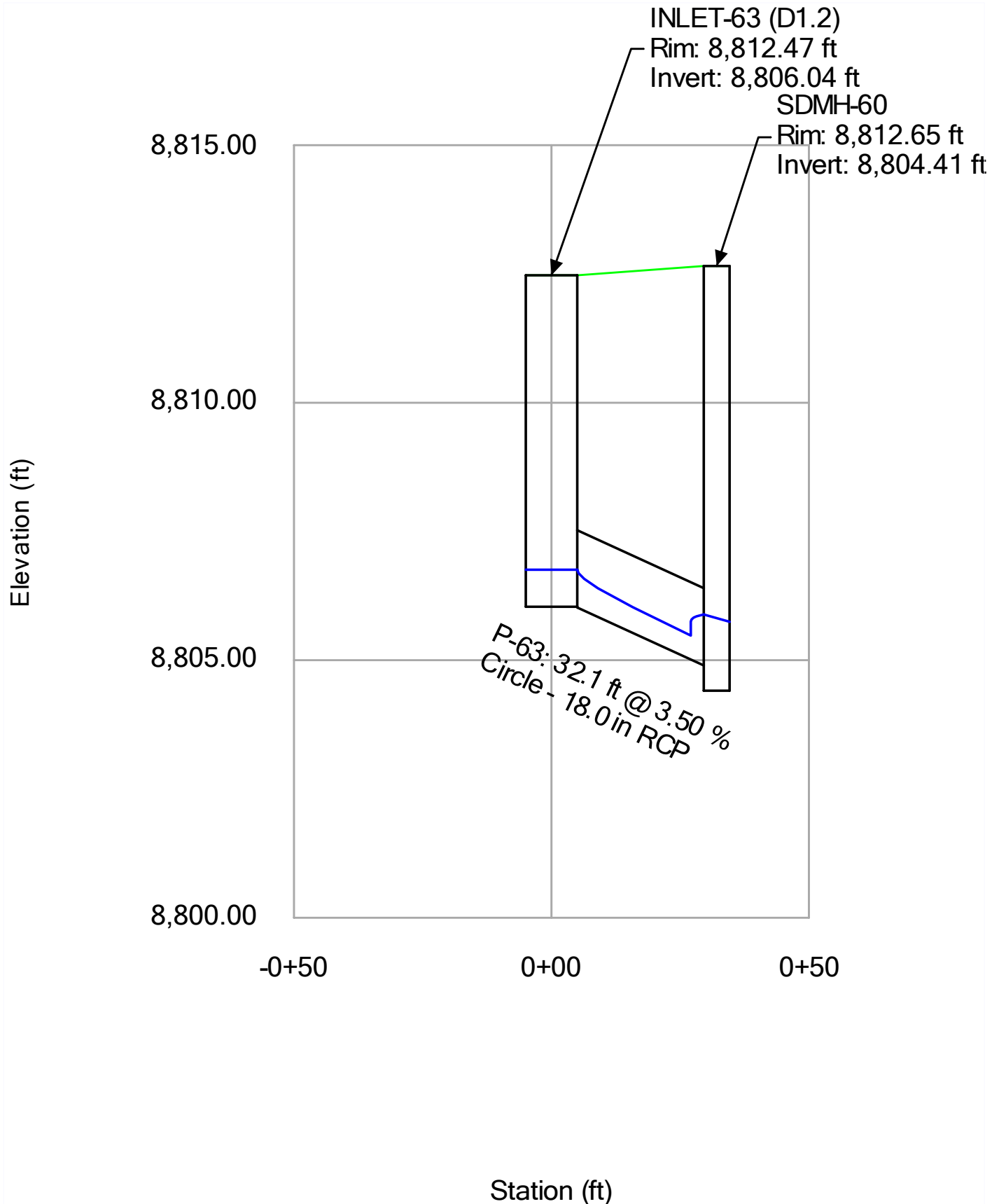


STORMCAD OUTPUT TABLES

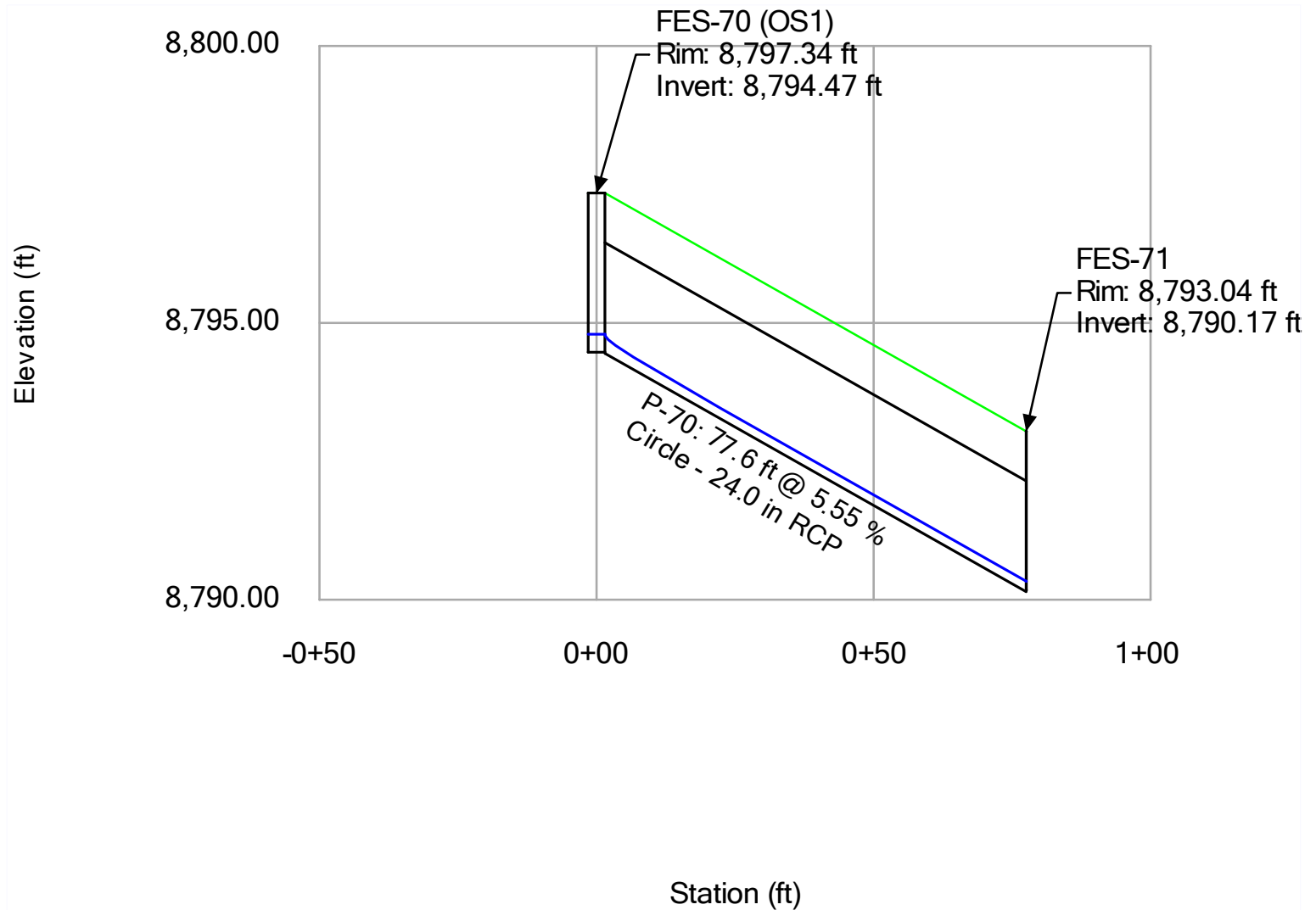
West Mountain - 10W - 100-Year



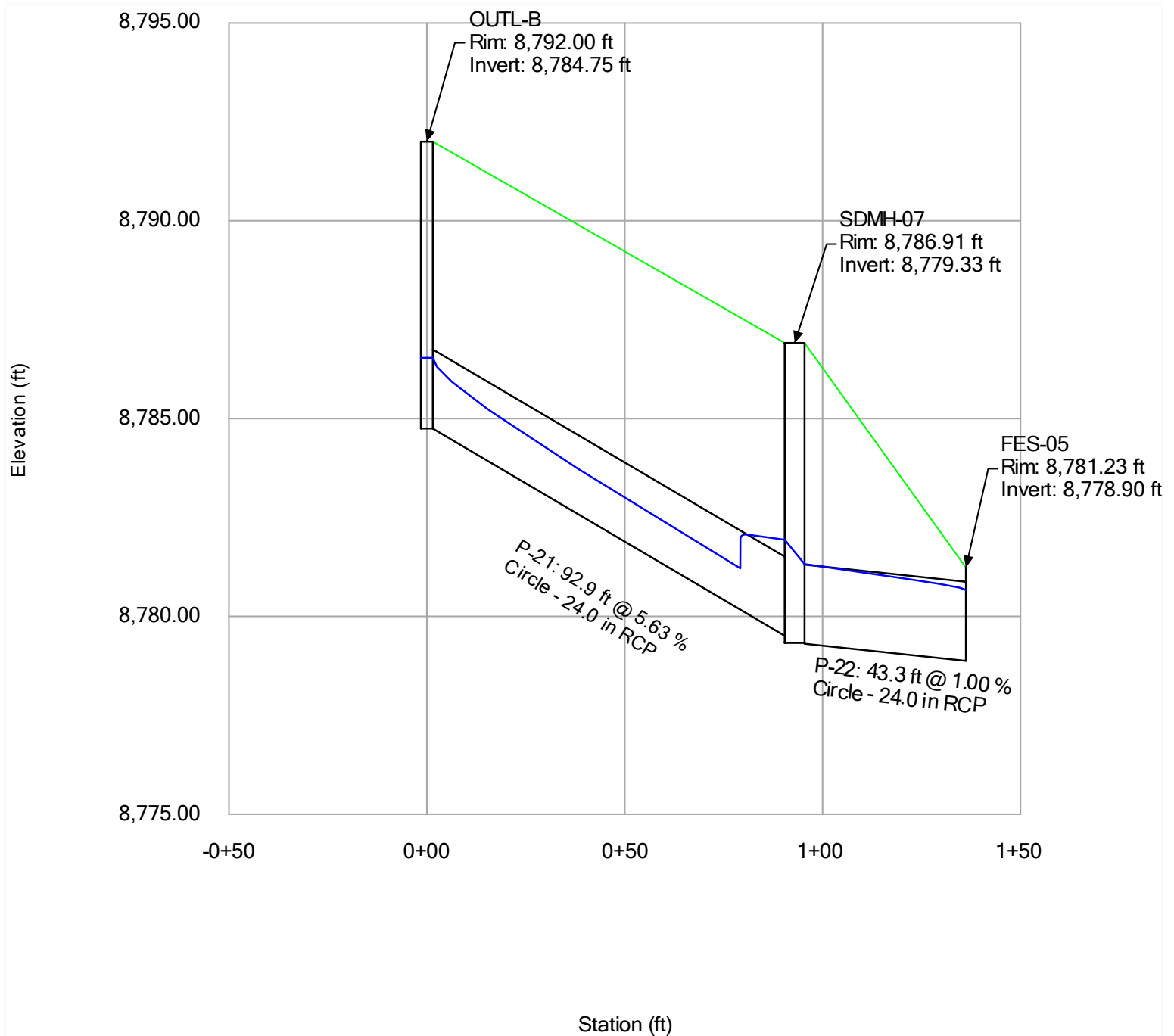
STORMCAD OUTPUT TABLES **West Mountain - 10W - 100-Year**



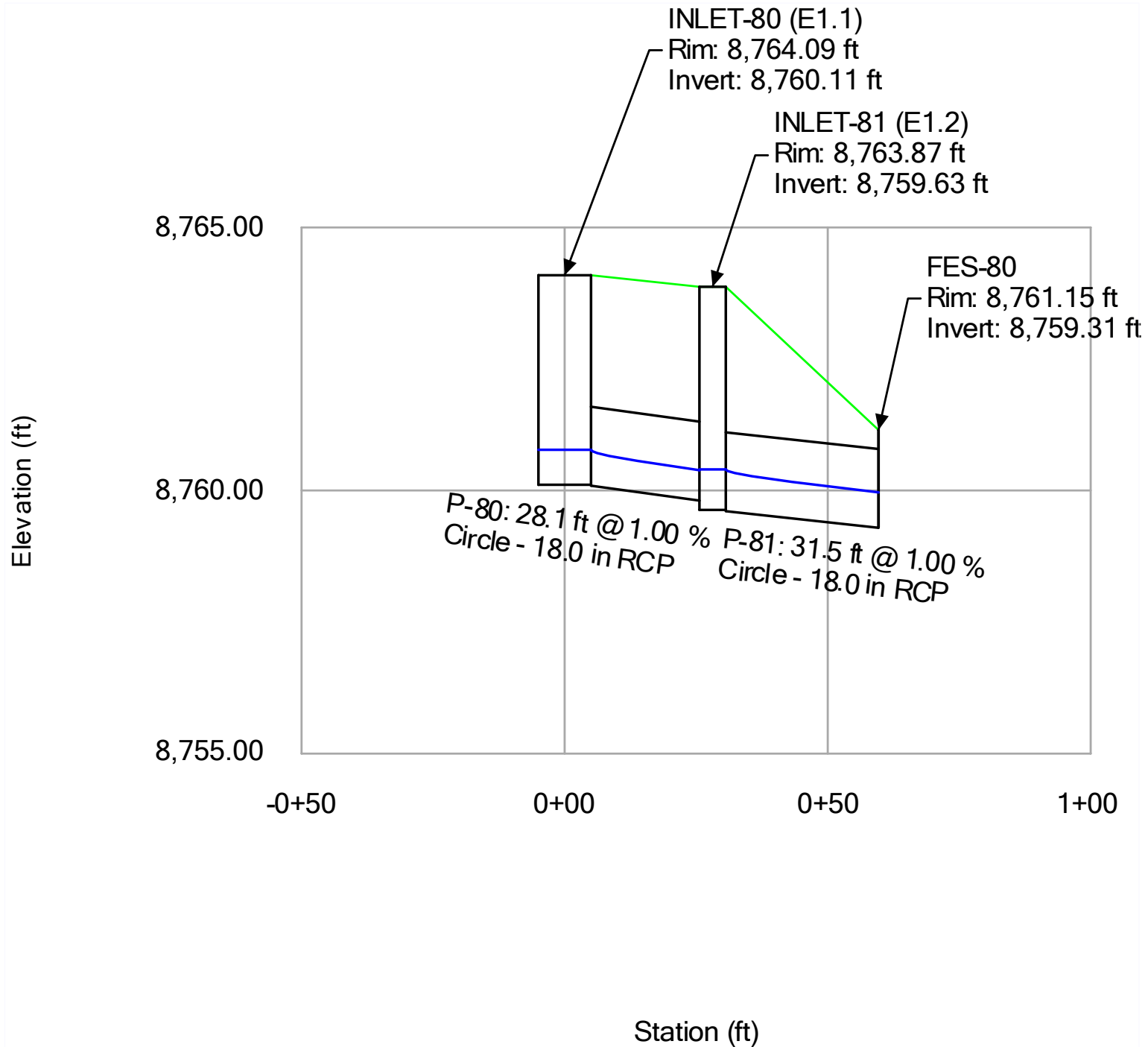
STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year



STORMCAD OUTPUT TABLES
West Mountain - 10W - 100-Year



STORMCAD OUTPUT TABLES **West Mountain - 10W - 100-Year**



APPENDIX D

DETENTION BASIN/ WATER QUALITY ENHANCEMENT BMP'S

Pond Percent Imperviousness Calculations

Temporary Sediment Basin A4 Exhibit
Temporary Sediment Basin A4 Stage-Storage Discharge Calculations
Temporary Sediment Basin A4 Stage Storage Discharge Table

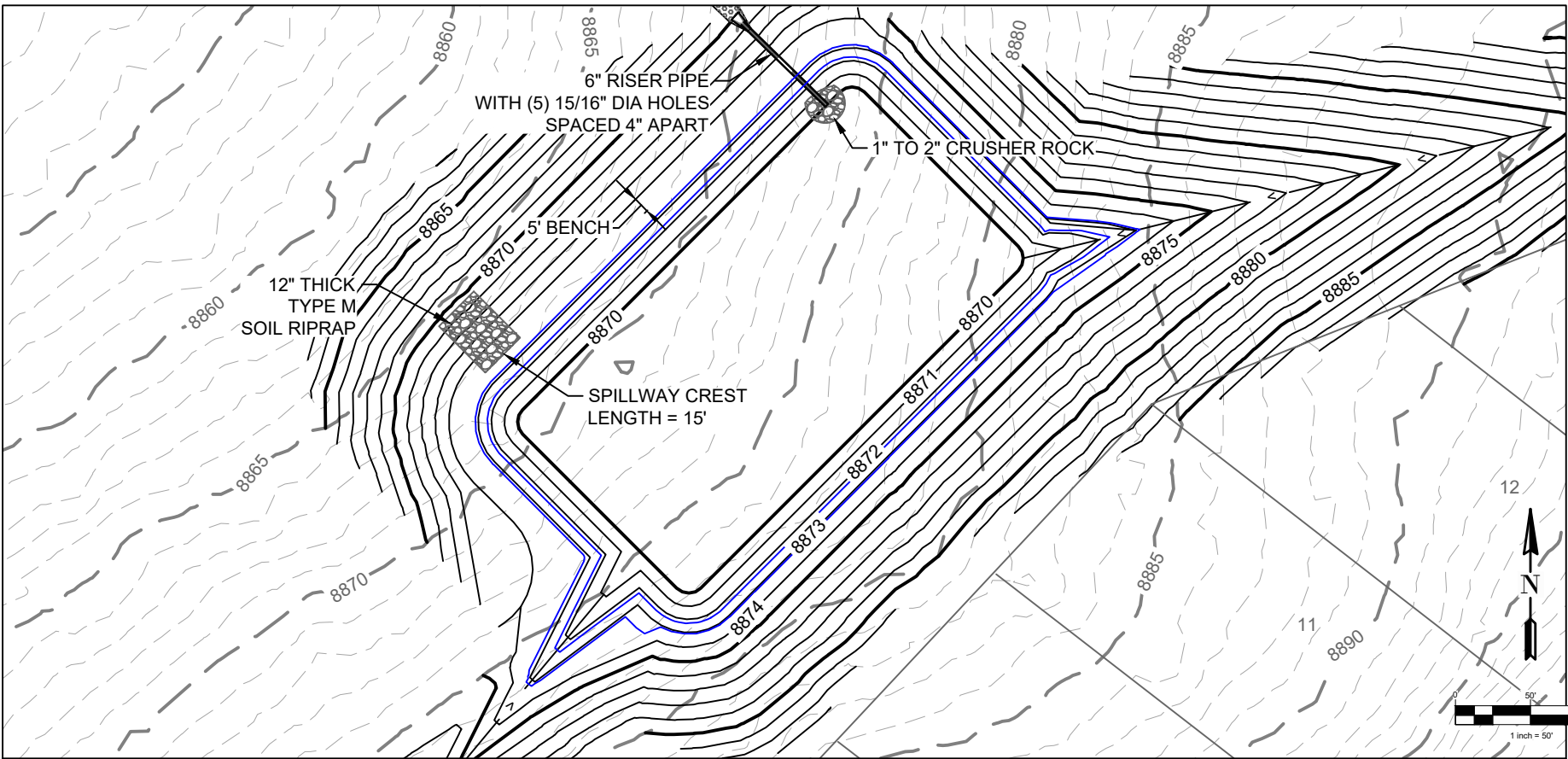
Pond B – FAA Method Detention Sizing
Pond B HEC-HMS Inflow Results
Pond B – MHFD-Detention_v4.07
Pond B Stage Storage Discharge Table

Temporary Sediment Pond C Exhibit
Temporary Sediment Pond C Stage-Storage Discharge Calculations
Temporary Sediment Basin C Stage Storage Discharge Table

Project Name: West Mountain - F1 - 10W
Prepared By: JNS

Pond Percent Impervious Calculations

Basin Id	Design Point	Basin Area (Ac)	Historic Flow Area	Paved Street, Roof, Drives, Walks Area	Single Family Lot Area	Single Family Lot Area	Multi-family Lots Area	Gravel Maint Access Area	EDBs Area	Weighted % Impervious
			5%	95%	35%	55%	70%	60%	25%	
A4.1	A4.1	2.11	1.00	0.61		0.49				42.8%
A4.2	A4.2	0.48		0.48						95.0%
A4.3	A4.3	7.33	3.09			3.77			0.47	32.0%
Temp Sed Pond A4		9.92	4.09	1.09		4.27			0.47	37.4%
B	B	5.63	1.48			0.18	3.24	0.06	0.67	47.0%
B1.1	B1.1	2.49	0.02	0.63		1.84				64.8%
B1.2	B1.2	1.74	0.19	0.58	0.97					51.6%
B1.3	B1.3	4.02	1.26		2.75					25.6%
B1.4	B1.4	0.89	0.25	0.45		0.19				61.6%
B1.5	B1.5	1.19	0.24	0.66			0.28			70.6%
B2.1	B2.1	7.77	0.33		2.56		4.88			55.7%
B2.2	B2.2	0.52	0.04	0.48						87.3%
B2.3	B2.3	0.20	0.02	0.18						86.0%
B2.4	B2.4	0.40	0.08	0.32						77.0%
B3.1	B3.1	3.54					3.54			70.0%
B3.2	B3.2	3.04					3.04			70.0%
B3.3	B3.3	0.33		0.33						95.0%
B3.4	B3.4	0.28		0.28						95.0%
B3.5	B3.5	1.13	0.35	0.10			0.68			52.0%
B3.6	B3.6	0.15		0.15						95.0%
B4	B4	4.45	0.78	0.95		2.72				54.7%
Pond B		37.77	5.05	5.12	6.28	4.93	15.66	0.06	0.67	56.1%
C	C	1.71	1.14						0.57	11.7%
C1	C1	2.92	0.52	0.49	1.90					39.7%
C2.1	C2.1	0.78	0.32	0.46						57.8%
C2.2	C2.2	0.41	0.05	0.36						84.7%
C2.3	C2.3	3.44	1.41	0.15	1.88					25.4%
C2.4	C2.4	1.05	0.35	0.09	0.61					30.1%
C2.5	C2.5	0.16	0.03	0.12						75.4%
C2.6	C2.6	1.38	0.70	0.34	0.34					34.5%
C2.7	C2.7	0.48	0.13	0.35						70.3%
Temp Sed Pond C		12.34	4.67	2.36	4.74				0.57	34.7%



TEMP SED BASIN VOLUME CALCULATION PER MHFD DETAIL SC-7

BASINS	DEVELOPED?	AREA (AC)	IMPERVIOUSNESS	ADDITIONAL VOLUME PER TABLE SB-1 (FT ³ /AC)	VOLUME REQ (FT ³)
A4.1	Y	2.11	43%	2030	4283
A4.2	Y	0.48	95%	6460	3101
A4.3	Y	7.33	32%	1600	11728
TOTAL DEVELOPED AREA		9.92	-	3600	35712
				TOTAL REQUIRED VOLUME	54824

Elev	Stage	Notes	Area		Volume		
			[SF]	[AC]	Incr. [CF]	Total [CF]	Total [AC-FT]
8870.00	0.00		11312	0.2597	0	0	0
8870.25	0.25		11759	0.2699	2884	2884	0.0662
8870.50	0.50		12218	0.2805	2997	5881	0.1350
8870.75	0.75		12710	0.2918	3116	8997	0.2065
8871.00	1.00		13218	0.3034	3241	12238	0.2809
8871.25	1.25		13728	0.3152	3368	15606	0.3583
8871.50	1.50		14254	0.3272	3498	19104	0.4386
8871.58	1.58	Orifice 1	14425	0.3312	1147	20251	0.4649
8871.75	1.75		14793	0.3396	2484	22735	0.5219
8871.91	1.91	Orifice 2	15146	0.3477	2395	25130	0.5769
8872.00	2.00		15330	0.3519	1371	26501	0.6084
8872.24	2.24	Orifice 3	15892	0.3648	3747	30248	0.6944
8872.25	2.25		15915	0.3654	159	30407	0.6980
8872.50	2.50	10-Year Max Depth	16494	0.3787	4051	34458	0.7910
8872.57	2.57	Orifice 4	16658	0.3824	1160	35618	0.8177
8872.75	2.75		17082	0.3921	3037	38655	0.8874
8872.90	2.90	Orifice 5	17435	0.4003	2589	41244	0.9468
8873.00	3.00	Riser Pipe Opening/Spillway Invert	17674	0.4057	1755	42999	0.9871
8873.10	3.10	100-Year Max Depth	18181	0.4174	1793	44792	1.0283
8873.25	3.25		18345	0.4211	2739	47531	1.0912
8873.50	3.50		18996	0.4361	4668	52199	1.1983
8873.75	3.75		19667	0.4515	4833	57032	1.3093
8874.00	4.00		20243	0.4647	4989	62021	1.4238

Project Name: West Mountain - F1 - 10W.1 & 11W
Prepared By: JNS

Temporary Sediment Basin A4 - Stage-Storage Discharge Calculations

User Input	Orifice Diameter (in) =	0.9375
	Spillway Width (ft) =	15
	Bottom Elevation (ft) =	8870

Pond C - Pond Volume Calculations							Cicular Orifice 1		Cicular Orifice 2		Cicular Orifice 3		Cicular Orifice 4		Cicular Orifice 5		Riser Pipe Opening		Spillway		Total Flow		
							Cd = 0.6		Cd = 0.6		Cd = 0.6		Cd = 0.6		Cd = 0.6		Cd = 0.6					Cd = 0.6	
							Diameter (in) = 0.9375		Diameter (in) = 0.9375		Diameter (in) = 0.9375		Diameter (in) = 0.9375		Diameter (in) = 0.9375		Diameter (in) = 8		Diameter (in) = 8			Length (ft) = 15	
							CL = 8871.29		CL = 8871.63		CL = 8871.96		CL = 8872.29		CL = 8872.63		CL = 8872.00		CL = 8872.00			Cbcw = 3	
							FL = 8871.25		FL = 8871.583333		FL = 8871.916667		FL = 8872.25		FL = 8872.583333		FL = 8873		FL = 8873			Z = 4	
							A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.19635		Invert = 8873				
Elev	Stage	Notes	Area		Volume			H		H		H		H		H		H		H			
					Incr.	Total	Total	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)
8870.00	0.00		[SF]	[AC]	[CF]	[CF]	[AC-FT]	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)		
8870.00	0.00		11312	0.2597	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8870.25	0.25		11759	0.2699	2884	2884	0.0662	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8870.50	0.50		12218	0.2805	2997	5881	0.1350	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8870.75	0.75		12710	0.2918	3116	8997	0.2065	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8871.00	1.00		13218	0.3034	3241	12238	0.2809	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8871.25	1.25		13728	0.3152	3368	15606	0.3583	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
8871.50	1.50		14254	0.3272	3498	19104	0.4386	0.21	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01		
8871.58	1.58	Orifice 1	14425	0.3312	1147	20251	0.4649	0.29	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02		
8871.75	1.75		14793	0.3396	2484	22735	0.5219	0.46	0.02	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03		
8871.91	1.91	Orifice 2	15146	0.3477	2395	25130	0.5769	0.62	0.02	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04		
8872.00	2.00		15330	0.3519	1371	26501	0.6084	0.71	0.02	0.37	0.02	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05		
8872.24	2.24	Orifice 3	15892	0.3648	3747	30248	0.6944	0.95	0.03	0.61	0.02	0.28	0.02	0.00	0.00	0.00	0.00	0.24	0.46	0.00	0.53		
8872.25	2.25		15915	0.3654	159	30407	0.6980	0.96	0.03	0.62	0.02	0.29	0.02	0.00	0.00	0.00	0.00	0.25	0.47	0.00	0.54		
8872.50	2.50	10-Year Max Depth	16494	0.3787	4051	34458	0.7910	1.21	0.03	0.87	0.03	0.54	0.02	0.21	0.01	0.00	0.00	0.50	0.67	0.00	0.76		
8872.57	2.57	Orifice 4	16658	0.3824	1160	35618	0.8177	1.28	0.03	0.94	0.03	0.61	0.02	0.28	0.02	0.00	0.00	0.57	0.71	0.00	0.81		
8872.75	2.75		17082	0.3921	3037	38655	0.8874	1.46	0.04	1.12	0.03	0.79	0.03	0.46	0.02	0.12	0.01	0.75	0.82	0.00	0.94		
8872.90	2.90	Orifice 5	17435	0.4003	2589	41244	0.9468	1.61	0.04	1.27	0.03	0.94	0.03	0.61	0.02	0.27	0.02	0.90	0.90	0.00	1.04		
8873.00	3.00	Riser Pipe Opening/Spillway Invert	17674	0.4057	1755	42999	0.9871	1.71	0.04	1.37	0.03	1.04	0.03	0.71	0.02	0.37	0.02	1.00	0.95	0.00	1.09		
8873.10	3.10	100-Year Max Depth	18181	0.4174	1793	44792	1.0283	1.81	0.04	1.47	0.04	1.14	0.03	0.81	0.03	0.47	0.02	1.10	0.99	0.10	2.60		
8873.25	3.25		18345	0.4211	2739	47531	1.0912	1.96	0.04	1.62	0.04	1.29	0.03	0.96	0.03	0.62	0.02	1.25	1.06	0.25	7.15		
8873.50	3.50		18996	0.4361	4668	52199	1.1983	2.21	0.04	1.87	0.04	1.54	0.04	1.21	0.03	0.87	0.03	1.50	1.16	0.50	18.95		
8873.75	3.75		19667	0.4515	4833	57032	1.3093	2.46	0.05	2.12	0.04	1.79	0.04	1.46	0.04	1.12	0.03	1.75	1.25	0.75	35.35		
8874.00	4.00		20243	0.4647	4989	62021	1.4238	2.71	0.05	2.37	0.05	2.04	0.04	1.71	0.04	1.37	0.03	2.00	1.34	1.00	56.15		

Project Name: West Mountain - F1 - 10W.1 & 11W

Prepared By: JNS

Temp Sed Basin A4 Stage Storage Discharge Table

Temp Sed Basin A4 Area-Elevation-Discharge Table			
Stage (ft)	Elevation (ft)	Area (ft ²)	Discharge (cfs)
0	8870	11312	0.0
0.25	8870.25	11759	0.0
0.5	8870.5	12218	0.0
0.75	8870.75	12710	0.0
1	8871	13218	0.0
1.25	8871.25	13728	0.0
1.5	8871.5	14254	0.0
1.58	8871.58	14425	0.0
1.75	8871.75	14793	0.0
1.91	8871.91	15146	0.0
2	8872	15330	0.0
2.24	8872.24	15892	0.5
2.25	8872.25	15915	0.5
2.5	8872.5	16494	0.8
2.57	8872.57	16658	0.8
2.75	8872.75	17082	0.9
2.9	8872.9	17435	1.0
3	8873	17674	1.1
3.1	8873.1	18181	2.6
3.25	8873.25	18345	7.1
3.5	8873.5	18996	18.9
3.75	8873.75	19667	35.4
4	8874	20243	56.1

DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: **West Mountain - F1 - 10W**

Basin ID: **Pond B**

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

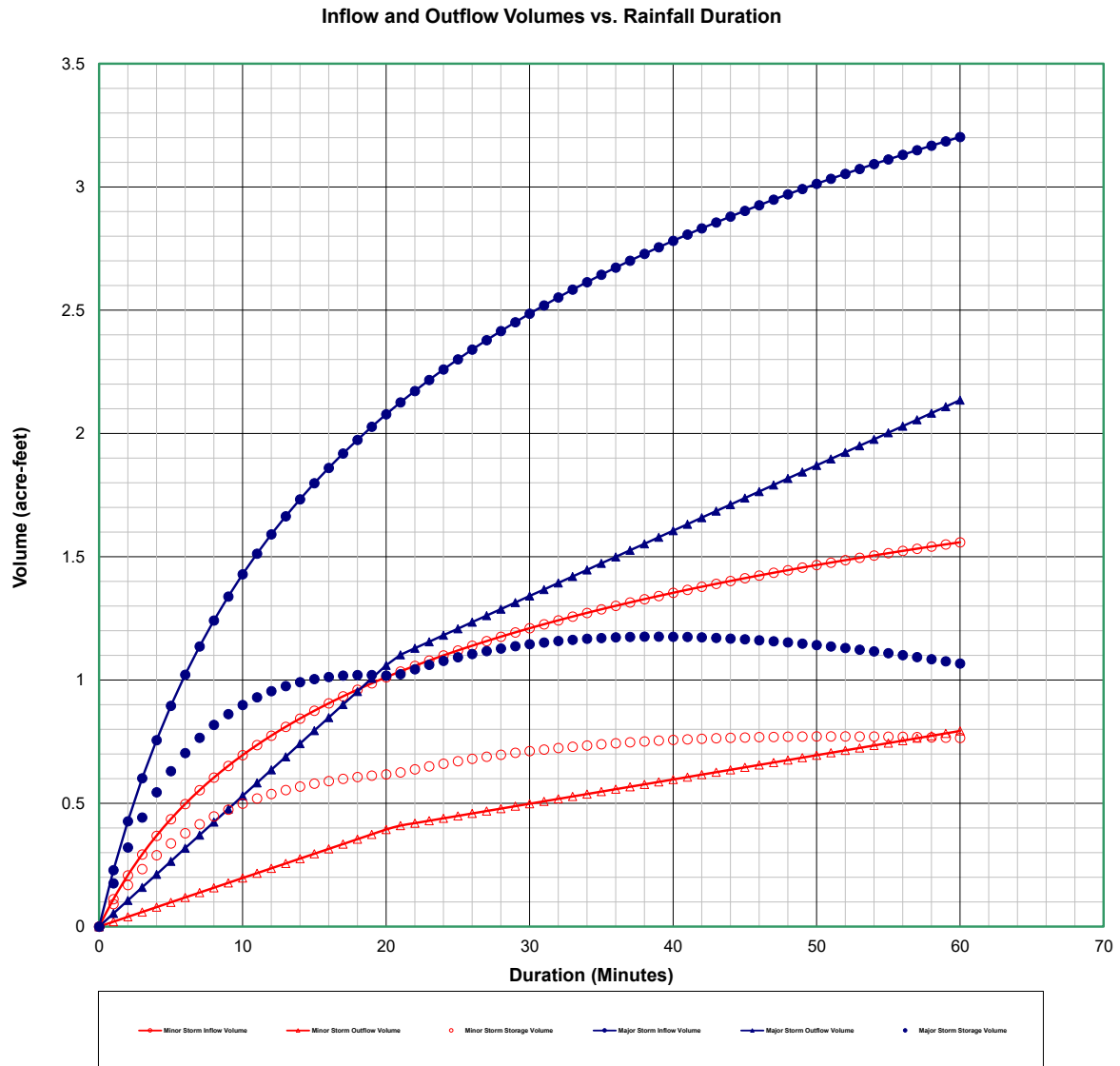
Determination of MINOR Detention Volume Using Modified FAA Method							Determination of MAJOR Detention Volume Using Modified FAA Method						
Design Information (Input): Catchment Drainage Imperviousness $I_a = 56.00$ percent Catchment Drainage Area $A = 37.710$ acres Predevelopment NRCS Soil Group $Type = D$ A, B, C, or D Return Period for Detention Control $T = 10$ years (2, 5, 10, 25, 50, or 100) Time of Concentration of Watershed $T_c = 21$ minutes Allowable Unit Release Rate $q = 0.38$ cfs/acre One-hour Precipitation $P_1 = 1.01$ inches Design Rainfall IDF Formula $i = C_1 \cdot P_1 / (C_2 + T_c)^{C_3}$ Coefficient One $C_1 = 28.50$ Coefficient Two $C_2 = 10$ Coefficient Three $C_3 = 0.786$							Design Information (Input): Catchment Drainage Imperviousness $I_a = 56.00$ percent Catchment Drainage Area $A = 37.710$ acres Predevelopment NRCS Soil Group $Type = D$ A, B, C, or D Return Period for Detention Control $T = 100$ years (2, 5, 10, 25, 50, or 100) Time of Concentration of Watershed $T_c = 21$ minutes Allowable Unit Release Rate $q = 1.02$ cfs/acre One-hour Precipitation $P_1 = 1.64$ inches Design Rainfall IDF Formula $i = C_1 \cdot P_1 / (C_2 + T_c)^{C_3}$ Coefficient One $C_1 = 28.50$ Coefficient Two $C_2 = 10$ Coefficient Three $C_3 = 0.786$						
Determination of Average Outflow from the Basin (Calculated): Runoff Coefficient $C = 0.49$ Inflow Peak Runoff $Qp-in = 36.14$ cfs Allowable Peak Outflow Rate $Qp-out = 14.29$ cfs Mod. FAA Minor Storage Volume = 33,605 cubic feet Mod. FAA Minor Storage Volume = 0.771 acre-ft							Determination of Average Outflow from the Basin (Calculated): Runoff Coefficient $C = 0.62$ Inflow Peak Runoff $Qp-in = 74.24$ cfs Allowable Peak Outflow Rate $Qp-out = 38.46$ cfs Mod. FAA Major Storage Volume = 51,236 cubic feet Mod. FAA Major Storage Volume = 1.176 acre-ft						
1 < Enter Rainfall Duration Incremental Increase Value Here (e.g. 5 for 5-Minutes)													
Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)	Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)
0	0.00	0.000	0.00	0.00	0.000	0.000	0	0.00	0.000	0.00	0.00	0.000	0.000
1	4.37	0.111	1.00	14.29	0.020	0.092	1	7.10	0.229	1.00	38.46	0.053	0.176
2	4.08	0.208	1.00	14.29	0.039	0.168	2	6.63	0.427	1.00	38.46	0.106	0.321
3	3.83	0.293	1.00	14.29	0.059	0.234	3	6.22	0.601	1.00	38.46	0.159	0.442
4	3.62	0.368	1.00	14.29	0.079	0.289	4	5.87	0.756	1.00	38.46	0.212	0.545
5	3.43	0.436	1.00	14.29	0.098	0.339	5	5.56	0.896	1.00	38.46	0.265	0.631
6	3.26	0.497	1.00	14.29	0.118	0.379	6	5.29	1.022	1.00	38.46	0.318	0.704
7	3.10	0.553	1.00	14.29	0.138	0.415	7	5.04	1.136	1.00	38.46	0.371	0.766
8	2.97	0.604	1.00	14.29	0.157	0.447	8	4.82	1.242	1.00	38.46	0.424	0.818
9	2.84	0.652	1.00	14.29	0.177	0.474	9	4.62	1.339	1.00	38.46	0.477	0.862
10	2.73	0.695	1.00	14.29	0.197	0.499	10	4.44	1.429	1.00	38.46	0.530	0.899
11	2.63	0.736	1.00	14.29	0.217	0.520	11	4.27	1.513	1.00	38.46	0.583	0.930
12	2.54	0.774	1.00	14.29	0.236	0.538	12	4.12	1.591	1.00	38.46	0.636	0.955
13	2.45	0.810	1.00	14.29	0.256	0.554	13	3.98	1.664	1.00	38.46	0.689	0.976
14	2.37	0.844	1.00	14.29	0.276	0.568	14	3.84	1.733	1.00	38.46	0.742	0.992
15	2.29	0.875	1.00	14.29	0.295	0.580	15	3.72	1.799	1.00	38.46	0.795	1.004
16	2.22	0.905	1.00	14.29	0.315	0.590	16	3.61	1.860	1.00	38.46	0.848	1.012
17	2.16	0.934	1.00	14.29	0.335	0.599	17	3.50	1.919	1.00	38.46	0.901	1.018
18	2.10	0.961	1.00	14.29	0.354	0.607	18	3.41	1.974	1.00	38.46	0.954	1.021
19	2.04	0.987	1.00	14.29	0.374	0.613	19	3.31	2.027	1.00	38.46	1.007	1.021
20	1.99	1.011	1.00	14.29	0.394	0.618	20	3.23	2.078	1.00	38.46	1.060	1.018
21	1.94	1.035	0.99	14.16	0.410	0.625	21	3.14	2.126	0.99	38.11	1.102	1.024
22	1.89	1.057	0.97	13.84	0.419	0.638	22	3.07	2.173	0.97	37.25	1.129	1.044
23	1.84	1.079	0.95	13.55	0.429	0.650	23	2.99	2.217	0.95	36.47	1.155	1.062
24	1.80	1.100	0.93	13.28	0.439	0.661	24	2.92	2.260	0.93	35.75	1.182	1.078
25	1.76	1.120	0.91	13.04	0.449	0.671	25	2.86	2.301	0.91	35.09	1.208	1.093
26	1.72	1.139	0.90	12.81	0.459	0.680	26	2.80	2.341	0.90	34.48	1.235	1.106
27	1.68	1.158	0.88	12.60	0.469	0.689	27	2.74	2.379	0.88	33.91	1.261	1.118
28	1.65	1.176	0.87	12.41	0.478	0.697	28	2.68	2.416	0.87	33.39	1.288	1.128
29	1.62	1.193	0.86	12.22	0.488	0.705	29	2.62	2.451	0.86	32.90	1.314	1.137
30	1.58	1.210	0.84	12.06	0.498	0.712	30	2.57	2.486	0.84	32.44	1.341	1.145
31	1.55	1.226	0.83	11.90	0.508	0.718	31	2.52	2.519	0.83	32.02	1.367	1.152
32	1.53	1.242	0.82	11.75	0.518	0.724	32	2.48	2.552	0.82	31.62	1.394	1.158
33	1.50	1.257	0.81	11.61	0.528	0.730	33	2.43	2.583	0.81	31.24	1.420	1.163
34	1.47	1.272	0.80	11.48	0.538	0.735	34	2.39	2.614	0.80	30.89	1.447	1.167
35	1.44	1.287	0.79	11.35	0.547	0.739	35	2.35	2.644	0.79	30.56	1.473	1.171
36	1.42	1.301	0.79	11.24	0.557	0.744	36	2.31	2.673	0.79	30.24	1.500	1.173
37	1.40	1.315	0.78	11.13	0.567	0.748	37	2.27	2.701	0.78	29.94	1.526	1.175
38	1.37	1.328	0.77	11.02	0.577	0.751	38	2.23	2.729	0.77	29.66	1.553	1.176
39	1.35	1.341	0.76	10.92	0.587	0.754	39	2.19	2.755	0.76	29.40	1.579	1.176
40	1.33	1.354	0.76	10.83	0.597	0.757	40	2.16	2.781	0.76	29.14	1.606	1.176
41	1.31	1.366	0.75	10.74	0.606	0.760	41	2.13	2.807	0.75	28.90	1.632	1.175
42	1.29	1.378	0.75	10.65	0.616	0.762	42	2.09	2.832	0.75	28.67	1.659	1.173
43	1.27	1.390	0.74	10.57	0.626	0.764	43	2.06	2.856	0.74	28.45	1.685	1.171
44	1.25	1.402	0.73	10.49	0.636	0.766	44	2.03	2.880	0.73	28.24	1.712	1.168
45	1.23	1.413	0.73	10.42	0.646	0.767	45	2.00	2.903	0.73	28.04	1.738	1.165
46	1.22	1.424	0.72	10.35	0.656	0.769	46	1.98	2.926	0.72	27.85	1.765	1.162
47	1.20	1.435	0.72	10.28	0.665	0.770	47	1.95	2.948	0.72	27.67	1.791	1.157
48	1.18	1.446	0.71	10.21	0.675	0.770	48	1.92	2.970	0.71	27.49	1.818	1.153
49	1.17	1.456	0.71	10.15	0.685	0.771	49	1.90	2.992	0.71	27.32	1.844	1.148
50	1.15	1.466	0.71	10.09	0.695	0.771	50	1.87	3.013	0.71	27.16	1.870	1.142
51	1.14	1.476	0.70	10.03	0.705	0.771	51	1.85	3.033	0.70	27.00	1.897	1.136
52	1.12	1.486	0.70	9.98	0.715	0.771	52	1.82	3.053	0.70	26.85	1.923	1.130
53	1.11	1.496	0.69	9.92	0.725	0.771	53	1.80	3.073	0.69	26.71	1.950	1.123
54	1.10	1.505	0.69	9.87	0.734	0.771	54	1.78	3.093	0.69	26.57	1.976	1.116
55	1.08	1.515	0.69	9.82	0.744	0.770	55	1.76	3.112	0.69	26.44	2.003	1.109
56	1.07	1.524	0.68	9.78	0.754	0.770	56	1.74	3.131	0.68	26.31	2.029	1.101
57	1.06	1.533	0.68	9.73	0.764	0.769	57	1.72	3.149	0.68	26.19	2.056	1.093
58	1.04	1.542	0.68	9.69	0.774	0.768	58	1.70	3.167	0.68	26.07	2.082	1.085
59	1.03	1.550	0.67	9.64	0.784	0.767	59	1.68	3.185	0.67	25.95	2.109	1.076
60	1.02	1.559	0.67	9.60	0.793	0.765	60	1.66	3.203	0.67	25.84	2.135	1.067
Mod. FAA Minor Storage Volume (cubic ft.) = 33,605 Mod. FAA Minor Storage Volume (acre-ft.) = 0.7715							Mod. FAA Major Storage Volume (cubic ft.) = 51,236 Mod. FAA Major Storage Volume (acre-ft.) = 1.1762						

UDFCD DETENTION BASIN VOLUME ESTIMATING WORKBOOK Version 2.35, Released January 2015

DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: West Mountain - F1 - 10W

Basin ID: Pond B



Pond B HEC-HMS Inflow results

Existing Conditions Inflow Time-Series Results						
Peak Flow Rate (cfs)	Storm Return Interval (yr)					
	Q2	Q5	Q10	Q25	Q50	Q100
	5.5	10.1	13.9	21.5	28.7	37
Time (hr:min)	Storm Return Interval (yr)					
	Q2	Q5	Q10	Q25	Q50	Q100
0:00	0.0	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.1	0.1	0.3
0:15	0.2	0.5	0.8	1.7	2.5	3.6
0:20	2.4	4.5	6.9	11.3	15.6	20.7
0:25	5.0	8.8	13.1	20.7	27.9	36.4
0:30	5.5	9.5	13.9	21.5	28.7	37.0
0:35	5.0	9.1	12.9	18.4	24.3	32.5
0:40	4.4	9.3	12.5	15.5	20.3	29.5
0:45	4.0	9.7	12.4	13.7	17.7	27.8
0:50	3.7	10.0	12.4	12.4	15.9	26.6
0:55	3.5	10.1	12.3	11.2	14.2	25.2
1:00	3.2	10.1	11.9	10.0	12.6	23.5
1:05	2.7	8.7	10.2	8.1	10.1	19.6
1:10	2.0	6.5	7.5	5.9	7.4	14.4
1:15	1.4	4.7	5.5	4.3	5.4	10.4
1:20	1.1	3.5	4.1	3.2	4.0	7.8
1:25	0.8	2.7	3.1	2.4	3.0	5.9
1:30	0.6	2.0	2.3	1.7	2.2	4.4
1:35	0.4	1.5	1.7	1.3	1.6	3.2
1:40	0.3	1.0	1.2	0.9	1.1	2.2
1:45	0.2	0.7	0.8	0.6	0.8	1.6
1:50	0.2	0.5	0.6	0.5	0.6	1.1
1:55	0.1	0.4	0.4	0.3	0.4	0.8
2:00	0.1	0.3	0.3	0.2	0.3	0.6
2:05	0.1	0.2	0.2	0.2	0.2	0.4
2:10	0.0	0.1	0.2	0.1	0.2	0.3
2:15	0.0	0.1	0.1	0.1	0.1	0.2
2:20	0.0	0.1	0.1	0.1	0.1	0.2
2:25	0.0	0.0	0.1	0.0	0.0	0.1
2:30	0	0	0	0	0	0.1
2:35	0	0	0	0	0	0
2:40	0	0	0	0	0	0
2:45	0	0	0	0	0	0
2:50	0	0	0	0	0	0
2:55	0	0	0	0	0	0
3:00	0	0	0	0	0	0
3:05	0	0	0	0	0	0
3:10	0	0	0	0	0	0
3:15	0	0	0	0	0	0
3:20	0	0	0	0	0	0
3:25	0	0	0	0	0	0
3:30	0	0	0	0	0	0
3:35	0	0	0	0	0	0
3:40	0	0	0	0	0	0
3:45	0	0	0	0	0	0
3:50	0	0	0	0	0	0
3:55	0	0	0	0	0	0
4:00	0	0	0	0	0	0
4:05	0	0	0	0	0	0
4:10	0	0	0	0	0	0
4:15	0	0	0	0	0	0
4:20	0	0	0	0	0	0
4:25	0	0	0	0	0	0
4:30	0	0	0	0	0	0
4:35	0	0	0	0	0	0
4:40	0	0	0	0	0	0
4:45	0	0	0	0	0	0
4:50	0	0	0	0	0	0
4:55	0	0	0	0	0	0
5:00	0	0	0	0	0	0
5:05	0	0	0	0	0	0
5:10	0	0	0	0	0	0
5:15	0	0	0	0	0	0
5:20	0	0	0	0	0	0
5:25	0	0	0	0	0	0
5:30	0	0	0	0	0	0
5:35	0	0	0	0	0	0
5:40	0	0	0	0	0	0
5:45	0	0	0	0	0	0
5:50	0	0	0	0	0	0
5:55	0	0	0	0	0	0
6:00	0	0	0	0	0	0

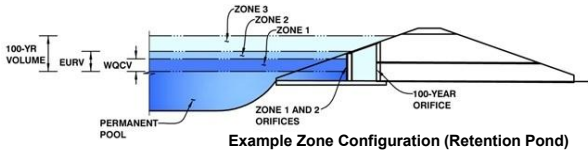
Proposed Conditions Inflow Time-Series Results						
Peak Flow Rate (cfs)	Storm Return Interval (yr)					
	Q2	Q5	Q10	Q25	Q50	Q100
	13.8	21.2	28.6	40.7	51.5	63.4
Time (hr:min)	Storm Return Interval (yr)					
	Q2	Q5	Q10	Q25	Q50	Q100
0:00	0.0	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.1	0.1	0.2	0.3
0:10	0.2	0.4	0.6	1.0	1.5	2.0
0:15	1.6	2.8	4.0	6.3	8.4	10.9
0:20	8.2	12.8	17.6	25.6	32.8	40.8
0:25	13.8	21.2	28.6	40.7	51.5	63.4
0:30	13.5	20.5	27.5	38.7	48.7	59.6
0:35	11.0	17.9	23.5	31.1	38.8	49.3
0:40	9.2	17.2	21.6	25.2	31.3	43.1
0:45	8.1	17.2	20.8	21.7	26.7	39.7
0:50	7.4	17.1	20.2	19.3	23.7	37.2
0:55	6.7	16.9	19.4	17.2	21.0	34.6
1:00	6.1	16.4	18.5	15.1	18.2	31.7
1:05	4.9	13.9	15.5	12.0	14.5	26.1
1:10	3.6	10.1	11.2	8.7	10.5	19.0
1:15	2.5	7.2	8.1	6.3	7.5	13.7
1:20	1.9	5.4	6.0	4.6	5.6	10.2
1:25	1.4	4.1	4.6	3.5	4.2	7.7
1:30	1.0	3.1	3.4	2.6	3.1	5.7
1:35	0.8	2.2	2.5	1.8	2.2	4.1
1:40	0.5	1.6	1.8	1.3	1.6	2.9
1:45	0.4	1.1	1.2	0.9	1.1	2.1
1:50	0.3	0.8	0.9	0.7	0.8	1.5
1:55	0.2	0.6	0.6	0.5	0.6	1.1
2:00	0.1	0.4	0.5	0.3	0.4	0.8
2:05	0.1	0.3	0.3	0.3	0.3	0.6
2:10	0.1	0.2	0.2	0.2	0.2	0.4
2:15	0.1	0.2	0.2	0.1	0.2	0.3
2:20	0.0	0.1	0.1	0.1	0.1	0.2
2:25	0.0	0.1	0.1	0.1	0.1	0.1
2:30	0	0.1	0.1	0	0	0.1
2:35	0	0	0	0	0	0.1
2:40	0	0	0	0	0	0
2:45	0	0	0	0	0	0
2:50	0	0	0	0	0	0
2:55	0	0	0	0	0	0
3:00	0	0	0	0	0	0
3:05	0	0	0	0	0	0
3:10	0	0	0	0	0	0
3:15	0	0	0	0	0	0
3:20	0	0	0	0	0	0
3:25	0	0	0	0	0	0
3:30	0	0	0	0	0	0
3:35	0	0	0	0	0	0
3:40	0	0	0	0	0	0
3:45	0	0	0	0	0	0
3:50	0	0	0	0	0	0
3:55	0	0	0	0	0	0
4:00	0	0	0	0	0	0
4:05	0	0	0	0	0	0
4:10	0	0	0	0	0	0
4:15	0	0	0	0	0	0
4:20	0	0	0	0	0	0
4:25	0	0	0	0	0	0
4:30	0	0	0	0	0	0
4:35	0	0	0	0	0	0
4:40	0	0	0	0	0	0
4:45	0	0	0	0	0	0
4:50	0	0	0	0	0	0
4:55	0	0	0	0	0	0
5:00	0	0	0	0	0	0
5:05	0	0	0	0	0	0
5:10	0	0	0	0	0	0
5:15	0	0	0	0	0	0
5:20	0	0	0	0	0	0
5:25	0	0	0	0	0	0
5:30	0	0	0	0	0	0
5:35	0	0	0	0	0	0
5:40	0	0	0	0	0	0
5:45	0	0	0	0	0	0
5:50	0	0	0	0	0	0
5:55	0	0	0	0	0	0
6:00	0	0	0	0	0	0

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.07 (June 2025)

Project: West Mountain - F1 - 10W

Basin ID: Pond B



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	4.27	0.702	Orifice Plate
Zone 2 (User)	4.47	0.069	Rectangular Orifice
Zone 3 (User)	7.13	1.176	Weir&Pipe (Restrict)
Total (all zones)		1.947	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration SCM)

Underdrain Orifice Invert Depth = N/A ft (distance below the filtration media surface)
Underdrain Orifice Diameter = N/A inches

Calculated Parameters for Underdrain

Underdrain Orifice Area = N/A ft²
Underdrain Orifice Centroid = N/A feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation SCM)

Centroid of Lowest Orifice = 0.00 ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = 4.27 ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = 18.00 inches
Orifice Plate: Orifice Area per Row = 2.25 sq. inches (diameter = 1-11/16 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row = 1.563E-02 ft²
Elliptical Half-Width = N/A feet
Elliptical Slot Centroid = N/A feet
Elliptical Slot Area = N/A ft²

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.50	3.00					
Orifice Area (sq. inches)	2.25	2.25	2.25					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

Invert of Vertical Orifice = 4.27 ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice = 4.47 ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Height = 2.00 inches
Vertical Orifice Width = 10.00 inches

Calculated Parameters for Vertical Orifice

Zone 2 Rectangular Not Selected
Vertical Orifice Area = 0.14 ft²
Vertical Orifice Centroid = 0.08 feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected		Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, H _o =	7.00	N/A	ft (relative to basin bottom at Stage = 0 ft)	7.00	N/A	feet
Overflow Weir Front Edge Length =	4.00	N/A	feet	4.00	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V	6.13	N/A	
Horiz. Length of Weir Sides =	4.00	N/A	feet	12.66	N/A	ft ²
Overflow Grate Type =	Close Mesh Grate	N/A		6.33	N/A	ft ²
Debris Clogging % =	50%	N/A	%			

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected		Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.25	N/A	ft (distance below basin bottom at Stage = 0 ft)	2.07	N/A	ft ²
Outlet Pipe Diameter =	24.00	N/A	inches	0.71	N/A	feet
Restrictor Plate Height Above Pipe Invert =	15.00		inches	1.82	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Calculated Parameters for Spillway

Spillway Invert Stage =	8.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth =	0.88	feet	
Spillway Crest Length =	20.00	feet	Stage at Top of Freeboard =	9.88	feet	
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.72	acres	
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	3.65	acre-ft	

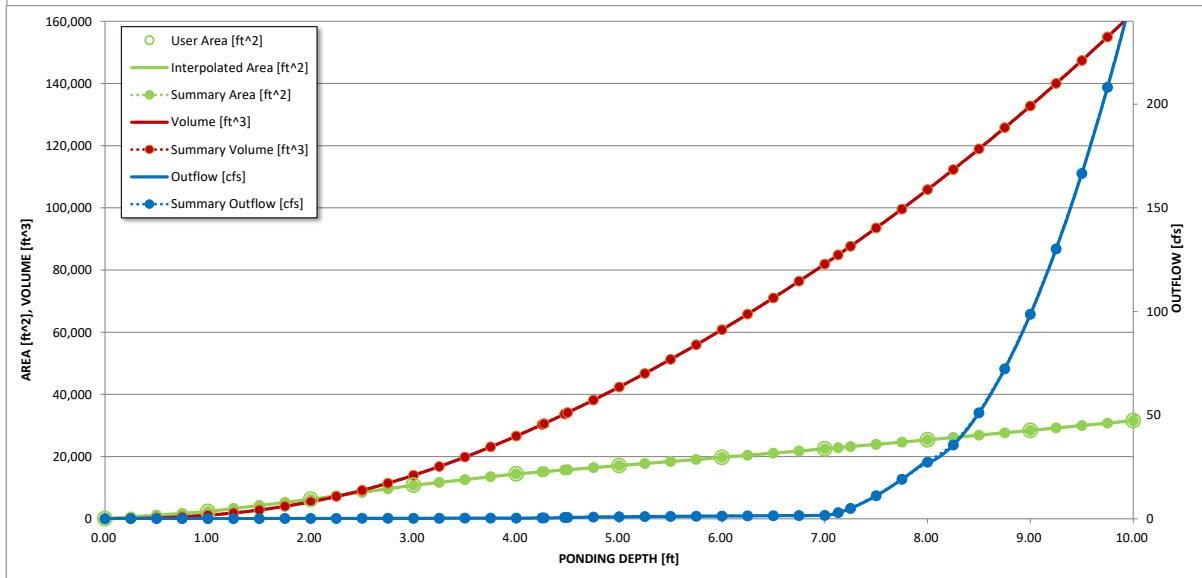
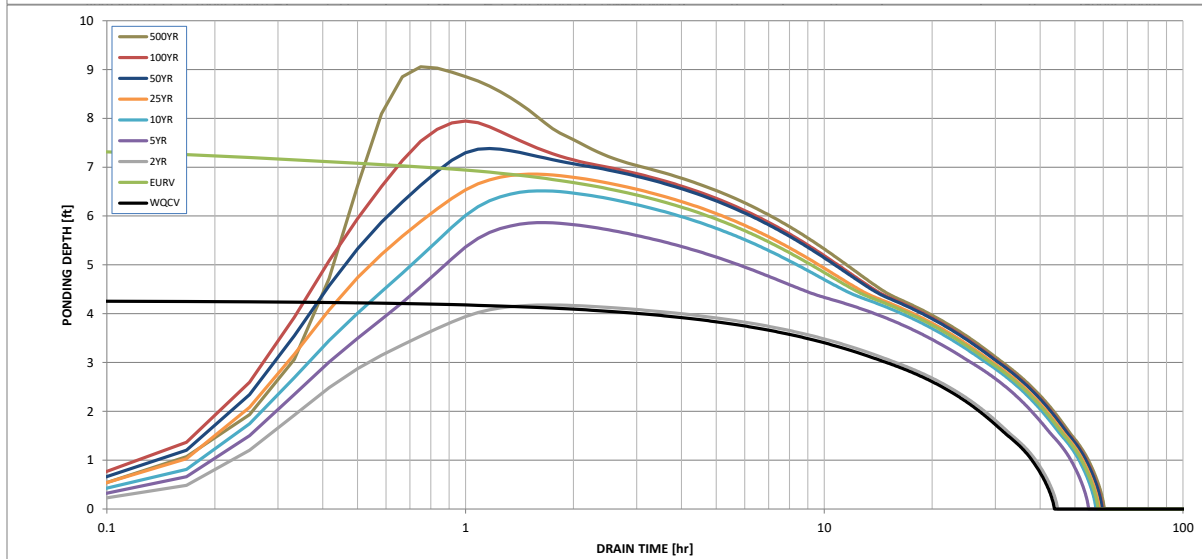
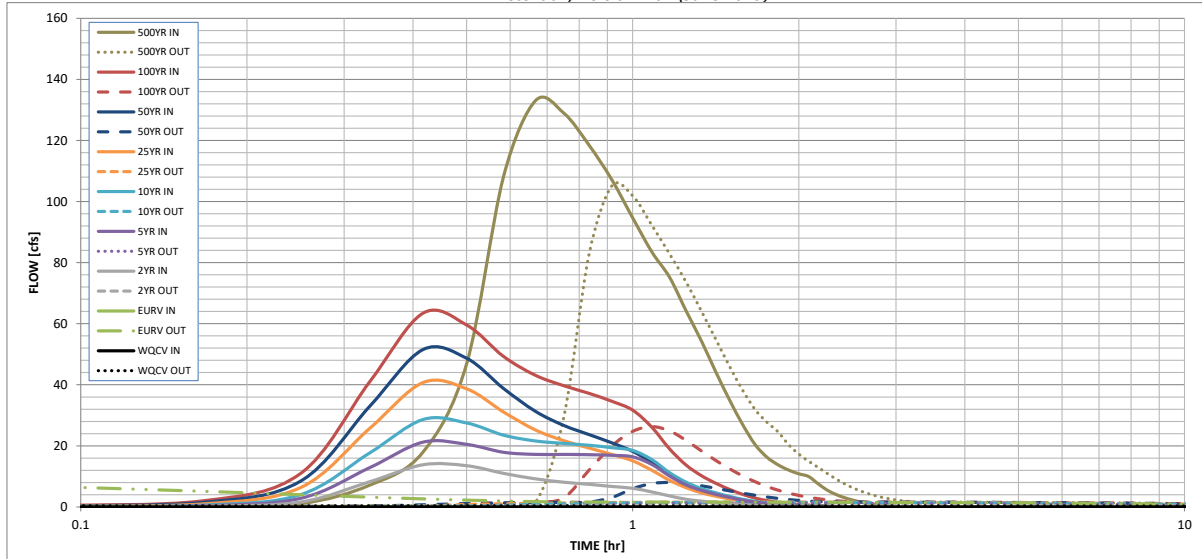
Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =									
One-Hour Rainfall Depth (in) =	N/A	N/A	0.56	0.88	1.01	1.08	1.26	1.64	3.14
CUHP Runoff Volume (acre-ft) =	0.702	2.144	0.802	1.417	1.686	1.961	2.497	3.767	8.657
User Override Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.714	1.459	1.789	1.970	2.450	3.508	8.657
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.1	0.8	1.1	4.3	9.5	21.6	65.7
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A	5.5	10.1	13.9	21.5	28.7	37.0	
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.15	0.27	0.37	0.57	0.76	0.98	1.74
Peak Inflow Q (cfs) =	N/A	N/A	13.8	21.2	28.6	40.7	51.5	63.4	133.0
Peak Outflow Q (cfs) =	0.4	9.4	0.4	1.3	1.5	1.6	8.0	26.3	105.1
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.1	0.1	0.3	0.7	1.6
Structure Controlling Flow =	Vertical Orifice 1	Overflow Weir 1	Plate	Vertical Orifice 1	Vertical Orifice 1	Vertical Orifice 1	Overflow Weir 1	Overflow Weir 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	0.74	N/A	N/A	N/A	N/A	0.5	1.9	2.1
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	39	47	40	46	48	48	47	45	35
Time to Drain 99% of Inflow Volume (hours) =	42	53	43	51	53	54	54	53	47
Maximum Ponding Depth (ft) =	4.27	7.50	4.18	5.86	6.52	6.86	7.38	7.95	9.05
Area at Maximum Ponding Depth (acres) =	0.35	0.55	0.34	0.44	0.49	0.51	0.54	0.58	0.66
Maximum Volume Stored (acre-ft) =	0.702	2.147	0.668	1.333	1.635	1.804	2.082	2.396	3.081

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.07 (June 2025)



S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

Time Interval	SOURCE	CUHP	CUHP	USER	USER	USER	USER	USER	USER	CUHP
	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0	0.00	0.00	0.00	0.10	0.10	0.20	0.30	0.00
	0:10:00	0	0.00	0.20	0.40	0.60	1.00	1.50	2.00	1.07
	0:15:00	0	0.00	1.60	2.80	4.00	6.30	8.40	10.90	7.07
	0:20:00	0	0.00	8.20	12.80	17.60	25.60	32.80	40.80	17.88
	0:25:00	0	0.00	13.80	21.20	28.60	40.70	51.50	63.40	46.72
	0:30:00	0	0.00	13.50	20.50	27.50	38.70	48.70	59.60	108.05
	0:35:00	0	0.00	11.00	17.90	23.50	31.10	38.80	49.30	133.03
	0:40:00	0	0.00	9.20	17.20	21.60	25.20	31.30	43.10	129.00
	0:45:00	0	0.00	8.10	17.20	20.80	21.70	26.70	39.70	118.52
	0:50:00	0	0.00	7.40	17.10	20.20	19.30	23.70	37.20	107.17
	0:55:00	0	0.00	6.70	16.90	19.40	17.20	21.00	34.60	94.68
	1:00:00	0	0.00	6.10	16.40	18.50	15.10	18.20	31.70	83.51
	1:05:00	0	0.00	4.90	13.90	15.50	12.00	14.50	26.10	75.19
	1:10:00	0	0.00	3.60	10.10	11.20	8.70	10.50	19.00	64.18
	1:15:00	0	0.00	2.50	7.20	8.10	6.30	7.50	13.70	54.23
	1:20:00	0	0.00	1.90	5.40	6.00	4.60	5.60	10.20	43.98
	1:25:00	0	0.00	1.40	4.10	4.60	3.50	4.20	7.70	34.83
	1:30:00	0	0.00	1.00	3.10	3.40	2.60	3.10	5.70	26.91
	1:35:00	0	0.00	0.80	2.20	2.50	1.80	2.20	4.10	20.43
	1:40:00	0	0.00	0.50	1.60	1.80	1.30	1.60	2.90	16.34
	1:45:00	0	0.00	0.40	1.10	1.20	0.90	1.10	2.10	13.81
	1:50:00	0	0.00	0.30	0.80	0.90	0.70	0.80	1.50	12.07
	1:55:00	0	0.00	0.20	0.60	0.60	0.50	0.60	1.10	10.85
	2:00:00	0	0.00	0.10	0.40	0.50	0.30	0.40	0.80	9.96
	2:05:00	0	0.00	0.10	0.30	0.30	0.30	0.30	0.60	7.63
	2:10:00	0	0.00	0.10	0.20	0.20	0.20	0.20	0.40	5.54
	2:15:00	0	0.00	0.10	0.20	0.20	0.10	0.20	0.30	4.12
	2:20:00	0	0.00	0.00	0.10	0.10	0.10	0.10	0.20	3.07
	2:25:00	0	0.00	0.00	0.10	0.10	0.10	0.10	0.10	2.28
	2:30:00	0	0.00	0.00	0.10	0.10	0.00	0.00	0.10	1.66
	2:35:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.21
	2:40:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87
	2:45:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59
	2:50:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
	2:55:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
	3:00:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
	3:05:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	3:10:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.07 (June 2025)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

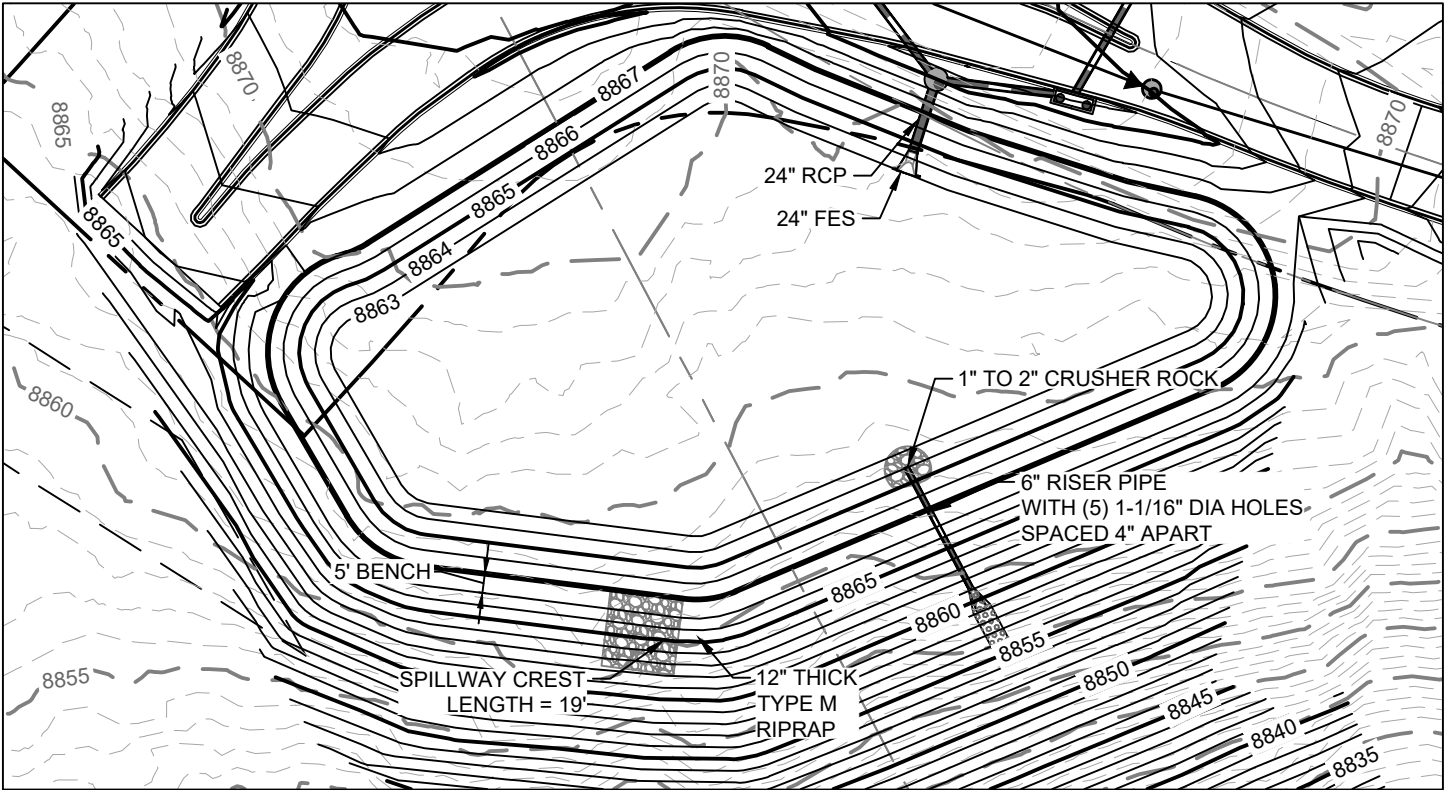
[illegible]

Project Name: West Mountain - F1 - 10W.1 & 11W
Prepared By: JNS

Pond B Stage Storage Discharge Tables

Pond B Area-Elevation-Discharge Table						
Stage (ft)	Elevation (ft)	Area (ft ²)	Incremental Volume (ft ³)	Volume (ft ³)	Volume (Ac-ft)	Discharge (cfs)
0	8785	35	0	0	0.00	0
0.25	8785.25	605	80	80	0.00	0.04
0.5	8785.5	1176	223	303	0.01	0.05
0.75	8785.75	1746	365	668	0.02	0.07
1	8786	2316	508	1176	0.03	0.08
1.25	8786.25	3302	702	1878	0.04	0.08
1.5	8786.5	4288	949	2827	0.06	0.09
1.75	8786.75	5273	1195	4022	0.09	0.14
2	8787	6259	1442	5463	0.13	0.16
2.25	8787.25	7391	1706	7170	0.16	0.18
2.5	8787.5	8523	1989	9159	0.21	0.19
2.75	8787.75	9655	2272	11431	0.26	0.21
3	8788	10787	2555	13986	0.32	0.22
3.25	8788.25	11701	2811	16797	0.39	0.27
3.5	8788.5	12615	3040	19837	0.46	0.3
3.75	8788.75	13530	3268	23105	0.53	0.32
4	8789	14444	3497	26602	0.61	0.34
4.25	8789.25	15112	3695	30296	0.70	0.36
4.27	8789.27	15166	303	30599	0.70	0.37
4.47	8789.47	15701	3087	33686	0.77	0.61
4.5	8789.5	15781	472	34158	0.78	0.64
4.75	8789.75	16449	4029	38187	0.88	0.82
5	8790	17118	4196	42382	0.97	0.95
5.25	8790.25	17772	4361	46744	1.07	1.06
5.5	8790.5	18427	4525	51269	1.18	1.16
5.75	8790.75	19081	4689	55957	1.28	1.25
6	8791	19736	4852	60809	1.40	1.33
6.25	8791.25	20426	5020	65829	1.51	1.41
6.5	8791.5	21115	5193	71022	1.63	1.48
6.75	8791.75	21805	5365	76387	1.75	1.55
7	8792	22495	5538	81925	1.88	1.61
7.13	8792.13	22871	2949	84873	1.95	2.89
7.25	8792.25	23219	2765	87639	2.01	5.00
7.5	8792.5	23942	5895	93534	2.15	11.13
7.75	8792.75	24666	6076	99610	2.29	19.06
8	8793	25390	6257	105867	2.43	27.31
8.25	8793.25	26148	6442	112309	2.58	35.56
8.5	8793.5	26905	6632	118941	2.73	51.12
8.75	8793.75	27663	6821	125762	2.89	72.29
9	8794	28421	7011	132772	3.05	98.67
9.25	8794.25	29206	7203	139976	3.21	130.11
9.5	8794.5	29992	7400	147375	3.38	166.59
9.75	8794.75	30777	7596	154972	3.56	208.11
10	8795	31563	7793	162764	3.74	254.73

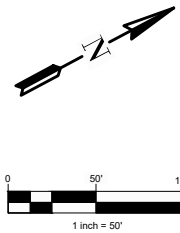
2/2/2026 9:06 AM : X:\GRAND PARK\DOCUMENTS\REPORTS\RAINAGE\16.1 - FILING 1 - 8WB, 9W, 10W, 11W\PHASE 3 - 10WD - POND & WQ CALC\TEMP SEDIMENT POND EXHIBIT.DWG;



TEMP SED POND VOLUME CALCULATION PER MHFD DETAIL SC-7

BASINS	DEVELOPED?	AREA (AC)	IMPERVIOUSNESS	ADDITIONAL VOLUME PER TABLE SB-1 (FT ³ /AC)	VOLUME REQ. (FT ³)
C	Y	1.71	12%	800	1372
C1	Y	2.92	40%	2030	5927
C2.1	Y	0.78	58%	2980	2334
C2.2	Y	0.41	85%	4360	1769
C2.3	Y	3.44	25%	1600	5502
C2.4	Y	1.05	30%	1600	1686
C2.5	Y	0.16	75%	4360	676
C2.6	Y	1.38	34%	1600	2215
C2.7	Y	0.48	70%	3560	1721
TOTAL DEVELOPED AREA		12.34	-	3600	44420
				TOTAL REQUIRED VOLUME	67318

STAGE STORAGE TABLE						
ELEV	AREA (sq. ft.)	DEPTH (ft)	AVG END INC. VOL. (cu. ft.)	AVG END TOTAL VOL. (cu. ft.)	CONIC INC. VOL. (cu. ft.)	CONIC TOTAL VOL. (cu. ft.)
8,863.00	15,310.80	N/A	N/A	0.00	N/A	0.00
8,864.00	17,546.28	1.00	16428.54	16428.54	16415.85	16415.85
8,865.00	19,887.36	1.00	18716.82	35145.36	18704.61	35120.46
8,866.00	22,334.08	1.00	21110.72	56256.09	21098.90	56219.36
8,867.00	24,886.35	1.00	23610.22	79866.30	23598.71	79818.07



Project Name: West Mountain - F1 - 10W.1 & 11W
Prepared By: JNS

Temporary Sediment Basin C - Stage-Storage Discharge Calculations

User Input	Orifice Diameter (in) =	1.0625
	Spillway Width (ft) =	19
	Bottom Elevation (ft) =	8863

Pond C - Pond Volume Calculations							Cicular Orifice 1		Cicular Orifice 2		Cicular Orifice 3		Cicular Orifice 4		Cicular Orifice 5		Riser Pipe Opening		Spillway		Total Flow
							Cd = 0.6		Cd = 0.6		Cd = 0.6		Cd = 0.6		Cd = 0.6		Cd = 0.6				
							Diameter (in) = 1.0625		Diameter (in) = 1.0625		Diameter (in) = 1.0625		Diameter (in) = 1.0625		Diameter (in) = 1.0625		Diameter (in) = 8		Length (ft)	19	
							CL = 8864.29		CL = 8864.63		CL = 8864.96		CL = 8865.29		CL = 8865.63		CL = 8866.00		Cbcw = 3		
							FL = 8864.25		FL = 8864.58		FL = 8864.92		FL = 8865.25		FL = 8865.58		FL = 8866.00		Z = 4		
							A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.00616		A(sf) = 0.196349541		Invert = 8866		
Elev	Stage	Notes	Area		Volume			H (ft)	Q (cfs)	H (ft)	Q (cfs)	H (ft)	Q (cfs)	H (ft)	Q (cfs)	H (ft)	Q (cfs)	H (ft)	Q (cfs)	H (ft)	Q (cfs)
					Incr. [CF]	Total [CF]	Total [AC-FT]														
8863.00	0.00		[SF]	[AC]	[CF]	[CF]	[AC-FT]														
8863.00	0.00		15311	0.3515	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8863.25	0.25		15861	0.3641	3897	3897	0.0895	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8863.50	0.50		16417	0.3769	4035	7931	0.1821	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8863.75	0.75		16978	0.3898	4174	12106	0.2779	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8864.00	1.00		17546	0.4028	4316	16421	0.3770	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8864.25	1.25		18123	0.4160	4459	20880	0.4793	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8864.50	1.50		18705	0.4294	4604	25483	0.5850	0.21	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
8864.58	1.58	Orifice 1	18893	0.4337	1504	26987	0.6195	0.29	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
8864.75	1.75		19293	0.4429	3246	30233	0.6941	0.46	0.02	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
8864.91	1.91	Orifice 2	19673	0.4516	3117	33350	0.7656	0.62	0.02	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
8865.00	2.00		19887	0.4565	1780	35130	0.8065	0.71	0.02	0.37	0.02	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
8865.24	2.24	Orifice 3	20466	0.4698	4842	39973	0.9176	0.95	0.03	0.61	0.02	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
8865.25	2.25		20491	0.4704	205	40178	0.9224	0.96	0.03	0.62	0.02	0.29	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
8865.50	2.50		21100	0.4844	5199	45376	1.0417	1.21	0.03	0.87	0.03	0.54	0.02	0.21	0.01	0.00	0.00	0.00	0.00	0.00	0.10
8865.57	2.57	Orifice 4	21271	0.4883	1483	46859	1.0757	1.28	0.03	0.94	0.03	0.61	0.02	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.10
8865.70	2.70	10-Year Max Depth	21591	0.4957	2786	49645	1.1397	1.41	0.04	1.07	0.03	0.74	0.03	0.41	0.02	0.07	0.01	0.00	0.00	0.00	0.12
8865.75	2.75		21714	0.4985	1083	50728	1.1646	1.46	0.04	1.12	0.03	0.79	0.03	0.46	0.02	0.12	0.01	0.00	0.00	0.00	0.12
8865.90	2.90	Orifice 5	22085	0.5070	3285	54013	1.2400	1.61	0.04	1.27	0.03	0.94	0.03	0.61	0.02	0.27	0.02	0.00	0.00	0.00	0.14
8866.00	3.00	Riser Pipe Opening/Spillway Invert	22334	0.5127	2221	56234	1.2910	1.71	0.04	1.37	0.03	1.04	0.03	0.71	0.02	0.37	0.02	0.00	0.00	0.00	0.15
8866.20	3.20	100-Year Max Depth	22838	0.5243	4517	60751	1.3947	1.91	0.04	1.57	0.04	1.24	0.03	0.91	0.03	0.57	0.02	0.20	0.42	0.20	5.85
8866.25	3.25		22964	0.5272	1145	61896	1.4209	1.96	0.04	1.62	0.04	1.29	0.03	0.96	0.03	0.62	0.02	0.25	0.47	0.25	8.06
8866.50	3.50		23600	0.5418	5821	67717	1.5546	2.21	0.04	1.87	0.04	1.54	0.04	1.21	0.03	0.87	0.03	0.50	0.67	0.50	22.70
8866.75	3.75		24240	0.5565	5980	73697	1.6918	2.46	0.05	2.12	0.04	1.79	0.04	1.46	0.04	1.12	0.03	0.75	0.82	0.75	42.71
8867.00	4.00		24886	0.5713	6141	79837	1.8328	2.71	0.05	2.37	0.05	2.04	0.04	1.71	0.04	1.37	0.03	1.00	0.95	1.00	67.76

Project Name: West Mountain - F1 - 10W.1 & 11W

Prepared By: JNS

Temp Sed Basin C Stage Storage Discharge Table

Temp Sed Basin C Area-Elevation-Discharge Table			
Stage (ft)	Elevation (ft)	Area (ft ²)	Discharge (cfs)
0	8863	15311	0.0
0.25	8863.25	15861	0.0
0.5	8863.5	16417	0.0
0.75	8863.75	16978	0.0
1	8864	17546	0.0
1.25	8864.25	18123	0.0
1.5	8864.5	18705	0.0
1.58	8864.58	18893	0.0
1.75	8864.75	19293	0.0
1.91	8864.91	19673	0.0
2	8865	19887	0.0
2.24	8865.24	20466	0.1
2.25	8865.25	20491	0.1
2.5	8865.5	21100	0.1
2.57	8865.57	21271	0.1
2.7	8865.7	21591	0.1
2.75	8865.75	21714	0.1
2.9	8865.9	22085	0.1
3	8866	22334	0.1
3.2	8866.2	22838	5.9
3.25	8866.25	22964	8.1
3.5	8866.5	23600	22.7
3.75	8866.75	24240	42.7
4	8867	24886	67.8

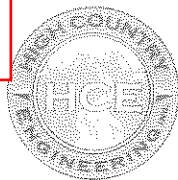
APPENDIX E

REFERENCES

Storm Drainage Master Plan for Grand Park by High Country Engineering, Inc. Dated February 17, 2006.

A Pragmatic Slope-Adjusted Curve Number Model to Reduce Uncertainty in Predicting Flood Runoff from Steep Watersheds. Ajmal, Wassem, Kim, & Kim. 2020.

Sediment Basin Details from MHFD's *Urban Storm Drainage Criteria Manual* vol. 3, 2010 (Revised March 2024), pp. 486-492.



An Employee-Owned Company

AND SUPERVISOR

EXCERPTS FROM
STORM DRAINAGE
MASTER PLAN
FOR
GRAND PARK

FRASER, COLORADO

October 10, 2005
Revised February 17, 2006

PREPARED FOR:

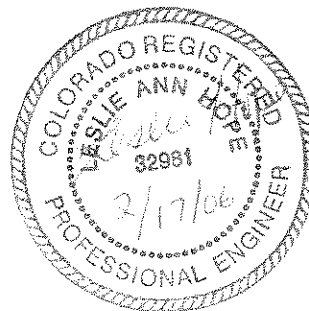
Cornerstone Winter Park Holdings, LLC

HCE JOB NO. 2052014.00

Prepared by:

A handwritten signature in cursive script that reads "Leslie A. Hope".

Leslie A. Hope, P.E.
High Country Engineering, Inc.
14 Inverness Drive East, Suite F-120
Englewood, CO 80112



GRAND PARK STORM DRAINAGE MASTER PLAN

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 EXECUTIVE SUMMARY	2
2.0 INTRODUCTION	4
2.1 GENERAL.....	4
2.2 PURPOSE.....	4
2.3 MASTER PLAN – GENERAL	4
2.4 PROPOSED LAND USE	5
3.0 HYDROLOGY / HYDRAULIC ANALYSIS	7
3.1 GENERAL.....	7
3.2 DESIGN RAINFALL.....	7
3.3 BASIN CHARACTERISTICS.....	7
3.4 CURVE NUMBER “CN”	8
3.5 EXISTING FACILITIES	8
4.0 PROPOSED DRAINAGE IMPROVEMENTS.....	11
4.1 GENERAL.....	11
4.2 DESIGN BASIS	13
4.3 MINOR DRAINAGE SYSTEMS.....	14
4.4 PHASING OF IMPROVEMENTS	14
4.5 FEMA FIRM MAPPING	14
5.0 REFERENCES	16

LIST OF FIGURES

FIGURE 1 VICINITY MAP	3
FIGURE 2 SCS SURVEY	9
FIGURE 3 EXISTING DRAINAGE MAP	10
FIGURE 4 PROPOSED DRAINAGE BASIN MAP	12
FIGURE 5 FIRM MAP.....	15

APPENDIX A:	HYDROLOGIC INPUT
APPENDIX B:	HYDROLOGIC OUTPUT
APPENDIX C:	CULVERT CALCULATIONS

GRAND PARK STORM DRAINAGE MASTER PLAN

1.0 EXECUTIVE SUMMARY

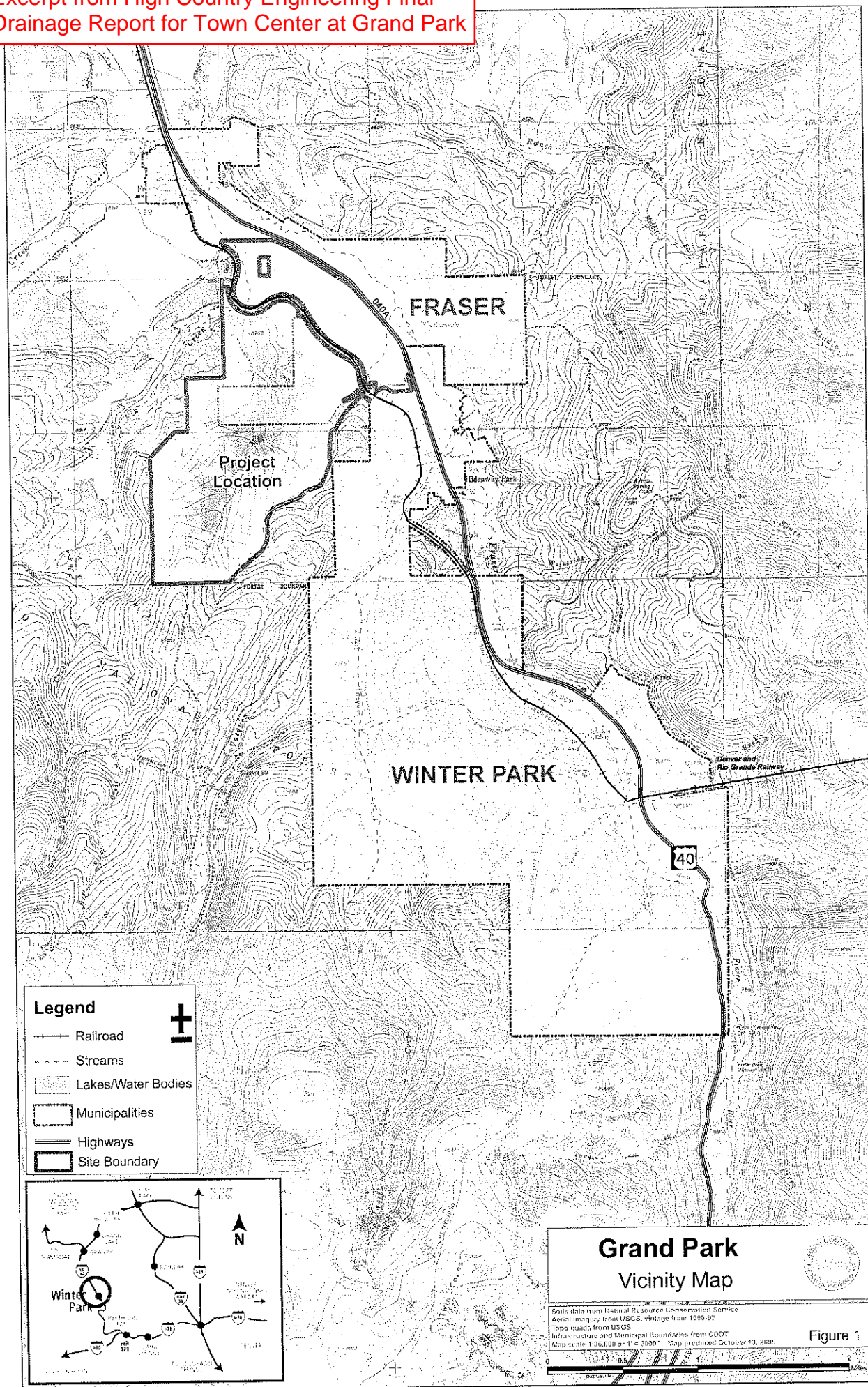
The “Grand Park Storm Drainage Master Plan” was prepared for Cornerstone Winterpark Holdings LLC. The purpose of this report is to identify regional drainage facilities required to safely convey the developed storm events, up to the 100 year storm, to the historic receiving basins while improving the water quality of the developed flows prior to discharging to the receiving streams. These facilities will consist of regional detention ponds / water quality facilities to reduce the developed flow rates to historic rates and recommendations for proposed culverts and channels.

The results of this study are: identifying the historic and developed drainage basin boundaries, determining the respective 2 year and 100 year stormwater flow rates and volumes, determining sizing of the detention facilities to reduce the peak flow rates, and providing designs for water quality features to be incorporated in the regional facilities and proposed developments. Structural and non-structural water quality enhancement measures were incorporated based on the guidelines provided in the Urban Drainage Criteria Manual, Volume III.

The overall drainage of the Grand Park area has been divided into two major subareas: drainage to Elk Creek and drainage to Leland Creek; see Figure 1. The land generally flows from the south toward the Denver and Rio Grande Railroad and ultimate discharge to the Fraser River.

Under the existing conditions, the Denver and Rio Grande Railroad embankment attenuates stormwater flows prior to discharging to the Fraser Draw. There are three existing culverts located under the Denver and Rio Grande Railroad within the project limits: one on the east side for Elk Creek, one in the middle of the development for a no-name drainage way, and a third on the east side for Leland Creek. The Leland Creek and Fraser River are a part of a FEMA designated floodplain. This report does not address any potential FEMA CLOMR applications.

For proposed conditions, the existing culverts will be used to convey flows under the Railroad, from the regional detention ponds located south of the railroad to the plateau between US 40 and the Railroad. The plateau area contains wetland areas that will not be disturbed with the proposed development. At this time, no pipe borings under the railroad or US 40 are being proposed. Discharge from the development, in general, will be to the north toward the Fraser River. Conveyance of stormwater will be accommodated via a combination of storm drainage pipes, grass-lined swales, regional detention facilities, and potentially check dams and drop structures. Water quality enhancement features will be incorporated into the design of the swales and detention facilities. These facilities will be constructed to accommodate up to the 100 year developed flows.



GRAND PARK STORM DRAINAGE MASTER PLAN

2.0 INTRODUCTION

2.1 GENERAL

The Grand Park Storm Drainage Master Plan has been prepared to provide an overall guide to the management of stormwater associated with the proposed development of Grand Park and tributary drainage areas. This Master Plan is a dynamic document and should be revised periodically to reflect changes from conceptual to actual. The Master Drainage Plan presents the results of hydrologic and hydraulic analyses evaluating the effects of the proposed development on the historic runoff patterns, based on current available information. Grand County Storm Drainage Design Criteria and the Urban Drainage and Flood Control District criteria were utilized for the development of this report.

The Grand Park subdivision is located in Grand County, and is approximately 1,311-acres of land. Grand Park is located in Sections 20, 28, 29, 30, 31, 32, Township 1 South, Range 75 West of the Sixth Principal Meridian, Town of Fraser, Grand County, Colorado. The proposed development is a Planned Unit Development consisting of a wide range of single family, multi-family, commercial, lodging, and open space uses.

2.2 PURPOSE

The purpose of this study is to prepare a master drainage study for the Grand Park development area. The Master Plan includes:

1. Development and evaluation of the results of a hydrologic model for the basins.
2. Determine the sizes of major culverts, and detention structures.
3. Establish design criteria for water quality treatment and stormwater management.

2.3 MASTER PLAN – GENERAL

Due to the substantial size of Grand Park, long-term planning for the phased development of Grand Park is essential. Paramount to the planning is the phased development of the infrastructure necessary to serve Grand Park.

It was anticipated that the planning for infrastructure to service Grand Park would be done in three stages: 1. Master Plans, 2. Preliminary Plans, 3. Final Subdivision Platting.

1. Master Plans. The first stage of planning is to be comprised of the development and approval of the “Storm Drainage Master Plan” for Grand Park. The Master Plan is intended to serve as conceptual preliminary long-term planning and forecasting document, and may be updated, from time to time, as development actually occurs. It is anticipated that the Storm

GRAND PARK STORM DRAINAGE MASTER PLAN

Drainage Master Plan would address the necessary regional storm drainage facilities for Grand Park.

2. Preliminary Plans. The second stage of planning is to consist of the development and approval of Preliminary Plans for the individual phases of Grand Park.

In preparing Phased Preliminary Plans, if upstream development occurs prior to the construction of downstream storm drainage improvements, it is contemplated that the upstream property will cause to be constructed necessary downstream storm drainage improvements as reflected in this Storm Drainage Master Plan. As all property in Grand Park is developed, the property will be required to establish or set aside such land areas as may be necessary to accomplish upstream and downstream drainage and water quality mitigation, in general accordance with this Storm Drainage Master Plan.

The precise boundaries of the basins are subject to modification as more accurate topographic information becomes available, or as the subject land is graded for final development. Lands located in one basin as reflected in the Proposed Drainage Basin Map (Figure 5) may be later graded to drain into a different basin, provided appropriate measures are taken to accommodate such modifications. The grading and basin utilization patterns of a particular parcel of land shall be set forth in the Phased Preliminary Plan(s) and Final plat(s) affecting the parcel of land.

Each Phased Preliminary Plan shall set forth the development assumptions under which it was prepared (regarding land uses and densities) and will address: the impact of the development of the Phased Area on other Phase Areas already developed or approved; (2) the estimated timing of the improvements to be installed; and (3) phasing of improvements

3. Final Subdivision Platting. The third and final stage of planning is to be comprised of the development and approval of plats. The platting process shall be conducted consistent with the then-existing City ordinances, rules, regulations and guidelines for platting, amended, as appropriate, by any applicable Annexation Agreements affecting the land to be platted.

2.4 PROPOSED LAND USE

The land usage is outlined in the Grand Park Planned Unit Development Master Land Use Plan. A list of the land usage by area is presented in Table 1.

GRAND PARK STORM DRAINAGE MASTER PLAN

Table 1. Master Plan Areas		
Designation	Type	Density (Units per Acre)
1Wa	Multi-family Attached, Lodging Units, Commercial	7.6 units / acre
1Wb	Multi- Family Attached	6.8 units / acre
2W	Single Family, Multi-family Attached, Lodging Units, Commercial	7.6 units / acre
3Wa	Multi- Family Attached	13.1 units / acre
3Wb	Single Family, Multi-family Attached	4.7 units / acre
3Wc	Multi-family Attached, Commercial	5.2 units / acre
4W	Multi-family Attached, Commercial	9.3 units / acre
5W	Single Family, Multi-family Attached	4.5 units / acre
6W	Public Site	
7W	Single Family, Multi-family Attached	8.1 units / acre
8Wa	Single Family, Multi-family Attached	2.0 units / acre
8Wb	Multi- Family Attached	2.2 units / acre
9W	Single Family, Multi-family Attached, Lodging Units, Commercial	4.7 units / acre
10W	Single Family, Multi-family Attached, Lodging Units, Commercial	4.7 units / acre
11W	Single Family, Multi-family Attached, Lodging Units	2.6 units / acre
12W	Multi-family Attached, Lodging Units	3.5 units / acre
13Wa	Single family	1.4 units / acre
13Wb	Single family	0.6 units / acre
14W	Single family	1.5 units / acre
15W	Single family	0.5 units / acre
16W	Single family	1.0 units / acre
17W	Single family	0.5 units / acre
18W	Single family	2.5 units / acre
19W	Single Family, Multi-family Attached	3.1 units / acre
20W	Single Family, Multi-family Attached	2.1 units / acre
21W	Single Family, Multi-family Attached	5.1 units / acre

GRAND PARK STORM DRAINAGE MASTER PLAN

3.0 HYDROLOGY / HYDRAULIC ANALYSIS

3.1 GENERAL

A hydrologic analysis was performed on the study area to define the peak runoff flows and volumes for the 2- and 100-year, 24 hour design storm frequencies. The peak flow information obtained from the analysis was used to evaluate existing drainage facilities, identify potential drainage problems, and to design drainage improvements.

The computer program HEC-HMS was used to determine runoff quantities for each basin. Runoff hydrographs were developed for each basin. The basin parameter required for HEC-HMS input include:

- Area,
- Flow length,
- Slope,
- Time of Concentration / Lag Time,
- Percent Impervious,
- Runoff coefficient
- Rainfall Hyetograph.

Appendix A provides the parameters used in the existing and proposed conditions in the HEC-HMS model.

3.2 DESIGN RAINFALL

Rainfall depths for each storm frequency were taken from the NOAA Atlas:

Table 2. Storm Duration Precipitation Depths	
2 Year – 6 Hour	0.98 inch
2 Year – 24 Hour	1.32 inches
100 Year – 6 Hour	2.17 inches
100 Year – 24 Hour	2.98 inches

3.3 BASIN CHARACTERISTICS

The amount of impervious area within each basin was estimated for existing and future development conditions. These values are presented in Appendix A. Impervious percentages were calculated using values from Volume I of the Urban Drainage and Flood Control District Criteria Manual (2001). The soils types within the onsite and offsite drainage basins consist of:

Cowdrey Loam (15 – 45% slope)	Hydrologic Group: C
Cumilic Cryaquolis	Hydrologic Group: D

GRAND PARK STORM DRAINAGE MASTER PLAN

Frisco Peeler Gravelly Sandy Loam (2 – 6%)	Hydrologic Group: B
Frisco Peeler Gravelly Sandy Loam (6 – 25%)	Hydrologic Group: B
Frisco Peeler Gravelly Sandy Loam (25 – 65%)	Hydrologic Group: B
Scott Cobbly Sandy Loam (15 – 65%)	Hydrologic Group: B
Tine Gravelly Sandy Loam (0 – 3%)	Hydrologic Group: A

The basin soil type is predominantly representative of Soils Group B in accordance with the National Resources Conservation Service (NRCS) soils classifications. See Figure 2 – Soils Survey.

3.4 CURVE NUMBER “CN”

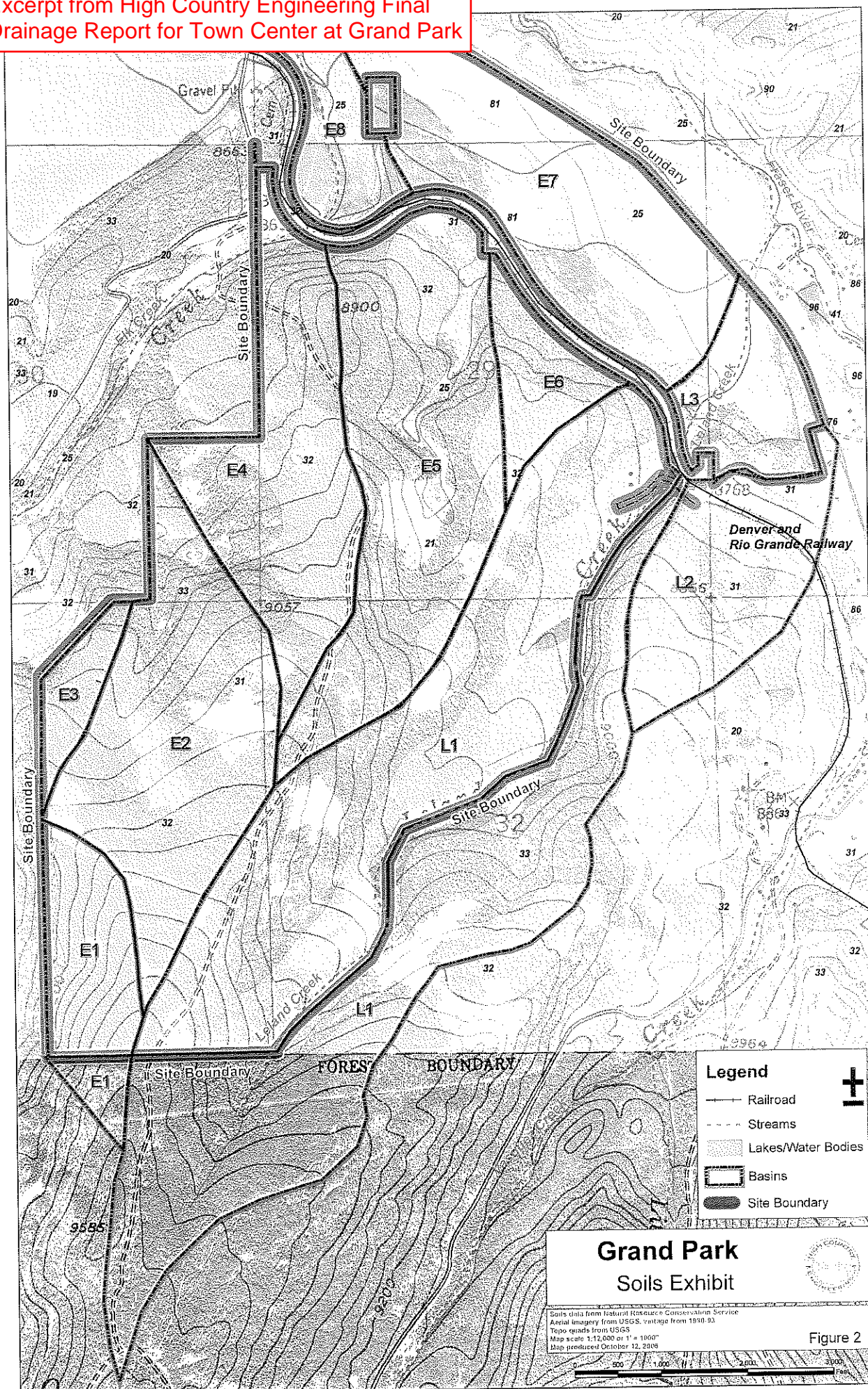
The National Resources Conservation Service (SCS Method) was used in this study to approximate peak runoff. The curve number is based on the soils type, the land usage and the vegetative cover.

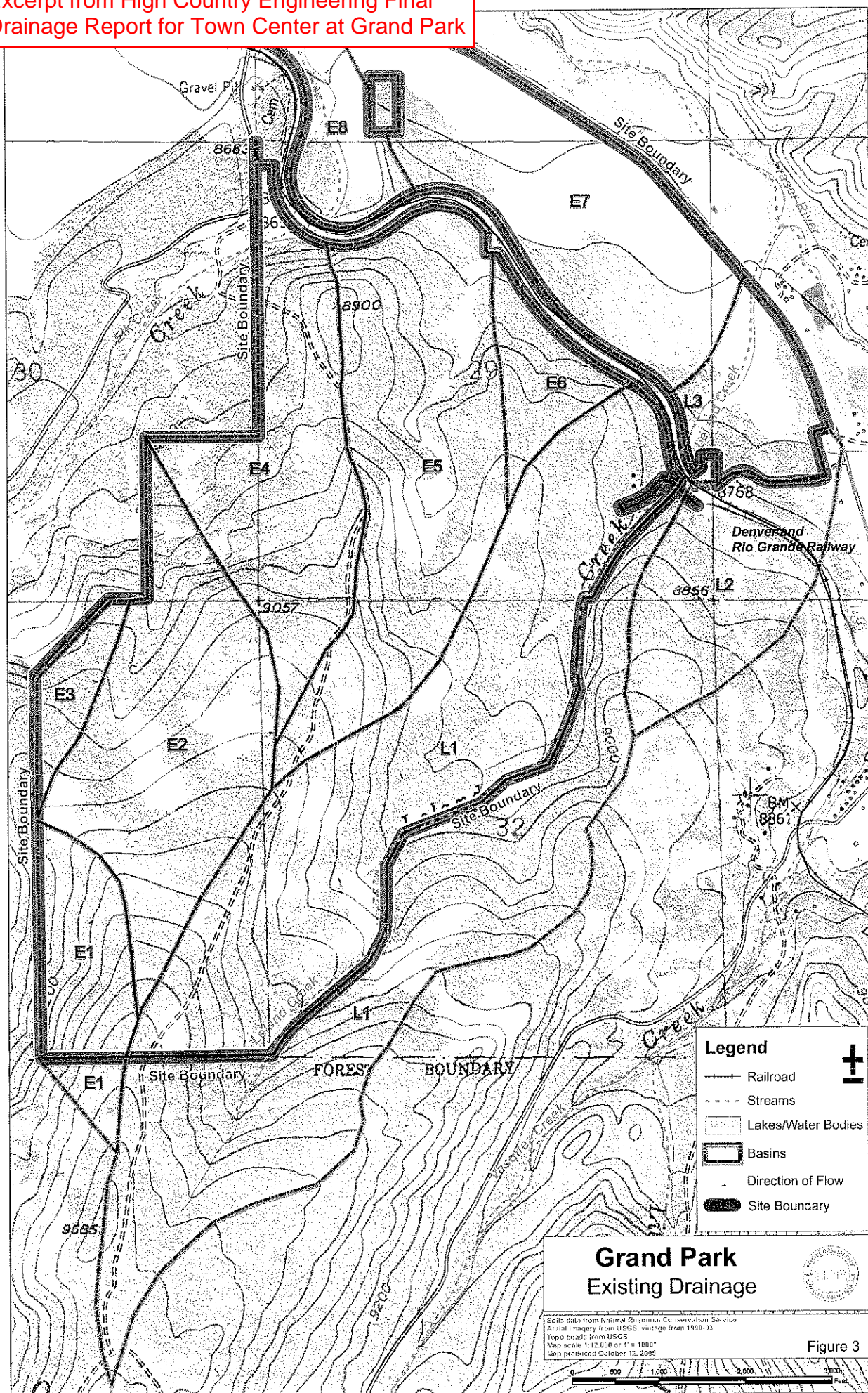
3.5 EXISTING FACILITIES

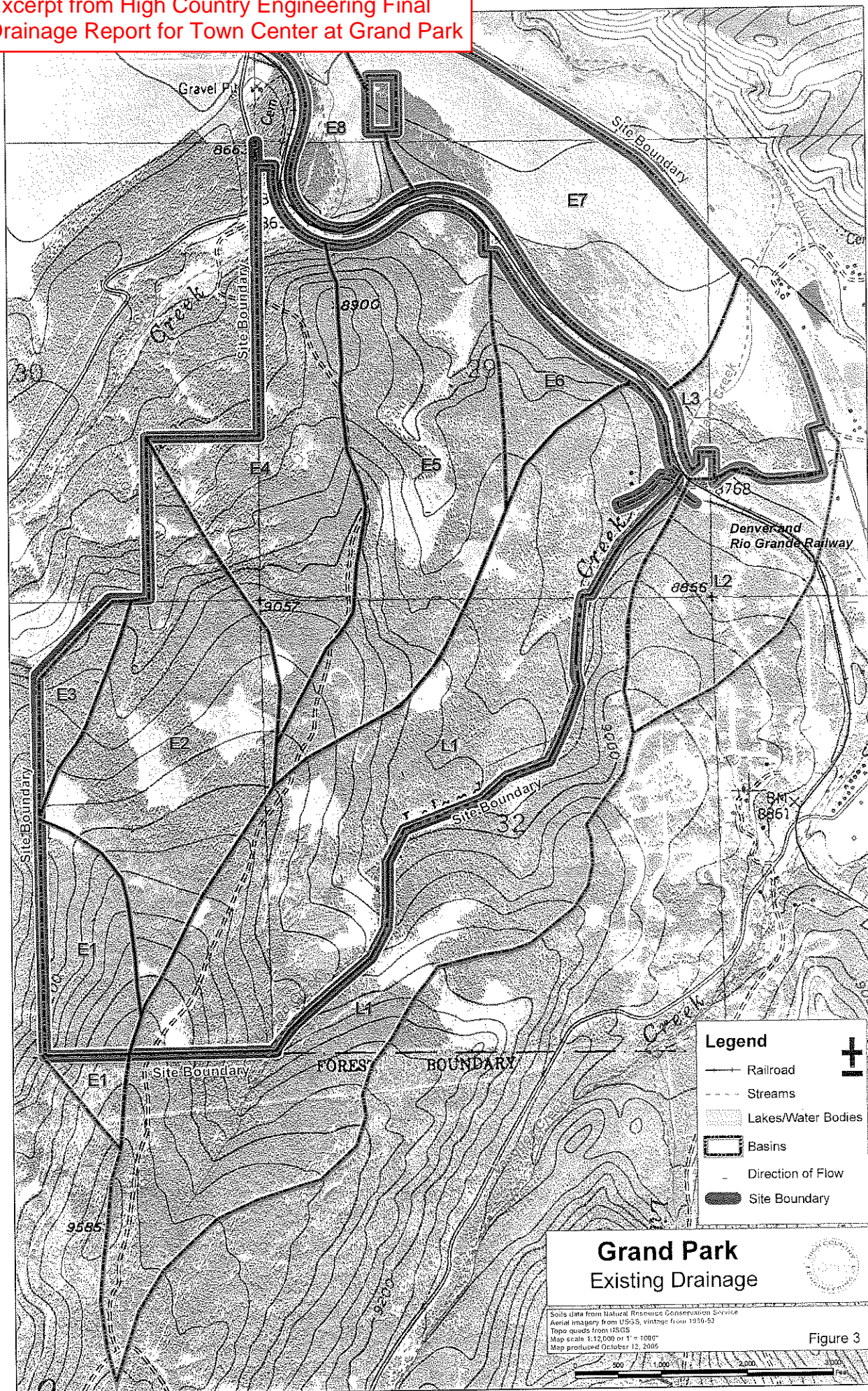
Denver and Rio Grande Culvert Crossing Analysis

Based on the results of field observations by High Country Engineering, Inc., three major culvert crossings under the Denver and Rio Grande Railroad were identified. These major crossings are Design Point 4 – Elk Creek, Design Point 6 – No name drainage, Design Point 9 – Leland Creek. A summary of their hydraulic properties is presented below.

Design Point	Description	2 yr – 24 hr Existing Flow (cfs)	100 yr – 24 hr Existing Flow (cfs)
4	Elk Creek at Railroad	2.4	39.6
6	No name drainage at Railroad	0.75	19.3
9	Leland Creek at Railroad	9.2	182
8	Elk Creek at US 40	6.9	145
7	No name drainage at US 40	2.9	50.5
11	Leland Creek at US 40	9.5	189







GRAND PARK STORM DRAINAGE MASTER PLAN

These culvert crossings are constructed with reinforced concrete pipe or corrugated metal pipe. The capacity of these culverts was determined using the top of the rail elevation and also at three feet below the top of rail (bottom of ballast elevation). Capacity analysis of the major stormwater culverts was performed using Autocad Hydrology, which utilizes the FHWA's HY-8 program. The software uses headwater elevation, tailwater elevation and pipe friction for capacity analysis. The results are shown in Table 3.

Table 3. Existing Culvert Capacities					
Design Point	Size (ft)	Quantity	Invert	Max. Water Surface Elevation	Estimated Capacity (cfs)
Elk Creek	3.5	1	8634	8652.75	196
No name	4.0	1	8692.7	8698.8	56.5
Leland Creek	4.0	1	8760.0	8765.0	237.2

4.0 PROPOSED DRAINAGE IMPROVEMENTS

4.1 GENERAL

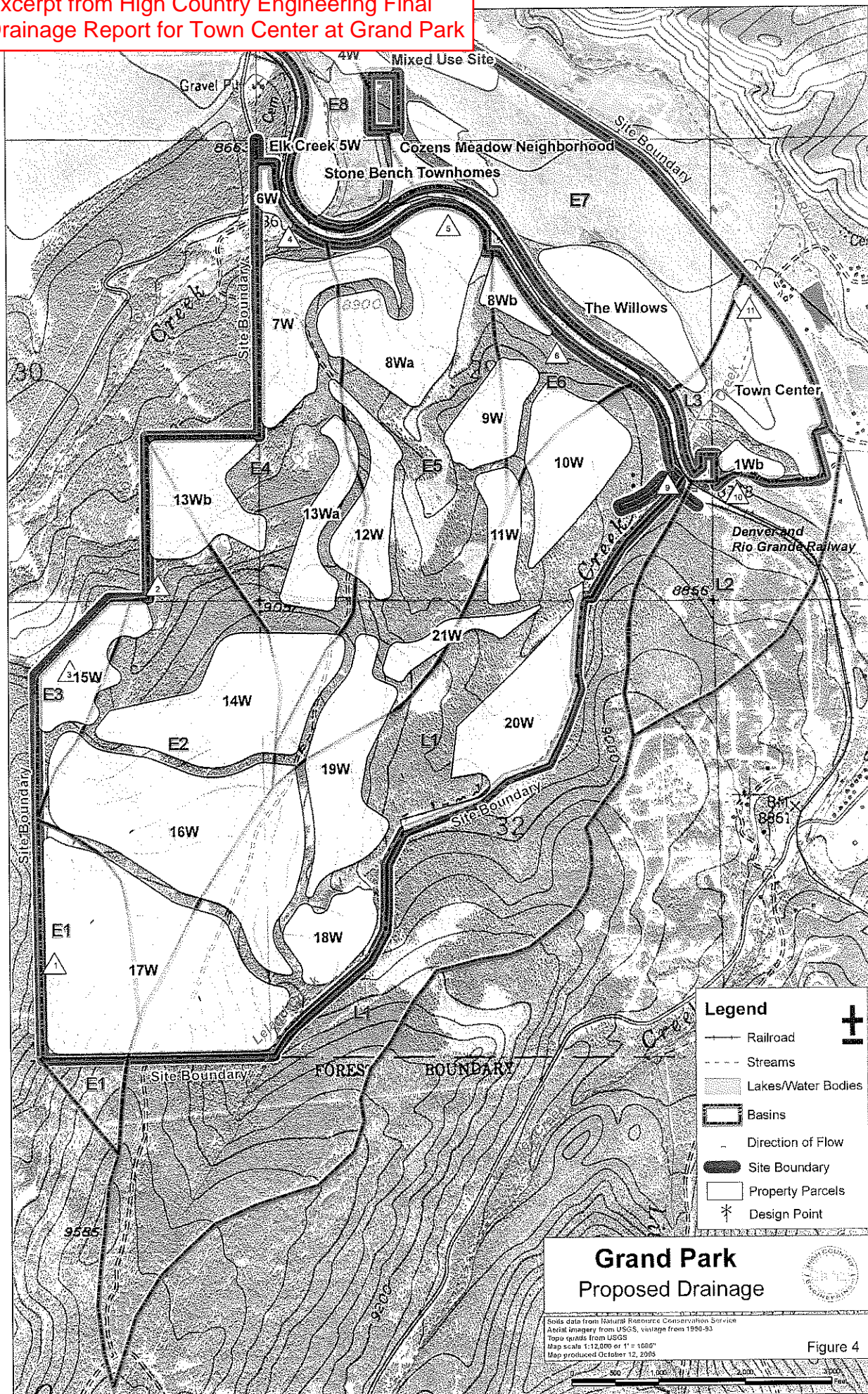
Proposed drainage improvements were developed for each drainage basin, utilizing Grand County Storm Drainage Criteria and Urban Drainage and Flood Control District's criteria.

This study did not attempt to forecast lot-specific drainage improvements, but limited itself to the overall stormwater management of each drainage basin.

The proposed drainage improvements were evaluated based on the stormwater routing results and consists of the following:

1. Grass-lined swales and stormwater conveyance channels,
2. Local and regional detention facilities,
3. Culvert crossings (reinforced concrete pipes and box culverts).

Grass-lined swales and channels will be used to convey flows to detention facilities. Storm runoff will be detained in detention facilities for all storm frequencies up to and including the 100-year event. The size and discharge from these detention facilities will be determined based on the capacities of downstream drainage facilities and land availability. Improved channels with drop structures and check dams will be sized to convey the peak 100 year discharges based on fully developed conditions or detained flows, as applicable. The 100 year detention volumes were



calculated using both the SCS Tabular Method and the UDFCD's equation $V = K \cdot A$. The results of the analysis are included in the Appendix.

The proposed channels will in general, be grass-lined trapezoidal type channels with a variable width bottom and side slopes typically designed at a maximum ratio of three (horizontal) to one (vertical) ratio. The longitudinal slope is adjusted to limit the velocities to a maximum of 5 feet per second during the 100 year event. Some of the large grass-lined channels are proposed to include grade control structures (drop structures) to reduce the amount of earthwork required to construct the channel. Of note, in areas where deep excavations would be required to construct a channel, utilization of storm drain pipe was also considered, to avoid excavating larger areas of land that would be taken up by the side-slopes of the channel excavations.

Below is a summary of developed flows prior to entering the proposed detention facilities:

Design Point	Description	2 yr – 24 hr Proposed Flow (cfs)	100 yr – 24 hr Proposed Flow (cfs)
4	Elk Creek at Railroad	6.2	104
6	No name drainage at Railroad	7.4	56.5
9	Leland Creek at Railroad	8.2	186
8	Elk Creek at US 40	44.1	371
7	No name drainage at US 40	90.4	389
11	Leland Creek at US 40	16.6	197

Water quality enhancement features will be incorporated into the swales, channels, and detention facilities to enhance the water quality resulting from the impacts of future urbanization, on the drainage basins.

1.1 DESIGN BASIS

Preliminary and final design of proposed facilities will be performed in accordance with Town of Fraser's and Grand County's requirements. Detention ponds will incorporate multi-level outlets to control 10-year and 100-year storm events, as well as less frequent events. The applicable Best Management (BMP) of Volume III of the UDFCD Criteria Manual will be used during final design to mitigate potential adverse water quality impacts resulting from development. Detention pond and cell layouts as well as configuration of outlet structures will be established during the Preliminary Design phase, at which time a design report will be prepared presenting development of design concepts. Design reports will include preliminary plans and profiles of channels, storm sewers and culverts.

GRAND PARK STORM DRAINAGE MASTER PLAN

Railroad culvert capacities and US 40 capacities or historic discharge rates, whichever is less. Discharges from areas south of US 40 are proposed to be detained discharges to ensure that discharges to off-site areas are at or below historic discharge rates.

4.3 MINOR DRAINAGE SYSTEMS

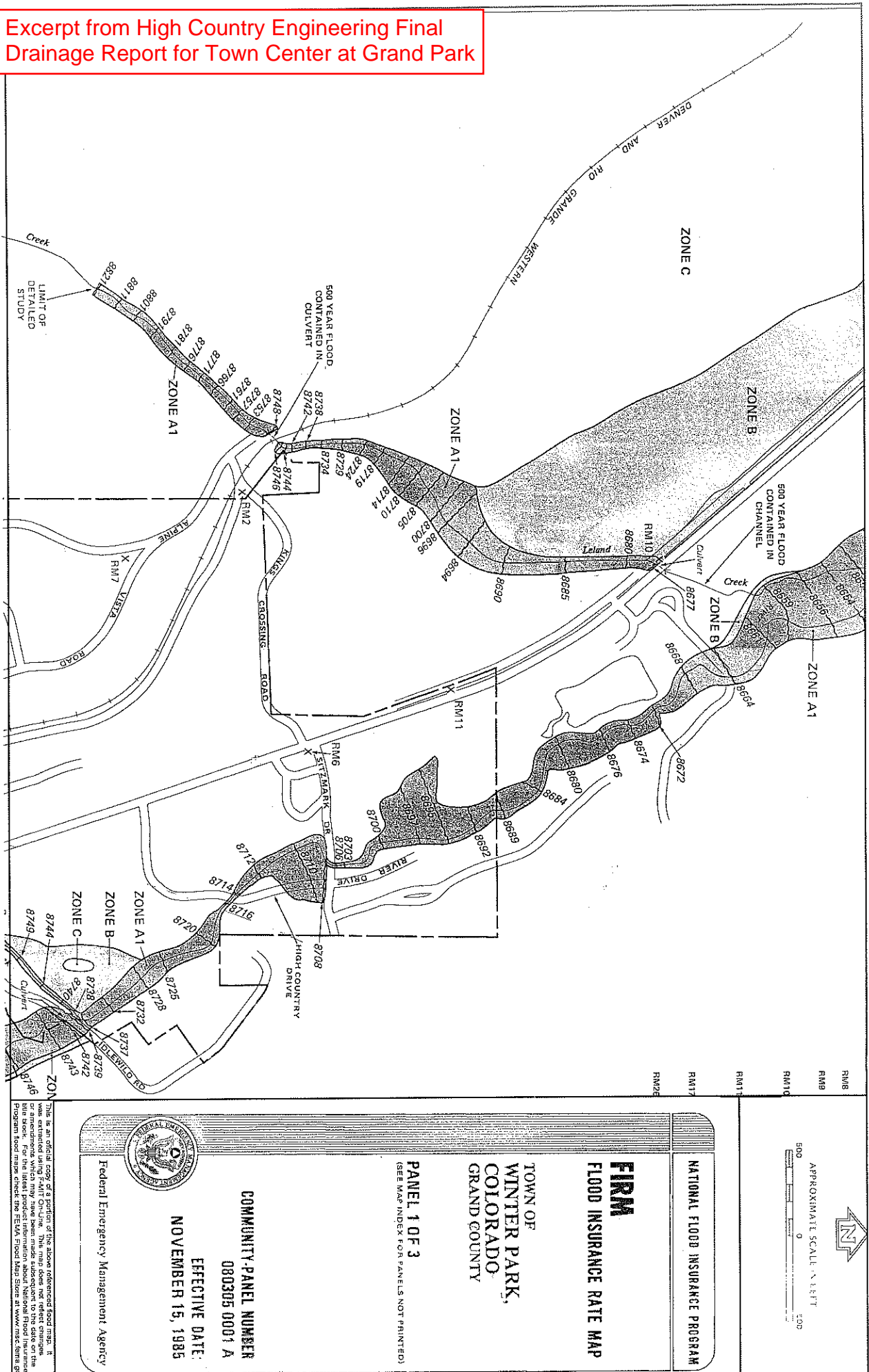
Minor drainage systems will be designed and implemented in accordance with this study during the platting phase of development throughout Grand Park.

4.4 PHASING OF IMPROVEMENTS

Phasing of the stormwater management system will depend on the timing of various developments throughout Grand Park. Regional drainage facilities will be implemented as demand warrants. It is anticipated that each Phased Preliminary Plan to be prepared for Grand Park, will provide design and construction details concerning the drainage facilities to be constructed in such Phase Area, or which may need to be constructed outside of the Phase Area, as a result of the Phase Area development.

4.5 FEMA FIRM MAPPING

The proposed development is contained within the FEMA FIRM map, 080305 001A – Town of Winter Park, Colorado, (Effective Date November 15, 1985). The FIRM map provides 100 year water surface elevations for Leland Creek and the Fraser River. A portion of the site adjacent to US Highway 40 is contained within Zone B – areas subject to 500 year flooding. The remainder of the development is outside the 500 year flooding limits.



GRAND PARK STORM DRAINAGE MASTER PLAN

5.0 REFERENCES

1. Soil Survey of Grand County Area, Colorado, U.S. Department of Agriculture, Natural Resource Conservation Service, Denver, Colorado.
2. Urban Storm Drainage Criteria Manual, Urban Drainage & Flood Control District (UD&FCD), prepared by Wright – McLaughlin Engineers, March 1969, Revised June 2001.
3. Grand County Storm Drainage Design and Criteria Manual.
4. NOAA Atlas No. 2, "Precipitation - Frequency Atlas of the Western United States, Volume III - Colorado", Miller, J. F., R. H. Frederick, R. J. Tracy, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 1976.

APPENDIX A – HYDROLOGIC INPUT

Subbasin Area

HMS * Basin Model * Subbasin Global Editor

Sort Help

Basin Model ID: Grand Park Developed

Subbasin Name	Area (sq mi)
Basin E1	0.110
Basin E2	0.297
Basin E3	0.038
Basin E4	0.244
Basin E5	0.345
Basin E6	0.064
Basin E7	0.287
Basin E8	0.077
Basin L1	0.975
Basin L2	0.168
Basin L3	0.093

Reach Parameters – Developed Conditions

HMS * Basin Model * Kinematic Wave Routing							
Sort Help							
Basin Model ID: Grand Park Developed							
Reach Name	Cross Section Shape	Reach Length (ft)	Energy Slope (ft/ft)	Bottom Width or Diameter (ft)	Side Slope (xH:1V)	Manning's n	Min Num. Route Incs.
Reach-1	TRAPEZOID	2417	0.033	100	20	0.03	50
Reach-2	TRAPEZOID	2847	0.039	100	20	0.03	50
Reach-3	TRAPEZOID	3257	0.43	100	20	0.02	50
Reach-4	TRAPEZOID	4519	0.027	100	20	0.02	50
Reach-5	TRAPEZOID	610	0.0164	50	10	0.030	50

Reach Parameters – Existing Conditions

HMS * Basin Model * Kinematic Wave Routing							
Sort Help							
Basin Model ID: Grand Park							
Reach Name	Cross Section Shape	Reach Length (ft)	Energy Slope (ft/ft)	Bottom Width or Diameter (ft)	Side Slope (xH:1V)	Manning's n	Min Num. Route Incs.
Reach-1	TRAPEZOID	2417	0.033	100	20	0.030	50
Reach-2	TRAPEZOID	2847	0.039	100	20	0.03	50
Reach-3	TRAPEZOID	3257	0.43	100	20	0.03	50
Reach-4	TRAPEZOID	4519	0.027	100	20	0.03	50
Reach-5	TRAPEZOID	610	0.0164	50	10	0.030	50

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 39.90199°N 105.77495°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	0.98	0.16
2-year 24-hour	1.32	0.06
100- year 6- hour	2.17	0.36
100- year 24-hour	2.98	0.12

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Fri Oct 14 11:58:44 2005

Region 2

2-Year Rainfall

Y_2 = 2-yr 1-hr estimated value

$$X_1 = 0.98 = (6\text{-hr})$$

$$X_2 = 1.32 = (24\text{-hr})$$

$$\begin{aligned} Y_2 &= 0.011 + 0.942 [(X_1)(X_2/X_2)] \\ &= 0.011 + 0.942 [0.98 (0.98/1.32)] \\ &= 0.696 = (1\text{-hr}) \end{aligned}$$

$$2\text{hr} = 0.341(6\text{-hr}) + 0.659(1\text{-hr}) = 0.793$$

$$3\text{hr} = 0.569(6\text{-hr}) + 0.431(1\text{-hr}) = 0.858$$

$$12\text{hr} = 1.2 \text{ (from Figure 17)}$$

$$5\text{min} = 0.29(1\text{-hr}) = 0.202$$

$$10\text{min} = 0.45(1\text{-hr}) = 0.313$$

$$15\text{min} = 0.57(1\text{-hr}) = 0.397$$

$$30\text{min} = 0.79(1\text{-hr}) = 0.550$$

10-Year Rainfall

Y_{10} = 10-yr 1-hr estimated value

$$X_1 = 6\text{-hr} = 1.40$$

$$X_2 = 24\text{-hr} = 1.98$$

100-Year Rainfall

$$Y_{100} = 0.494 + 0.755 [(X_3)(X_3/X_4)]$$

$$X_3 = 2.17 = (6\text{-hr})$$

$$X_4 = 2.98 = (24\text{-hr})$$

$$\begin{aligned} Y_{100} &= 0.494 + 0.755 [(2.17)(2.17/2.98)] \\ &= 1.687 = (1\text{-hr}) \end{aligned}$$

$$2\text{hr} = 0.341(6\text{-hr}) + 0.659(1\text{-hr}) = 1.851$$

$$3\text{hr} = 0.569(6\text{-hr}) + 0.431(1\text{-hr}) = 1.962$$

$$12\text{hr} \approx 2.5 \text{ (from Figure 17)}$$

$$5\text{min} = 0.29(1\text{-hr}) = 0.489$$

$$10\text{min} = 0.45(1\text{-hr}) = 0.759$$

$$15\text{min} = 0.57(1\text{-hr}) = 0.962$$

$$30\text{min} = 0.79(1\text{-hr}) = 1.333$$

Colorado

Discussion of Maps

Figures 30 through 41 present precipitation-frequency maps for Colorado for 6- and 24-hr durations. Figures 20 through 31 are for annual (all-season) values for the 2-, 5-, 10-, 25-, 50-, and 100-yr return periods. Figure 12 through 43 are for the May through October season and size for probabilities of 0.50, 0.20, 0.10, 0.04, 0.02, and 0.01. The isopleth maps represent the 360- and 1,440-min durations for the partial-duration series. Data were tabulated for clock and observation-day intervals for the annual series and were adjusted by the empirical factors given in the ANALYSIS section.

Isoline Interval. The isoline interval selected was designed to provide a reasonably complete description of the isopleth pattern in various regions of the state. The isoline interval over most of the state on maps for the 24-hr duration is 0.2 in. for precipitation-frequency values below 3.0 in., 0.4 in. between 3.0 in. and 5.0 in., and 0.5 in. at values greater than 5.0 in. However, in southwestern Colorado along the San Juan Mountains, the annual maps use an isoline interval of 0.2 in. below precipitation-frequency values of 2.0 in., and 0.5 in. for values over 2.0 in. On the maps for the 6-hr duration, the interval is 0.1 in. for precipitation-frequency values under 1.2 in., at the 2-yr and 0.50 and 0.20 probability level (on maps for the May through October season). At longer return periods (or lower probabilities), the upper limit of the 0.1-in. isoline interval increases in order to maintain the isopleth gradient and degree of detail. On all maps for the 6-hr duration, the isoline interval changes from 0.2 in. below 3.0 in. to 0.4 in. over 3.0-in. precipitation-frequency values. Dashed intermediate lines have been placed between widely separated isolines and in regions where a linear interpolation between the normal isopleth interval would lead to erroneous interpolation "low" but close within the boundaries of a particular map have been bunched on the low-value side of the isoline.

Importance of snow in precipitation-frequency values. The annual maps in this Atlas represent frequency values of precipitation regardless of type. For many hydrologic purposes, precipitation falling as rain must be treated in a different manner from that falling as snow. The contribution of snow amounts to precipitation-frequency values in Colorado and the Rocky Mountain States (roughly Montana, Wyoming, Colorado, New Mexico, and Utah) was investigated. In this area, there were about 30 stations per state having 10 to 15 yrs of observation of snowfall as part of the precipitation observing program. For each such station, two data series were formed as discussed under Interpretation of Results, Importance of Snow in Estimating Frequency Values.

A ratio was formed of the 2-yr 24-hr value for the series containing maximum annual snow without regard to the type of precipitation and the 2-yr 24-hr value for the series with snow occurrence estimated. A plot of this ratio vs. latitude (fig. 15) shows that the estimated maximum in the latitude of Colorado and Utah. Overall of Colorado, the all-precipitation series tend to average about 10 percent higher than the series with snow eliminated. However, the elimination of the data shows that in the relatively flat areas of the state, the data shows that in the west between the two series are minor. With data from this area eliminated, the difference between the two series averages about

Table 11. Equations for estimating 1-hr values in Colorado with statistical parameters for each equation

Region of applicability*	Equation	Corr. coeff.	No. of stations	Mean of computed values (inches)	Standard error of estimate (inches)
South Platte, Republican, Arkansas, and Cimarron River Basins (11)	$Y_{1-hr} = 0.218 + 0.709[(X_2/X_1)^{0.5}]$ $Y_{1-hr} = 1.897 + 0.439[(X_2/X_1)^{0.5}]$	0.94	75	1.01	0.074
San Juan, Upper Rio Grande, Upper Colorado, and Gunnison River Basins and Green River Basin below confluence with the Yampa River (2)	$Y_{1-hr} = -0.011 + 0.942[(X_2/X_1)^{0.5}]$ $Y_{1-hr} = 0.494 + 0.755[(X_2/X_1)^{0.5}]$	0.84 0.95 0.90	75 86 95	2.68 0.72 1.96	.317 .085 .290
Yampa and Green River Basins above confluence of Green and Yampa Rivers (3)	$Y_{1-hr} = 0.019 + 0.711[(X_2/X_1)^{0.5}]$ $Y_{1-hr} = 0.338 + 0.670[(X_2/X_1)^{0.5}]$.82	98	0.40	.031
North Platte (4)	$Y_{1-hr} = 0.028 + 0.890[(X_2/X_1)^{0.5}]$ $Y_{1-hr} = 0.671 + 0.757[(X_2/X_1)^{0.5}]$ $- 0.003Z$	0.80 0.93 0.91	73 90 95	1.04 0.60 1.71	.141 .062 .236

*Numbers in parentheses refer to geographic regions shown in figure 19. See text for more complete description.

List of variables

Y_2 = 2-yr 1-hr estimated value

Y_{1-hr} = 100-yr 1-hr estimated value

X_1 = 2-yr 6-hr value from precipitation-frequency maps

X_2 = 2-yr 24-hr value from precipitation-frequency maps

X_3 = 100-yr 6-hr value from precipitation-frequency maps

X_4 = 100-yr 24-hr value from precipitation-frequency maps

Z = point elevation in hundreds of feet

Table 12. Adjustment factors to obtain mean estimates from 1-hr values

Duration (min)	5	10	15	30
Ratio to 1-hr	0.29	0.45	0.57	0.79

(Adopted from U.S. Weather Bureau Technical Paper No. 40, 1961.)

Procedures for Estimating Values for Durations Other Than 6 and 24 Hrs

The isopleth maps in this Atlas are for 6- and 24-hr durations. For many hydrologic purposes, values for other durations are necessary. Such values can be estimated using the 6- and 24-hr maps and the empirical methods outlined in the following sections. The procedures described below for obtaining 1-, 2-, and 3-hr estimates were developed specifically for this Atlas. The procedures for obtaining estimates for less than 1-hr duration and for 12-hr duration were adopted from *Weather Bureau Technical Paper No. 40* (U.S. Weather Bureau 1961) only after investigation demonstrated their applicability to data from the area covered by this Atlas.

Procedures for estimating 1-hr (60-min) precipitation-frequency values. Multiple-regression screening techniques were used to develop equations for estimating 1-hr duration values. Factors considered in the screening process were restricted to those that could be determined easily from the maps of this Atlas or from generally available topographic maps.

The 11 western states were separated into several geographic regions. The regions were chosen on the basis of meteorological and climatological homogeneity and are generally combinations of river basins separated by prominent divides. Four of these geographic regions are partially within Colorado. For some purposes and use as an overlay on the precipitation-frequency maps, these regions are outlined on figure 19. The four Colorado regions in part of the region that lies to the east of the Continental Divide and the crest of the Sangre de Cristo and Sacramento Mountains and is south of the divide separating the drainage basins of the North and South Platte Rivers. It consists of that portion of Colorado drained by the South Platte, Republican, Arkansas, and Cimarron Rivers (Region 1, fig. 19). The second region consists of the area drained by the San Juan, Upper Rio Grande, Upper Colorado, and Gunnison Rivers and by the Green River below its confluence with the Yampa River (Region 2, fig. 19). This is part of a larger region that extends from southwestern Colorado westward to the western foothills of New Mexico. The third region is the mountainous portion of the area between the Continental Divide and the crest of the Cascade Range. The portion that lies within Colorado is the northwestern portion of the State that is drained by the Yampa River and the Green River above its confluence with the Yampa River (Region 3, fig. 19). A small portion of Colorado drained by the North Platte is Region 4, figure 19. The larger region of which this is a part includes that portion of Wyoming and Montana east of the Continental Divide. Equations to provide estimates for the 1-hr duration for 2- and 100-yr return periods are shown in table 11. Also listed are the statistical parameters associated with each equation. In these equations, the variable $[(X_2/X_1)^{0.5}]$ or

15 percent, with some individual differences as large as 40 to 50 percent. About half the stations have differences greater than 10 percent. These differences indicate that frequency values computed from an annual series of rainfall amounts only would be different from those composed of all-precipitation values, and two separate sets of precipitation-frequency maps were needed.

Snowfall observations are made at only about 15 percent of the precipitation stations used in this study. For this reason, a rainfall-frequency study could not be made by direct methods. Since most snowfall occurs during the colder half of the year, a series containing only values for the May to October season was compared with the series that was based on rainfall only. The two series were in good agreement, except for a slight bias toward higher values for the May to October season. This bias results from some large amounts in late October and early May occurring as snow and thus excluded from the rainfall-only series. The average difference is only about 4 percent, with no consistent preference toward higher elevations or particular geographic regions.

Two sets of maps were prepared for Colorado. The first set consists of annual maps based on precipitation data from all months of the year without regard to the type of precipitation, rain, rain and snow mixed, all snow, hail, etc. The second set of maps was made in this second series to differentiate between types of precipitation occurring within these months, but the investigations mentioned in the preceding paragraph indicate that these maps will approximate the values that would be obtained by using a data series made up of precipitation events that are exclusively rain. Since data for only part of the year were used, these maps have been labeled with the appropriate probabilities rather than with a return period in years (figs. 32-43).

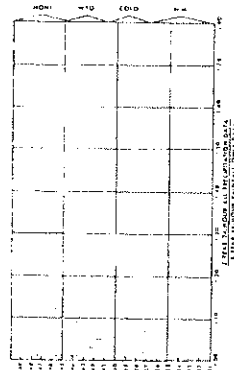


Figure 15. Ratio of 2-yr 24-hr value for all data to 2-yr 24-hr value for rainfall only vs. latitude

Figure 17. Precipitation depth-duration diagram (6- to 24-hr)

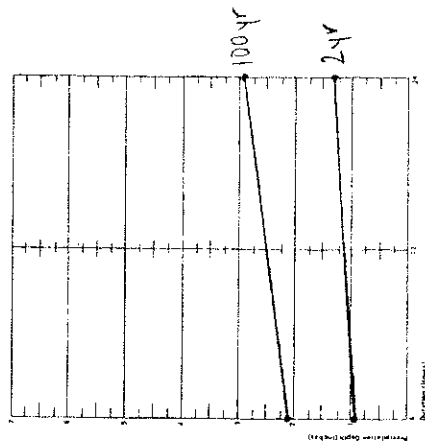


Illustration of Use of Precipitation-Frequency Maps, Diagrams, and Equations

To illustrate the use of these maps, values were read from figures 20 to 31 for the point at 39°00' N and 106°00' W. These values are shown in boldface type in table 13. The values read from the maps should be plotted on the return-period diagram of figure 6 because (1) not all points are as easy to locate on a series of maps as are latitude-longitude intersections, (2) there may be some slight registration differences in printing, and (3) precise interpolation between isolines is difficult. This has been done for the 24-hr values in table 13 (fig. 18a) and a line of best fit has been drawn subjectively. On this nomogram, the line fits the data rather well. Had any points deviated noticeably from the line, the value would have been read from the line and the new value substituted in table 13 and adopted in preference to the original readings.

The 2- and 100-yr 1-hr values for the point were computed from the equations applicable to Region 1, figure 19 (table 11), since the point is east of the Continental Divide. The 2-yr 1-hr value is estimated at 0.71 in (2-yr 6- and 24-hr values from table 13), the estimated 100-yr 1-hr value is 1.86 in (100-yr 6- and 24-hr values from table 13) and elevation of 9,500 ft. By plotting these 1-hr values on figure 6 and connecting them with a straight line, one can obtain estimates for return periods of 5, 10, 25, and 50 yrs.

The 2- and 3-hr values can be estimated by using the nomogram of figure 16 or equations (3) and (4). The 1- and 6-hr values for the desired return period are obtained as above. Plot these points on the nomogram of figure 16 and connect them with a straight line. Read the estimates for 2 or 3 hrs at the intersection of the connecting line and the 2- and 3-hr vertical lines. An example is shown in figure 18b for the 2-yr return period. The 2-yr 2-hr (0.83 in) and 2-yr 3-hr (0.91 in) values are in italics on table 13.

(XX,XX,X.X) can be regarded as the 6-hr value times the slope of the line connecting the 6- and 24-hr values for the appropriate return period.

A. With any variation into regions, the boundary can only be regarded as the steepest portion of a zone of transition between regions. These equations have been used for boundary discontinuities by computing values using equations from both sides of the boundary. Differences were found to be mostly under 15 percent. However, it is suggested that when computing estimates along or within a few miles of a regional boundary, computations be made using equations applicable to each region and that the average of such computations be adopted.

Estimates of 1-hr precipitation-frequency values for return periods of 2 and 100 yrs. The 1-hr values for the 2- and 100-yr return periods can be plotted on the nomogram of figure 6 to obtain values for return periods greater than 2 yrs or less than 100 yrs. Draw a straight line connecting the 2- and 100-yr values and read the desired return-period value from the nomogram.

Estimates for 2- and 3-hr (120- and 180-min) precipitation-frequency values. To obtain estimates of precipitation-frequency values for 2 or 3 hrs, plot the 1- and 6-hr values from the Atlas on the appropriate nomogram of figure 16. Draw a straight line connecting the 1- and 6-hr values, and read the 2- and 3-hr values from the nomogram. This nomogram is independent of return period. It was developed using data from the same regions used to develop the 1-hr equations.

The mathematical solution from the data used to develop figure 16 gives the following equations for estimating the 2- and 3-hr values:

$$\begin{aligned} \text{For Region 1,} \quad & 2\text{-hr} = 0.342 (6\text{-hr}) + 0.658 (1\text{-hr}) \quad (3) \\ \text{figure 19} \quad & 3\text{-hr} = 0.597 (6\text{-hr}) + 0.403 (1\text{-hr}) \quad (4) \\ \text{For Region 2,} \quad & 2\text{-hr} = 0.341 (6\text{-hr}) + 0.659 (1\text{-hr}) \quad (5) \\ \text{figure 19} \quad & 3\text{-hr} = 0.569 (6\text{-hr}) + 0.431 (1\text{-hr}) \quad (6) \\ \text{For Region 3,} \quad & 2\text{-hr} = 0.250 (6\text{-hr}) + 0.750 (1\text{-hr}) \quad (7) \\ \text{and 4, figure 19} \quad & 3\text{-hr} = 0.467 (6\text{-hr}) + 0.533 (1\text{-hr}) \quad (8) \end{aligned}$$

Estimates for 12-hr (720-min) precipitation-frequency values. To obtain estimates for the 12-hr duration, plot values from the 6- and 24-hr maps on figure 17. Read the 12-hr estimates at the intersection of the line connecting these points with the 12-hr duration line of the nomogram.

Estimates for less than 1 hr. To obtain estimates for durations of less than 1 hr, apply the values in table 12 to the 1-hr value for the return period of interest.

	1-hr	2-hr	3-hr	6-hr	24-hr
2-yr	0.71	0.83	0.91	1.05	1.58
5-yr				1.38	1.99
10-yr				1.59	2.27
25-yr				1.90	2.65
50-yr				2.19	2.95
100-yr	1.86			2.39	3.35

Table 13. Precipitation data for depth-frequency atlas computation point 106°00' W., 39°00' N.

Figure 18. Precipitation depth-duration diagram (1- to 6-hr)
a. South Platte, Republican, Arkansas, and Cimarron River Basins (Region 1, fig. 19).
b. San Juan, Upper Rio Grande, Upper Colorado, and Gunnison River Basins and Green River Basin below its confluence with the Yampa River (Region 2, fig. 19).
c. Yampa and Green River Basins above confluence of Green and Yampa Rivers (Region 3, fig. 19) and North Platte Drainage (Region 4, fig. 19).

100-Year Rainfall Data

HMS * Meteorologic Model

File Edit Help

Meteorologic Model: 100-Year Subbasin List

Description:

Precipitation |

Method: Frequency Storm

Exceedance Probability: 1 %

Series Type:

Max Intensity Duration: 5 Mins

Storm Duration: 24 Hr.

Peak Center: 50%

Storm Area (sq. mi.):

Duration	Precip Depth (in)
5 minutes	0.489
15 minutes	0.962
1 hour	1.687
2 hours	1.851
3 hours	1.962
6 hours	2.17
12 hours	2.5
24 hours	2.98

2-Year Rainfall Data

HMS * Meteorologic Model

File Edit Help

Meteorologic Model: 2-Year Subbasin List

Description:

Precipitation |

Method: Frequency Storm

Exceedance Probability: 1 %

Series Type:

Max Intensity Duration: 5 Mins

Storm Duration: 24 Hr.

Peak Center: 50%

Storm Area (sq. mi.):

Duration	Precip Depth (in)
5 minutes	0.202
15 minutes	0.397
1 hour	0.696
2 hours	0.793
3 hours	0.858
6 hours	0.98
12 hours	1.2
24 hours	1.32

Basin	Total Area (ac)	Total Area (mi ²)	Type B Area (ac)	Type C or D Area (ac)	Type A Area (ac)	Type B (%)	Type C or D (%)	Type A (%)	% Improv. (Runoff Co.)	C ₅ , Type B (Table RO-5)	C ₅ , Type C/D (Table RO-5)	C ₅ , Type A (Table RO-5)	C ₁₀₀ , Type A (Table RO-5)	C _f composite	C ₁₀₀ composite
E1	70.5	0.0	0.0	0.0	0.0	100%	0%	0%	2%	0.088	0.362	0.008	0.216	0.088	0.362
E2	190.7	0.219	190.7	0.0	0.0	100%	0%	0%	2%	0.088	0.362	0.008	0.216	0.088	0.362
E3	24.1	0.038	24.1	0.0	0.0	100%	0%	0%	2%	0.088	0.362	0.008	0.216	0.088	0.362
E4	156.6	0.244	122.9	33.7	0.0	78%	22%	0%	2%	0.088	0.362	0.008	0.216	0.088	0.362
E5	221.0	0.345	57.3	163.7	0.0	25%	74%	0%	2%	0.088	0.362	0.008	0.216	0.143	0.470
E6	41.0	0.064	15.7	25.3	0.0	38%	62%	0%	2%	0.088	0.362	0.008	0.216	0.134	0.452
E7	184.0	0.287	31.2	98.6	54.2	17%	54%	29%	2%	0.088	0.362	0.008	0.216	0.104	0.466
E8	49.5	0.077	11.8	36.5	1.1	24%	74%	2%	2%	0.088	0.362	0.008	0.216	0.107	0.399
L1	624.8	0.975	488.2	156.5	0.0	75%	25%	0%	2%	0.088	0.362	0.008	0.216	0.089	0.364
L2	107.7	0.168	107.5	0.6	0.0	100%	1%	0%	2%	0.088	0.362	0.008	0.216	0.129	0.444
L3	59.4	0.093	24.2	34.1	1.0	41%	58%	2%	2%	0.088	0.362	0.008	0.216		

Grand Park - Developed Conditions
HCE Project No. 2052014.00
Soils Classification for Runoff Coefficient

Basin	Total Area (ac)	Total Area (mi ²)	Type B Area (ac)	Type C or D Area (ac)	Type A Area (ac)	Type B (%)	Type C or D (%)	Type A (%)	% Imperv.	C ₅ -Type B (Table RO-5)	C ₅₀ -Type C/D (Table RO-5)	C ₅ -Type A (Table RO-5)	C ₁₀₀ -Type A (Table RO-5)	C ₅ composite	C ₁₀₀ composite
E1	70.5	0.110	70.5	0.0	0.0	100%	0%	0%	15%	0.420	0.540	0.100	0.280	0.170	0.420
E2	190.7	0.297	190.7	0.0	0.0	100%	0%	0%	15%	0.420	0.540	0.100	0.280	0.170	0.420
E3	24.1	0.038	24.1	0.0	0.0	100%	0%	0%	14%	0.415	0.545	0.095	0.275	0.165	0.415
E4	158.6	0.244	122.9	33.7	0.0	78%	22%	0%	26%	0.465	0.560	0.165	0.352	0.237	0.485
E5	221.0	0.345	57.3	163.7	0.0	25%	74%	0%	36%	0.225	0.380	0.165	0.352	0.237	0.485
E6	41.0	0.064	15.7	25.3	0.0	36%	62%	0%	41%	0.305	0.355	0.225	0.390	0.319	0.548
E7	184.0	0.287	31.2	98.6	54.2	17%	54%	29%	73%	0.525	0.580	0.475	0.410	0.336	0.551
E8	49.5	0.077	11.8	36.5	1.1	24%	74%	29%	32%	0.470	0.570	0.200	0.375	0.299	0.541
L1	624.8	0.975	468.2	156.5	0.0	75%	25%	0%	15%	0.420	0.540	0.100	0.280	0.188	0.450
L2	107.7	0.168	107.5	0.6	0.0	100%	0%	0%	2%	0.365	0.510	0.010	0.220	0.089	0.367
L3	59.4	0.093	24.2	34.1	1.0	41%	58%	2%	47%	0.340	0.513	0.285	0.455	0.362	0.559

English

[illegible]

PARCELS BY BASIN

Area in Acres			Parcels/Land Use																Cozans Meadow Neighborhood		Elk Creek 5W		Mixed Use Site		Stone Bench Townhomes		The Willows Ca		
BASIN	BASIN_AREA	LOCATION	10W	11W	12W	13Wa	13Wb	14W	15W	16W	17W	18W	19W	1Wb	20W	21W	4W	6W	7W	9Wa	9Wb	19W	13.578	10.073	6.554	29.668	2		
E1		12.489 Offsite																											
		57.985 Onsite									52.075																		
E1 Total		70.454									52.075																		
E2		190.678 Onsite					11.445	43.033	4.170	62.149	15.755																		
E3		24.086 Onsite							17.784	2.153																			
E4		156.640 Onsite																3.182	26.162	3.323									
E5		220.972 Onsite						7.016		0.922		14.705				6.070			6.020	49.084	1.019	12.525							
E6		41.025 Onsite	8.111	0.886																	5.535	6.621							
E7		183.955 Onsite															3.662							10.074		4.597	28.600		
E8		49.483 Onsite															3.856						13.579			1.954			
L1		299.307 Offsite														0.019													
		325.489 Onsite	26.536	7.950						31.399	42.348	18.182	25.353		40.033	3.845													
L1 Total		624.797	26.536	7.950						31.399	42.348	18.182	25.353		40.062	3.845													
L2		107.729 Offsite																											
L3		59.356 Onsite											4.208														1.070	2	

Table 2-2a.—Runoff curve numbers for urban areas¹

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area ²	A	B	C	D
<i>Fully developed urban areas (vegetation established)</i>					
Open space (lawns, parks, golf courses, cemeteries, etc.) ³ :					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) ⁴ ...		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
<i>Developing urban areas</i>					
Newly graded areas (pervious areas only, no vegetation) ⁵		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

¹Average runoff condition, and $I_a = 0.25$.

²The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system; impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

³CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

⁴Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

⁵Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c.—Runoff curve numbers for other agricultural lands¹

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. ²	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. ³	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods—grass combination (orchard or tree farm). ⁴	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. ⁵	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

¹Average runoff condition, and $I_a = 0.25$.

²Poor: < 50% ground cover or heavily grazed with no mulch.

Fair: 50 to 75% ground cover and not heavily grazed.

Good: > 75% ground cover and lightly or only occasionally grazed.

³Poor: < 50% ground cover.

Fair: 50 to 75% ground cover.

Good: > 75% ground cover.

⁴Actual curve number is less than 30; use CN = 30 for runoff computations.

⁵CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and-pasture.

⁶Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Loss Rate – Developed Conditions

HMS * Basin Model * SCS Curve Number			
Sort Help			
Basin Model ID: Grand Park Developed			
Subbasin Name	SCS Curve Number	Initial Abstraction (in)	Imperviousness (%)
Basin E6	80		2
Basin E5	82		2
Basin E4	73		2
Basin E3	65		2
Basin E2	65		2
Basin E1	65		2
Basin L2	60		2
Basin L1	68		2
Basin L3	83		2
Basin E8	80		2
Basin E7	89		2

Loss Rate – Existing Conditions

HMS * Basin Model * SCS Curve Number			
Sort Help			
Basin Model ID: Grand Park			
Subbasin Name	SCS Curve Number	Initial Abstraction (in)	Imperviousness (%)
Basin E6	68		2
Basin E5	69.6		2
Basin E4	63		2
Basin E3	60		2
Basin E2	60		2
Basin E1	60		2
Basin L2	60		2
Basin L1	70		2
Basin L3	68		2
Basin E8	69		2
Basin E7	60		2

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Developed Conditions
HCE Project No. 2052014.00
% Imperviousness & Curve Number

Basin	Total Area (ac)	Composite % Imp.	Type B (%)	Type C or D (%)	Type A (%)	Type B CN	Type C or D CN	Type A CN	Composite CN
E1	70.5	15%	100%	0%	0%	65	78	50	65
E2	190.7	15%	100%	0%	0%	65	78	50	65
E3	24.1	14%	100%	0%	0%	65	78	50	65
E4	156.6	26%	78%	22%	0%	70	82	54	73
E5	221.0	36%	26%	74%	0%	74	85	60	82
E6	41.0	41%	38%	62%	0%	76	83	62	80
E7	184.0	73%	17%	54%	29%	89	92	82	89
E8	49.5	32%	24%	74%	2%	72	83	57	80
L1	624.8	15%	75%	25%	0%	65	78	50	68
L2	107.7	2%	100%	1%	0%	60	75	36	60
L3	59.4	47%	41%	58%	2%	80	85	72	83

Planning Area	Average % Imperv	Type B CN	Type C or D CN	Type A CN
10W	80	90	93	87
11W	65	85	91	77
12W	80	90	93	87
13Wa	30	72	83	57
13Wb	25	70	82	54
14W	25	70	82	54
15W	17	67	80	50
16W	15	65	78	50
17W	20	68	83	51
18W	25	70	82	54
19W	60	81	85	72
1Wb	75	89	92	82
20W	65	85	91	77
21W	65	85	91	77
4W	90	94	95	90
6W	90	94	95	90
7W	65	85	91	77
8Wa	65	85	91	77
8Wb	70	87	90	80
9W	80	90	93	87

Lag Time – Developed Conditions

HMS * Basin Model * SCS UH

Sort Help

Basin Model ID: Grand Park Developed

Time Units : Minutes

Subbasin Name	SCS Lag (min)
Basin E1	12
Basin E2	21
Basin E3	14
Basin E4	25
Basin E5	30
Basin E6	13
Basin E7	16
Basin E8	27
Basin L1	51
Basin L2	16
Basin L3	15

Lag Time – Existing Conditions

HMS * Basin Model * SCS UH

Sort Help

Basin Model ID: Grand Park

Time Units : Minutes

Subbasin Name	SCS Lag (min)
Basin E1	16
Basin E2	25
Basin E3	19
Basin E4	32
Basin E5	35
Basin E6	24
Basin E7	32
Basin E8	53
Basin L1	64
Basin L2	26
Basin L3	25

No Baseflow for All Basins

TABLE RO-3

Recommended Percentage Imperviousness Values

Land Use or Surface Characteristics	Percentage Imperviousness
Business:	
Commercial areas	95
Neighborhood areas	85
Residential:	
Single-family	*
Multi-unit (detached)	60
Multi-unit (attached)	75
Half-acre lot or larger	*
Apartments	80
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	5
Playgrounds	10
Schools	50
Railroad yard areas	15
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	0
Lawns, clayey soil	0

* See Figures RO-3 through RO-5 for percentage imperviousness.

Based in part on the data collected by the District since 1969, an empirical relationship between C and the percentage imperviousness for various storm return periods was developed. Thus, values for C can be determined using the following equations (Urbanas, Guo and Tucker 1990).

$$C_A = K_A + (1.31i^3 - 1.44i^2 + 1.135i - 0.12) \text{ for } C_A \geq 0, \text{ otherwise } C_A = 0 \quad (\text{RO-6})$$

$$C_{CD} = K_{CD} + (0.858i^3 - 0.786i^2 + 0.774i + 0.04) \quad (\text{RO-7})$$

$$C_B = (C_A + C_{CD})/2$$

in which:

i = % imperviousness/100 expressed as a decimal (see Table RO-3)

TABLE RO-5
Runoff Coefficients, C

Percentage Imperviousness	Type C and D NRCS Hydrologic Soil Groups					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
0%	0.04	0.15	0.25	0.37	0.44	0.50
5%	0.08	0.18	0.28	0.39	0.46	0.52
10%	0.11	0.21	0.30	0.41	0.47	0.53
15%	0.14	0.24	0.32	0.43	0.49	0.54
20%	0.17	0.26	0.34	0.44	0.50	0.55
25%	0.20	0.28	0.36	0.46	0.51	0.56
30%	0.22	0.30	0.38	0.47	0.52	0.57
35%	0.25	0.33	0.40	0.48	0.53	0.57
40%	0.28	0.35	0.42	0.50	0.54	0.58
45%	0.31	0.37	0.44	0.51	0.55	0.59
50%	0.34	0.40	0.46	0.53	0.57	0.60
55%	0.37	0.43	0.48	0.55	0.58	0.62
60%	0.41	0.46	0.51	0.57	0.60	0.63
65%	0.45	0.49	0.54	0.59	0.62	0.65
70%	0.49	0.53	0.57	0.62	0.65	0.68
75%	0.54	0.58	0.62	0.66	0.68	0.71
80%	0.60	0.63	0.66	0.70	0.72	0.74
85%	0.66	0.68	0.71	0.75	0.77	0.79
90%	0.73	0.75	0.77	0.80	0.82	0.83
95%	0.80	0.82	0.84	0.87	0.88	0.89
100%	0.89	0.90	0.92	0.94	0.95	0.96
Percentage Imperviousness	Type B NRCS Hydrologic Soils Group					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
0%	0.02	0.08	0.15	0.25	0.30	0.35
5%	0.04	0.10	0.19	0.28	0.33	0.38
10%	0.06	0.14	0.22	0.31	0.36	0.40
15%	0.08	0.17	0.25	0.33	0.38	0.42
20%	0.12	0.20	0.27	0.35	0.40	0.44
25%	0.15	0.22	0.30	0.37	0.41	0.46
30%	0.18	0.25	0.32	0.39	0.43	0.47
35%	0.20	0.27	0.34	0.41	0.44	0.48
40%	0.23	0.30	0.36	0.42	0.46	0.50
45%	0.26	0.32	0.38	0.44	0.48	0.51
50%	0.29	0.35	0.40	0.46	0.49	0.52
55%	0.33	0.38	0.43	0.48	0.51	0.54
60%	0.37	0.41	0.46	0.51	0.54	0.56
65%	0.41	0.45	0.49	0.54	0.57	0.59
70%	0.45	0.49	0.53	0.58	0.60	0.62
75%	0.51	0.54	0.58	0.62	0.64	0.66
80%	0.57	0.59	0.63	0.66	0.68	0.70
85%	0.63	0.66	0.69	0.72	0.73	0.75
90%	0.71	0.73	0.75	0.78	0.80	0.81
95%	0.79	0.81	0.83	0.85	0.87	0.88
100%	0.89	0.90	0.92	0.94	0.95	0.96

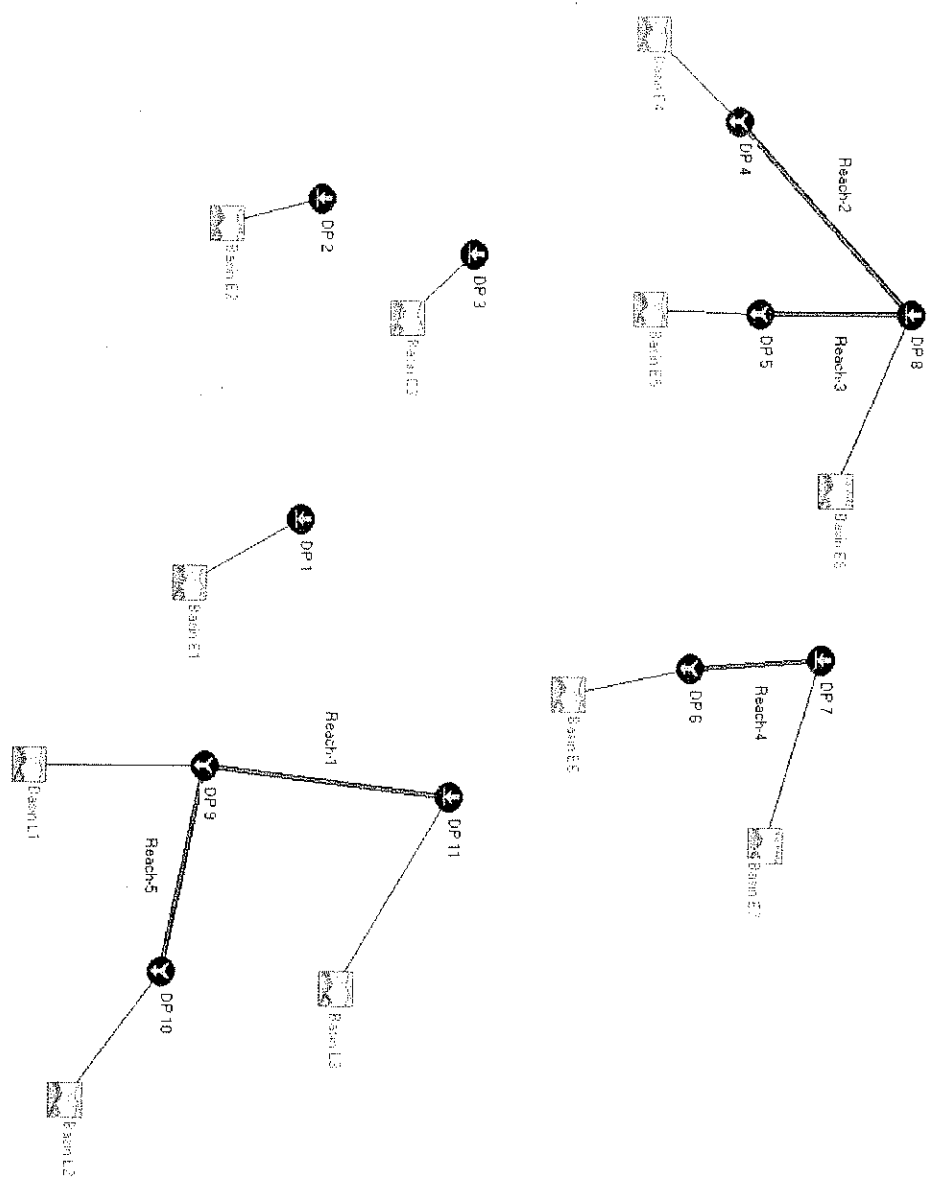
TABLE RO-5 (CONTINUED)

Runoff Coefficients, C

Percentage Imperviousness	Type A NRCS Hydrologic Soils Group					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
0%	0.00	0.00	0.05	0.12	0.16	0.20
5%	0.00	0.02	0.10	0.16	0.20	0.24
10%	0.00	0.06	0.14	0.20	0.24	0.28
15%	0.02	0.10	0.17	0.23	0.27	0.30
20%	0.06	0.13	0.20	0.26	0.30	0.33
25%	0.09	0.16	0.23	0.29	0.32	0.35
30%	0.13	0.19	0.25	0.31	0.34	0.37
35%	0.16	0.22	0.28	0.33	0.36	0.39
40%	0.19	0.25	0.30	0.35	0.38	0.41
45%	0.22	0.27	0.33	0.37	0.40	0.43
50%	0.25	0.30	0.35	0.40	0.42	0.45
55%	0.29	0.33	0.38	0.42	0.45	0.47
60%	0.33	0.37	0.41	0.45	0.47	0.50
65%	0.37	0.41	0.45	0.49	0.51	0.53
70%	0.42	0.45	0.49	0.53	0.54	0.56
75%	0.47	0.50	0.54	0.57	0.59	0.61
80%	0.54	0.56	0.60	0.63	0.64	0.66
85%	0.61	0.63	0.66	0.69	0.70	0.72
90%	0.69	0.71	0.73	0.76	0.77	0.79
95%	0.78	0.80	0.82	0.84	0.85	0.86
100%	0.89	0.90	0.92	0.94	0.95	0.96

APPENDIX B- HYDROLOGIC OUTPUT

Grand Park Master Drainage Plan



100-yr Existing Conditions

Hydrologic Element	Discharge Peak	Time of Peak	Volume (ac	Drainage Area
Basin E6	19.324		2.2342	0.064
DP 6	19.324		2.2342	0.064
Reach-4	19.148		2.1672	0.064
Basin E7	33.958		5.6703	0.287
DP 7	50.463		7.8376	0.351
Basin E4	39.604		6.0580	0.244
DP 4	39.604		6.0580	0.244
Reach-2	39.456		5.9452	0.244
Basin E5	93.513		13.188	0.345
DP 5	93.513		13.188	0.345
Reach-3	93.055		13.103	0.345
Basin E8	14.739		2.8117	0.077
DP 8	144.80		21.860	0.666
Basin E3	5.9553		0.75839	0.038
DP 3	5.9553		0.75839	0.038
Basin E2	40.212		5.8967	0.297
DP 2	40.212		5.8967	0.297
Basin L1	18.510		2.1992	0.110
DP 1	18.510		2.1992	0.110
Basin L2	22.406		3.3349	0.168
DP 10	22.406		3.3349	0.168
Reach-5	22.211		3.3140	0.168
Basin L1	172.59		37.471	0.975
DP 9	182.22		40.785	1.143
Reach-1	182.13		40.424	1.143
Basin L3	27.551		3.2445	0.093
DP 11	189.24		43.668	1.236

2-yr Existing Conditions

Hydrologic Element	Discharge Peak	Time of Peak	Volume (ac	Drainage Area
Basin E6	0.74542		0.18222	0.064
DP 6	0.74542		0.18222	0.064
Reach-4	0.73971		0.17154	0.064
Basin E7	2.8198		0.40225	0.287
DP 7	2.8510		0.57379	0.351
Basin E4	2.3979		0.38328	0.244
DP 4	2.3979		0.38328	0.244
Reach-2	2.3772		0.37110	0.244
Basin E5	3.9164		1.2088	0.345
DP 5	3.9164		1.2088	0.345
Reach-3	3.9070		1.1925	0.345
Basin E8	0.65430		0.24698	0.077
DP 8	6.9324		1.8106	0.666
Basin E3	0.49955			0.038
DP 3	0.49955			0.038
Basin E2	3.3527		0.41665	0.297
DP 2	3.3527		0.41665	0.297
Basin E1	1.5772		0.15453	0.110
DP 1	1.5772		0.15453	0.110
Basin L2	1.8632		0.23569	0.168
DP 10	1.8632		0.23569	0.168
Reach-5	1.8544		0.23475	0.168
Basin L1	8.6585		3.5367	0.975
DP 9	9.1755		3.7714	1.143
Reach-1	9.1722		3.7080	1.143
Basin L3	1.0660		0.26461	0.093
DP 11	9.5213		3.9726	1.236

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Summary of Results

Project : Grand Park

Run Name : Run 2

100-year Developed Conditions

Hydrologic Element	Discharge Peak	Time of Peak	Volume (ac	Drainage Area
Basin E6	58.514		4.3100	0.064
DP 6	58.514		4.3100	0.064
Reach-4	58.266		4.1881	0.064
Basin E7	369.67		28.966	0.287
DP 7	389.07		33.154	0.351
Basin E4	104.03		11.402	0.244
DP 4	104.03		11.402	0.244
Reach-2	103.96		11.289	0.244
Basin E5	224.62		25.350	0.345
DP 5	224.62		25.350	0.345
Reach-3	222.28		25.248	0.345
Basin E8	48.024		5.1549	0.077
DP 8	371.66		41.692	0.666
Basin E3	11.596		1.0982	0.038
DP 3	11.596		1.0982	0.038
Basin E2	74.579		8.5401	0.297
DP 2	74.579		8.5401	0.297
Basin E1	36.219		3.1821	0.110
DP 1	36.219		3.1821	0.110
Basin L2	28.249		3.3581	0.168
DP 10	28.249		3.3581	0.168
Reach-5	27.823		3.3345	0.168
Basin L1	176.12		33.408	0.975
DP 9	186.02		36.743	1.143
Reach-1	185.60		36.398	1.143
Basin L3	94.340		7.2045	0.093
DP 11	196.72		43.602	1.236

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Summary of Results

Project : Grand Park

Run Name : Run 4

2-year Developed Conditions

Hydrologic Element	Discharge Peak	Time of Peak	Volume (ac)	Drainage Area
Basin E6	7.4256		0.76401	0.064
DP 6	7.4256		0.76401	0.064
Reach-4	7.2605		0.78619	0.064
Basin E7	90.356		7.8460	0.287
DP 7	90.390		8.6321	0.351
Basin E4	6.2238		1.3307	0.244
DP 4	6.2238		1.3307	0.244
Reach-2	6.1836		1.2996	0.244
Basin E5	34.032		4.9823	0.345
DP 5	34.032		4.9823	0.345
Reach-3	33.888		4.9611	0.345
Basin E8	6.1455		0.91482	0.077
DP 8	44.126		7.1755	0.666
Basin E3	0.57987			0.038
DP 3	0.57987			0.038
Basin E2	3.7038		0.57448	0.297
DP 2	3.7038		0.57448	0.297
Basin E1	1.8115		0.21388	0.110
DP 1	1.8115		0.21388	0.110
Basin L2	2.4079		0.23600	0.168
DP 10	2.4079		0.23600	0.168
Reach-5	2.3886		0.23524	0.168
Basin L1	7.4891		2.7233	0.975
DP 9	8.2402		2.9585	1.143
Reach-1	8.2230		2.9043	1.143
Basin L3	15.280		1.4853	0.093
DP 11	16.616		4.3897	1.236

Detention Calculations – AutoCAD Hydrology Method
Design Point 4 – Elk Creek at Railroad

Detention Basin Storage			
InFlow File:			
Pond Name:			
Rainfall Distribution	Type II	v	
Rainfall Frequency	100 years	v	
Drainage Area	ac	156.8000	Select
Peak Inflow, qi	cfs	104.0000	
Peak Outflow, qo	cfs	39.6000	
Runoff Flow	in	0.8600	
Runoff Volume	acft	11.2366	
Storage Volume	acft	3.7181	
Maximum Storage Elevation	ft	0.0000	
New Load Save Pond SS Curve			
Data Input HydroGraph Output OK Cancel Help			

Design Point 6 – Unknown Drainage Culvert at Railroad

Detention Basin Storage			
InFlow File:			
Pond Name:			
Rainfall Distribution	Type II	v	
Rainfall Frequency	100 years	v	
Drainage Area	ac	41.0000	Select
Peak Inflow, qi	cfs	58.5000	
Peak Outflow, qo	cfs	19.3000	
Runoff Flow	in	1.2500	
Runoff Volume	acft	4.2706	
Storage Volume	acft	1.5368	
Maximum Storage Elevation	ft	0.0000	
New Load Save Pond SS Curve			
Data Input HydroGraph Output OK Cancel Help			
Basin file saved successfully.			

Design Point 9 – Leland Creek at Railroad

Detention Basin Storage			
InFlow File:			
Pond Name:			
Rainfall Distribution	Type II	▼	
Rainfall Frequency	100 years	▼	
Drainage Area	ac	732.5000	Select
Peak Inflow, qi	cfs	186.0200	
Peak Outflow, qo	cfs	148.8000	
Runoff Flow	in	0.5900	
Runoff Volume	acft	36.0123	
Storage Volume	acft	6.3375	
Maximum Storage Elevation	ft	0.0000	
New Load Save Pond SS Curve			
Data Input HydroGraph Output OK Cancel Help			

Design Point 8 – Elk Creek at US 40 Boundary

Detention Basin Storage			
InFlow File:			
Pond Name:			
Rainfall Distribution	Type II	▼	
Rainfall Frequency	100 years	▼	
Drainage Area	ac	127.1000	Select
Peak Inflow, qi	cfs	371.6600	
Peak Outflow, qo	cfs	144.8000	
Runoff Flow	in	1.1300	
Runoff Volume	acft	40.2161	
Storage Volume	acft	13.1208	
Maximum Storage Elevation	ft	0.0000	
New Load Save Pond SS Curve			
Data Input HydroGraph Output OK Cancel Help			
Basin file saved successfully.			

Design Point 7 – Unknown Drainage at US 40 Boundary

Detention Basin Storage

InFlow File:
Pond Name:

Rainfall Distribution: Type II
Rainfall Frequency: 100 years

Drainage Area: ac 225.0000

Peak Inflow, qi: cfs 389.0700

Peak Outflow, qo: cfs 50.4600

Runoff Flow: in 1.7400

Runoff Volume: acft 32.6230
Storage Volume: acft 17.0412
Maximum Storage Elevation: ft 0.0000

Design Point 11 – Leland Creek at US 40 Boundary

Detention Basin Storage

InFlow File:
Pond Name:

Rainfall Distribution: Type II
Rainfall Frequency: 100 years

Drainage Area: ac 791.9000

Peak Inflow, qi: cfs 196.7200

Peak Outflow, qo: cfs 157.3000

Runoff Flow: in 0.6300

Runoff Volume: acft 41.5722
Storage Volume: acft 7.3203
Maximum Storage Elevation: ft 0.0000

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Existing Conditions
HCE Project No. 2052014.00
Detention Volumes and Release Rates

Design Point 4 - Elk Creek at Railroad

Basin	Area (acres)	% Imperviousness	Type B	Type C
E4	156.6	26%	78%	22%

UDCFD Volume 2, Section 3.2.2 Empirical Equations for Sizing On-site Detention Storage Volumes

$$V_i = K_i \cdot A$$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{900}$$

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

I = 26.00 total ratio
Area = 156.6 acres

$$K_{100} = 0.046$$

$$K_{10} = 0.023$$

$$V_{100} = 7.198 \text{ acre-feet}$$

$$V_{10} = 3.570 \text{ acre-feet}$$

UDCFD Volume 2, Section 3.2.1 Allowable Release Rates

From Table SO-1 Maximum Allowable Unit Flow Release Rates:

	Soil Group B	C & D
10 year Flow	0.305	0.365
100 year Flow	0.460	0.560
10 yr Release Rate =	49.83	cfs
100 yr Release Rate =	75.48	cfs

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Existing Conditions
HCE Project No. 2052014.00
Detention Volumes and Release Rates

Design Point 6 - Unknown Drainage Culvert

Basin	Area (acres)	% Imperviousness	Type B	Type C
E6	41	41%	38%	62%

UDCFD Volume 2, Section 3.2.2 Empirical Equations for Sizing On-site Detention Storage Volumes

$$V_i = K_i \cdot A$$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{900}$$

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

I = 41.00 total ratio
Area = 41 acres

$$K_{100} = 0.073$$

$$K_{10} = 0.037$$

$$V_{100} = 3.009 \text{ acre-feet}$$

$$V_{10} = 1.519 \text{ acre-feet}$$

UDCFD Volume 2, Section 3.2.1 Allowable Release Rates

From Table SO-1 Maximum Allowable Unit Flow Release Rates:

	Soil Group B	C & D
10 year Flow	0.365	0.425
100 year Flow	0.500	0.580
10 yr Release Rate =	16.49	cfs
100 yr Release Rate =	22.53	cfs

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Existing Conditions
HCE Project No. 2052014.00
Detention Volumes and Release Rates

Design Point 9 - Leland Creek at Railroad

Basin	Area (acres)	% Imperviousness	A*I	(A*I)/ΣA	Type B	Type C
L1	624.8	15%	93.72	12.79%	75%	25%
L2	107.7	2%	2.1546	0.29%	100%	0%
Total	732.5			13.09%		

UDCFD Volume 2, Section 3.2.2 Empirical Equations for Sizing On-site Detention Storage Volumes

$$V_i = K_i * A$$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{900}$$

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

I = 13.09 total ratio
Area = 732.5 acres

$$K_{100} = 0.022$$

$$K_{10} = 0.011$$

$$V_{100} = 15.785 \text{ acre-feet}$$

$$V_{10} = 7.716 \text{ acre-feet}$$

UDCFD Volume 2, Section 3.2.1 Allowable Release Rates

From Table SO-1 Maximum Allowable Unit Flow Release Rates:

	Soil Group B	C & D
10 year Flow	0.230	0.310
100 year Flow	0.410	0.535
10 yr Release Rate =	180.94	cfs
100 yr Release Rate =	319.78	cfs

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Existing Conditions
HCE Project No. 2052014.00
Detention Volumes and Release Rates

Design Point 8 - Elk Creek at US 40 Boundary

Basin	Area (acres)	% Imperviousness	A*I	(A*I)/ΣA	Type B	Type C	Type A
E4	156.6	26%	40.7264	9.54%	78%	22%	0.00%
E5	221.0	36%	79.5492	18.62%	26%	74%	0.00%
E8	49.5	32%	15.84	3.71%	24%	74%	2%
Total	427.1			28.16%			

UDCFD Volume 2, Section 3.2.2 Empirical Equations for Sizing On-site Detention Storage Volumes

$$V_i = K_i \cdot A$$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{900}$$

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

I = 28.16 total ratio
Area = 427.1 acres

$$K_{100} = 0.050$$

$$K_{10} = 0.025$$

$$V_{100} = 21.346 \text{ acre-feet}$$

$$V_{10} = 10.615 \text{ acre-feet}$$

UDCFD Volume 2, Section 3.2.1 Allowable Release Rates

From Table SO-1 Maximum Allowable Unit Flow Release Rates:

	Soil Group B	C & D	A
10 year Flow	0.325	0.385	0.260
100 year Flow	0.475	0.570	0.375

$$10 \text{ yr Release Rate} = 152.75 \text{ cfs}$$

$$100 \text{ yr Release Rate} = 224.96 \text{ cfs}$$

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Existing Conditions
HCE Project No. 2052014.00
Detention Volumes and Release Rates

Design Point 7 - Unknown Drainage at US 40 Boundary

Basin	Area (acres)	% Imperviousness	A*I	(A*I)/ΣA	Type B	Type C	Type A
E6	41.0	41%	16.8182	7.48%	38%	62%	0%
E7	184.0	73%	134.2835	59.69%	17%	54%	29%
Total	225.0			67.17%			

UDCFD Volume 2, Section 3.2.2 Empirical Equations for Sizing On-site Detention Storage Volumes

$$V_i = K_i * A$$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{900}$$

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

I = 67.17 total ratio
Area = 225.0 acres

$$K_{100} = 0.119$$

$$K_{10} = 0.062$$

$$V_{100} = 26.739 \text{ acre-feet}$$

$$V_{10} = 13.927 \text{ acre-feet}$$

UDCFD Volume 2, Section 3.2.1 Allowable Release Rates

From Table SO-1 Maximum Allowable Unit Flow Release Rates:

	Soil Group B	C & D	A
10 year Flow	0.510	0.555	0.470
100 year Flow	0.605	0.665	0.545

10 yr Release Rate = 118.15 cfs

100 yr Release Rate = 140.30 cfs

Excerpt from High Country Engineering Final
Drainage Report for Town Center at Grand Park

Grand Park - Existing Conditions
HCE Project No. 2052014.00
Detention Volumes and Release Rates

Design Point 11 - Leland Creek at US 40 Boundary

Basin	Area (acres)	% Imperviousness	A*I	(A*I)/ΣA	Type B	Type C	Type A
L1	624.8	15%	93.72	11.84%	75%	25%	0.00%
L2	107.7	2%	2.1546	0.27%	100%	0%	0.00%
L3	59.4	47%	27.89727	3.52%	41%	58%	2%
Total	791.9			15.63%			

UDCFD Volume 2, Section 3.2.2 Empirical Equations for Sizing On-site Detention Storage Volumes

$$V_i = K_i * A$$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{900}$$

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

I = 15.63 total ratio
Area = 791.9 acres

$$K_{100} = 0.026$$

$$K_{10} = 0.013$$

$$V_{100} = 20.917 \text{ acre-feet}$$

$$V_{10} = 10.254 \text{ acre-feet}$$

UDCFD Volume 2, Section 3.2.1 Allowable Release Rates

From Table SO-1 Maximum Allowable Unit Flow Release Rates:

	Soil Group B	C & D	A
10 year Flow	0.250	0.240	0.170
100 year Flow	0.420	0.540	0.300

$$10 \text{ yr Release Rate} = 195.91 \text{ cfs}$$

$$100 \text{ yr Release Rate} = 355.23 \text{ cfs}$$

APPENDIX C – CULVERT CALCULATIONS

Elk Creek Capacity – Flow at Railroad Elevation

Culvert Design - elk creek ex 42in culvert.clt

Barrel Shape	CIRCULAR		
Tailwater	ft	2.5000	Select
Length	ft	84.7000	Select
Diameter	in	42.0000	Select
Flow	cfs	212.8900	Select
Manning's n		0.0130	Select
Roadway Elev	ft	8655.7500	Select
Inlet Elev	ft	8634.0000	Select
Outlet Elev	ft	8630.0000	Select
Headwater	ft	8655.7493	Inlet Control
Slope	ft/ft	0.0472	
Velocity	fps	25.9070	

8655.75

8634.00 8630.00

Settings Messages

Input New

Over-Top Load

P-Curve Save

Fit-Plot OK

Output Cancel

Help

Elk Creek Capacity – Flow at 3' below Railroad Elevation

Culvert Design - elk creek ex 42in culvert.clt

Barrel Shape	CIRCULAR		
Tailwater	ft	2.5000	Select
Length	ft	84.7000	Select
Diameter	in	42.0000	Select
Flow	cfs	195.8300	Select
Manning's n		0.0130	Select
Roadway Elev	ft	8655.7500	Select
Inlet Elev	ft	8634.0000	Select
Outlet Elev	ft	8630.0000	Select
Headwater	ft	8652.7512	Inlet Control
Slope	ft/ft	0.0472	
Velocity	fps	25.7108	

8655.75

8634.00 8630.00

Settings Messages

Input New

Over-Top Load

P-Curve Save

Fit-Plot OK

Output Cancel

Help

Unknown Drainage Capacity – Flow at Railroad Elevation

Culvert Design - unknown drainage culvert.clt

Barrel Shape	CIRCULAR		
Tailwater	ft	3.0000	Select
Length	ft	89.2400	Select
Diameter	in	48.0000	Select
Flow	cfs	121.1000	Select
Manning's n		0.0240	Select
Roadway Elev	ft	8698.8000	Select
Inlet Elev	ft	8692.7000	Select
Outlet Elev	ft	8680.3200	Select
Headwater	ft	8698.7988	Inlet Control
Slope	ft/ft	0.1387	
Velocity	fps	22.0371	

8698.80
8692.70
8680.32

Settings Messages

Input New

Over-Top Load

P-Curve Save

Fit-Plot OK

Output Cancel

Help

Unknown Drainage Capacity – Flow at 3' below Railroad Elevation

Culvert Design - unknown drainage culvert.clt

Barrel Shape	CIRCULAR		
Tailwater	ft	3.0000	Select
Length	ft	89.2400	Select
Diameter	in	48.0000	Select
Flow	cfs	56.4500	Select
Manning's n		0.0240	Select
Roadway Elev	ft	8698.8000	Select
Inlet Elev	ft	8692.7000	Select
Outlet Elev	ft	8680.3200	Select
Headwater	ft	8695.8045	Inlet Control
Slope	ft/ft	0.1387	
Velocity	fps	17.8792	

8698.80
8692.70
8680.32

Settings Messages

Input New

Over-Top Load

P-Curve Save

Fit-Plot OK

Output Cancel

Help

Leland Creek Capacity – Flow at Railroad Elevation

Culvert Design - leland creek ex 48in culvert.clt

Barrel Shape	CIRCULAR		
Tailwater	ft	3.0000	Select
Length	ft	85.4000	Select
Diameter	in	48.0000	Select
Flow	cfs	261.0900	Select
Manning's n		0.0130	Select
Roadway Elev	ft	8767.0400	Select
Inlet Elev	ft	8747.2300	Select
Outlet Elev	ft	8745.0400	Select
Headwater	ft	8767.0396	Inlet Control
Slope	ft/ft	0.0256	
Velocity	fps	20.7769	

8767.04

8747.23 8745.04

Settings Messages

Input New

Over-Top Load

P-Curve Save

Fit-Plot OK

Output Cancel

Help

Leland Creek Capacity – Flow at 3' below Railroad Elevation

Culvert Design - leland creek ex 48in culvert.clt

Barrel Shape	CIRCULAR		
Tailwater	ft	3.0000	Select
Length	ft	85.4000	Select
Diameter	in	48.0000	Select
Flow	cfs	237.2000	Select
Manning's n		0.0130	Select
Roadway Elev	ft	8767.0400	Select
Inlet Elev	ft	8747.2300	Select
Outlet Elev	ft	8745.0400	Select
Headwater	ft	8764.0393	Inlet Control
Slope	ft/ft	0.0256	
Velocity	fps	18.8758	

8767.04

8747.23 8745.04

Settings Messages

Input New

Over-Top Load

P-Curve Save

Fit-Plot OK

Output Cancel

Help

Article

A Pragmatic Slope-Adjusted Curve Number Model to Reduce Uncertainty in Predicting Flood Runoff from Steep Watersheds

Muhammad Ajmal ¹, Muhammad Waseem ², Dongwook Kim ³ and Tae-Woong Kim ^{4,*}

¹ Department of Agricultural Engineering, University of Engineering and Technology, Peshawar 25120, Pakistan; engr_ajmal@uetpeshawar.edu.pk

² Center of Excellence in Water Resources, University of Engineering and Technology, Lahore 54890, Pakistan; waseem.jatoi@cewre.edu.pk

³ Department of Civil and Environmental System Engineering, Hanyang University, Seoul 04763, Korea; midas515@hanyang.ac.kr

⁴ Department of Civil and Environmental Engineering, Hanyang University, Ansan 15588, Korea

* Correspondence: twkim72@hanyang.ac.kr; Tel.: +82-31-400-5184

Received: 26 April 2020; Accepted: 19 May 2020; Published: 21 May 2020

Abstract: The applicability of the curve number (CN) model to estimate runoff has been a conundrum for years, among other reasons, because it presumes an uncertain fixed initial abstraction coefficient ($\lambda = 0.2$), and because choosing the most suitable watershed CN values is still debated across the globe. Furthermore, the model is widely applied beyond its originally intended purpose. Accordingly, there is a need for more case-specific adjustments of the CN values, especially in steep-slope watersheds with diverse natural environments. This study scrutinized the λ and watershed slope factor effect in estimating runoff. Our proposed slope-adjusted CN ($CN_{II\alpha}$) model used data from 1779 rainstorm–runoff events from 39 watersheds on the Korean Peninsula (1402 for calibration and 377 for validation), with an average slope varying between 7.50% and 53.53%. To capture the agreement between the observed and estimated runoff, the original CN model and its seven variants were evaluated using the root mean square error (RMSE), Nash–Sutcliffe efficiency (NSE), percent bias (PB), and 1:1 plot. The overall lower RMSE, higher NSE, better PB values, and encouraging 1:1 plot demonstrated good agreement between the observed and estimated runoff by one of the proposed variants of the CN model. This plausible goodness-of-fit was possibly due to setting $\lambda = 0.01$ instead of 0.2 or 0.05 and practically sound slope-adjusted CN values to our proposed modifications. For more realistic results, the effects of rainfall and other runoff-producing factors must be incorporated in CN value estimation to accurately reflect the watershed conditions.

Keywords: initial abstraction coefficient; slope-adjusted curve number; rainfall; precise runoff; model accuracy

1. Introduction

There is plethora of process-based hydrological models, but they require extensive data, which is a limitation in ungauged watersheds. These process-based models are broadly used to estimate and/or predict hydrologic processes across landscapes and to assess the corresponding impacts of land use/cover changes [1]. Rainfall–runoff modeling is among the most fundamental concepts in hydrology, providing a starting point to estimate flood peaks and design structures. The rainfall–runoff process is a dynamic and complex hydrological phenomenon affected by different physical factors and their interactions [2]. Due to the non-linear relationship between rainfall and runoff, the development of a robust model to predict runoff in ungauged watersheds is difficult and time-consuming [3]. The least

complex model that reliably meets the anticipated application is often preferable [4]. The advantages of the Natural Resources Conservation Service (NRCS) curve number (CN) [1] model are its simplicity, predictability, and dependence on only one parameter. The CN model has well-documented data, has been globally tested, and has a rich literature. The CN is a function of soil permeability/infiltration capacity, land use/cover, and other runoff-producing conditions of a watershed; it quantifies direct runoff, requiring only the cumulative rainfall depth and the watershed's CN [5]. The initial abstraction coefficient (λ) and the CN in the CN model are vital to accurately estimate runoff from a watershed [6].

1.1. The CN Model Framework

The CN model is structured to quantify runoff depth (Q) using the cumulative rainstorm depth (P) and maximum potential water retention amount (S), a measure of the ability of a watershed to abstract and retain storm precipitation. Here, P , S , and Q are measured in millimeters.

$$Q = \frac{(P - \lambda S)^2}{P + (1 - \lambda)S} \text{ for } P \geq \lambda S \quad Q = 0 \text{ otherwise} \quad (1)$$

The initial abstraction is the rainstorm depth required before runoff begins. Originally, it was taken as $I_a = \lambda S = 0.2S$; here, S (mm) is related to CN via

$$CN = 100 \left(\frac{x}{x + S} \right) \text{ or } S = x \left(\frac{100}{CN} - 1 \right) \text{ for } x = 254 \text{ mm (or 10 in)} \quad (2)$$

The dimensionless CN varies from 0 to 100 [5]. Handbook tables for CN selection are based on soil types and land use/land cover. The threshold of $\lambda = 0.2$ is being actively debated across the globe for its inconsistent watershed runoff estimation because $\lambda = 0.05$ has been found to be much more representative [2]. Nevertheless, essentially all handbook CN table values correspond to $\lambda = 0.2$. The corresponding S for $\lambda = 0.05$ is different from that for $\lambda = 0.2$ and, hence, the resulted runoff values are different. The adjustment of CN from $\lambda = 0.2$ to $\lambda = 0.05$ has recently been adopted by the Task Group on Curve Number Hydrology [5], which recommends a new relation as $S_{0.05} = 1.42S_{0.2}$, and leads to

$$CN_{0.05} = \frac{100}{1.42 - 0.0042CN_{0.2}} \quad (3)$$

Several studies have shown considerable differences between handbook-tabulated CN values based on land cover/use and those estimated from watershed observations of rainfall–runoff events [2,5,7–10]. The differences are more prominent with smaller CN values and land types not clearly described in the CN tables [5]. Different studies have evidenced runoff prediction from different biomes using $\lambda < 0.2$ values [2,10–16], suggesting λ in the range of 0.01 to 0.05.

1.2. Effect of Slope on CN and Runoff Estimation

There is no handbook convention but, intuitively, higher-sloped watersheds should have higher CN values. Several CN-based models have documented positive slope-adjustment techniques [10,17–24]. However, some mild negative relationships for limited data are also available [5]. Steep slopes generally give a higher potential for runoff [25], but the impact of slope steepness on runoff generation is a debatable topic. Researchers from different biomes have reported increases in runoff that were attributed to a decrease in infiltration, less detention storage and ponding depth, and high flow velocity [10,19–22,25,26]. Some researchers have captured reduced runoff generation per unit of slope length from steep-slope watersheds with pronounced decreasing storm duration, which might be due to thinning and/or disruption of the crust, differential soil cracking, formation of rills, and more ponding depth [27–33]. However, other studies [34,35] found insignificant effects of slope steepness on runoff. These discrepancies are possibly due to contradiction in experimental settings, as well as land cover and use differences.

To accurately estimate runoff, the CN values found in handbook tables are more effective for rain-fed agricultural watersheds, are less efficient for semi-arid watersheds, and are least successful for forested watersheds [36]. The CN model has a spotty and inconsistent performance history for some forested watersheds (i.e., those in which infiltration potential usually exceeds the rainfall intensities), and for frequent, low-volume, and low-intensity rainfalls. Some researchers found notable problems associated with the tabulated CN values for heavy land cover and humid, forested watersheds, suggesting that the model is inapplicable for runoff estimation in such watersheds [2,9]. For many years, the CN values obtained from handbook tables have been problematic and may need case-specific adjustment when applied in regions with more complex natural environments. The accuracy of the CN value is vital in runoff estimation [37]. The objective of this study was to frame a practically sound slope-adjusted CN equation that could follow the CN theoretical limits (0, 100) and enhance the runoff prediction capability of the CN model from rainstorm events in steep-sloped watersheds.

2. Materials and Methods

2.1. Study Area Description and Climate

South Korea is typical of regions largely influenced by complicated geographical features. Its precipitation patterns have diverse seasonal and regional variability [38]. The elevation (area) of the watersheds included in this study vary from 26 m (42.32 km²) to 911 m (879.10 km²) above mean sea level. The average slope of the watershed ranges between 7.50% and 53.53%. The majority of the land cover (about 70.50%) is upland forests, followed by 20.26% agricultural land, urban areas (5.22%), grassland (1.56%), and other land cover distribution (2.45%). The dominant soil types are loam and sandy loam, with some fractions of silt loam. The location of watersheds is shown in Figure 1, and other details can be found in [10].

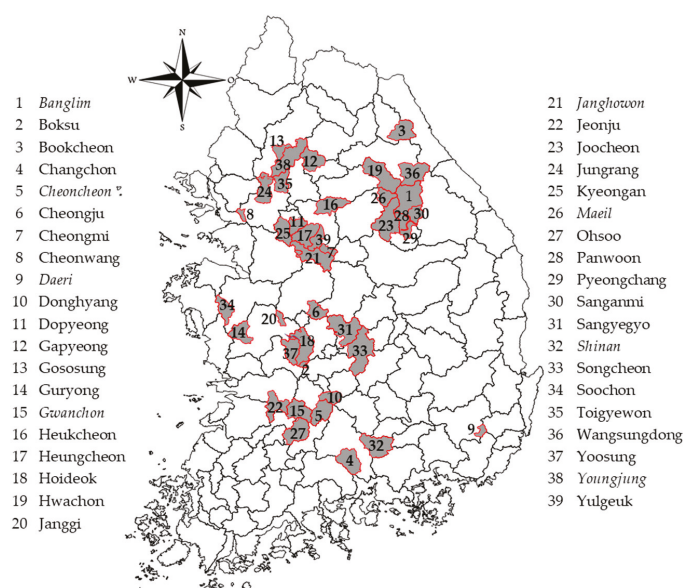


Figure 1. Location of watersheds in the study area. The watersheds in italics were used for validation.

The climatic patterns over the study area are quite variable due to the Asian monsoon. Winter is extremely dry and cold, and summer is warm and moist with frequent heavy rainstorms [38]. The mean annual precipitation (from 1970 to 2000) ranged between 1000 and 1800 mm from the central to the

southern regions. Approximately 50% to 60% of this precipitation falls at a high intensity and short duration from July to September [10].

2.2. Data Collection and Interpretation

Continuous rainfall and discharge data (from 2005 to 2012) for this study were collected from the Hydrological Survey Center (HSC) of South Korea. The straight-line hydrograph approach was used to separate direct runoff from the total discharge [10]. For any rain event, the prior five days' cumulative rainfall (P_5) was used to identify the watershed antecedent moisture [10,20,22,39]. The watershed weighted curve number (CN_{II}) corresponding to the normal conditions were derived from the documented tables on the basis of land use/cover and soil types. The CN_I (CN_{III}) for dry (wet) conditions were adjusted as recommended by Mishra et al. [40].

2.3. Slope-Adjusted Curve Number Considerations and Development

Although the CN model is extensively used for predicting runoff from ungauged watersheds, one study found considerable uncertainties when tabulated CN values were applied to estimate runoff from 10 mountainous, forested watersheds in the eastern United States [9]. Similarly, another study [41] observed substantial change in the watershed CN values, ranging from 55 to 70. Moreover, the use of hydrologic soil group D (and its corresponding CN) for forested, mountainous watersheds is incompatible with the National Engineering Handbook [42] guidelines. Although very limited attention has been given to incorporate slope factors in the existing CN models [43], one study reported that adjusting handbook CN values for slope factors significantly enhanced the predicted runoff [26]. To better capture the watershed response in runoff prediction, a slope-adjusted CN is required for steep-slope, mountainous watersheds [10].

Assuming that the handbook CN value is appropriate for a 5% slope [10,17,19,20,22,23], it needs to be adjusted for steep-slope watersheds. To improve the runoff prediction capability of the CN model, the slope-adjusted CN suggested by Sharpley and Williams [17] is generally expressed as

$$CN_{II\alpha} = a(CN_{III} - CN_{II})(1 - be^{-c\alpha}) + CN_{II} \quad (4)$$

where $CN_{II\alpha}$ is the slope-adjusted CN for the antecedent runoff condition representing the watershed normal moisture (ARC-II), CN_{II} and CN_{III} are the handbook CN values obtained from watershed characteristics for ARC-II and ARC-III (wet condition), and α is the watershed average soil slope (m/m). The approach of Sharpley and Williams [17] has three empirical parameters— a , b , and c —with optimized values of 1/3, 2, and 13.86, respectively. Their adjusted relationship leads to

$$CN_{II\alpha} = \left(\frac{CN_{III} - CN_{II}}{3} \right) (1 - 2e^{-13.86\alpha}) + CN_{II} \quad (5)$$

Retaining the assumption of Sharpley and Williams [17] for CN_{II} values applicable to a 5% average slope, another study [23] developed the following relationship to adjust CN values for other slopes:

$$S_{II\alpha} = S_{II} \left(1.1 - \frac{\alpha}{\alpha + e^{(3.7+0.02117\alpha)}} \right) \quad (6)$$

where S_{II} and $S_{II\alpha}$ are the S values for normal moisture condition and slope-adjusted normal moisture conditions, respectively, and α is the watershed mean slope in percentage. The slope-adjusted CN can be obtained from the above equation using the general S and CN interrelationship as it is found in Equation (2). According to Huang et al. [19], the approach in Sharpley and Williams [17] has not been intensively verified in the field. Hence, they adopted a simplified approach for the $CN_{II\alpha}$ determination

on the basis of their experiments for soil slopes ranging between 0.14 and 1.40, and proposed the following relationship:

$$CN_{II\alpha} = CN_{II} \left(\frac{322.79 + 15.63\alpha}{\alpha + 323.52} \right) \quad (7)$$

However, this relationship is unstable because it does not follow the CN theoretical limits.

An investigation by Garg et al. [26] showed that the differences between the tabulated CN values and those calculated from the approach in Huang et al. [19] were very small when compared to that of Sharpley and Williams [17]. This is why the approach in Huang et al. [19] depicted modest improvement in estimating large as well as small runoff events and produced results very close to the original CN model with handbook CN values. Any underestimation of the runoff events using the approach in Huang et al. [19] can be attributed to the empirically selected numerical constants of Equation (7), and needs validation using the measured rainfall-runoff data.

In another study, Ajmal et al. [10] developed a slope-adjusted average CN relationship using data from 39 mountainous watersheds. They calibrated the $CN_{II\alpha}$ using 1402 measured rainfall-runoff events from 31 watersheds and validated this with 377 rainfall-runoff events from the remaining eight watersheds. This is represented as

$$CN_{II\alpha} = CN_{II} \left[\frac{1.9274\alpha + 2.13273}{\alpha + 2.1791} \right] \quad (8)$$

The above relationship was derived on the basis of data from watersheds with an average slope between 7.50% and 53.53%, where, besides other typical watershed geophysical characteristics, most of the area (approximately 70.50%) was covered with upland forests. However, their approach was also inconsistent with the CN theoretical limits on the basis of the presumption that the CN tables were originally developed with a 5% average slope in their experimental plots [10,17,19]. Knowing CN_{II} , CN_{III} , and α as the mean slope of a watershed, the proposed slope-adjusted CN ($CN_{II\alpha}$) in its general form is presented as

$$CN_{II\alpha} = \left(\frac{CN_{III} - CN_{II}}{2} \right) \left[1 - e^{-b \times (\alpha - 0.05)} \right] + CN_{II} \quad (9)$$

2.4. Steps of Slope-Adjusted CN Parameter Optimization

1. Data pertaining to 39 watersheds in which 1779 rainstorms events occurred provided the known values of the rainstorm events, P ; the observed runoff, Q_o ; and the optimized CNs for each watershed. The least squares nonlinear orthogonal distance regression objective function in Origin Pro 9.6 software produced the optimized CN values from the following equation.

$$\sum_{i=1}^n (Q_o - Q_e)^2 = \sum \left\{ Q_o - \left[\frac{(P - 0.2 \times (\frac{25400}{CN} - 254))^2}{P + 0.8 \times (\frac{25400}{CN} - 254)} \right] \right\}^2 = \text{Minimum} \quad (10)$$

2. To optimize parameter b in Equation (9), the CNs obtained for the 39 watersheds from Equation (10) were divided into two sets, those of 31 watersheds (1402 rainstorm-runoff events) for calibration and those of 8 watersheds (377 rainstorm-runoff events) for validation. For calibration, the optimized CNs in step 1 were set as the target values challenging the right side of Equation (9) using the nonlinear regression least squares Levenberg-Marquardt algorithm in SPSS v.25 software. To take into account the individual watersheds' effects on parameter b optimization, the leave-one-out (LOOV) technique was adopted. The average of 31 calibrations repetitions was the value of $b = 7.125$. This led to recasting the proposed $CN_{II\alpha}$ as

$$CN_{II\alpha} = \left(\frac{CN_{III} - CN_{II}}{2} \right) \left[1 - e^{-7.125 \times (\alpha - 0.05)} \right] + CN_{II} \quad (11)$$

This can also be represented as

$$CN_{II\alpha} = (0.5 - 0.714e^{-7.125\alpha})(CN_{III} - CN_{II}) + CN_{II} \quad (12)$$

Introducing the CN_{III} conversion from CN_{II} after a suggestion in Mishra et al. [40] gives

$$CN_{III} = \frac{CN_{II}}{0.430 + 0.0057CN_{II}} \quad (13)$$

Imputing Equation (13) into Equation (11) and simplifying it, the proposed relationship can be recast as

$$CN_{II\alpha} = \left[\frac{CN_{II}(50 - 0.5CN_{II})}{CN_{II} + 75.43} \right] \times [1 - e^{-7.125(\alpha - 0.05)}] + CN_{II} \quad (14)$$

This proposed $CN_{II\alpha}$ relationship has twofold advantages over the previous three suggested relationships. The proposed model has only one parameter to be optimized compared to three in Sharpley and Williams [17] and Williams and Izaurralde [23], and two in Huang et al. [19], if the suggested parameter values are not applicable. Our proposed $CN_{II\alpha}$ works within the theoretical limits (i.e., 0 to 100), unlike that in Huang et al. [19], which loses its effectiveness after $CN_{II} = 94.27$ using the highest average slope of their watersheds. Similarly, the adjustment in Williams and Izaurralde [23] and Ajmal et al. [10] also fails to follow the CN theoretical limits. The different variants of the CN model are shown in Table 1.

Table 1. Models and their descriptions.

Parameters			
Model Identity	λ	CN ($CN_{II\alpha}$)	Model Expression
M1	0.20	*NEH-4 Tables	Equations (1) and (2)
M2	0.05	NEH-4 Tables	Equations (1)–(3)
M3	0.20	Sharpley and Williams [17]	Equations (1), (2) and (5)
M4	0.20	Huang et al. [19]	Equations (1), (2) and (7)
M5	0.20	Ajmal et al. [10]	Equations (1), (2) and (8)
M6	0.20	Proposed	Equations (1), (2) and (12)
M7	0.05	Proposed	Equations (1)–(3) and (12)
M8	0.01	Proposed	Equations (1), (2) and (12)

*NEH-4: National Engineering Handbook Section-4 [42].

3. Statistical Analysis for Model Performance Evaluation

This study estimated the agreement between a series of observed and estimated runoffs using the root mean square error (RMSE), Nash–Sutcliffe efficiency (NSE), percent bias (PB) [34], and/or graphical assessments augmented with model performance ratings [44]. Mathematically, these indicators are

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (Q_{oi} - Q_{ei})^2} \quad (15)$$

$$NSE = 1 - \left[\frac{\sum_{i=1}^n (Q_{oi} - Q_{ei})^2}{\sum_{i=1}^n (Q_{oi} - \bar{Q}_o)^2} \right] \quad (16)$$

$$PB = \left[\frac{\sum_{i=1}^n (Q_{oi} - Q_{ei})}{\sum_{i=1}^n Q_{oi}} \right] \times 100 \quad (17)$$

where Q_{oi} and Q_{ei} are the observed and estimated runoff values for rainstorm events 1 to n , and $\overline{Q_O}$ is the mean observed runoff in each watershed. The RMSE (0 to ∞) values closer to zero depict more appropriateness of the model to estimate runoff. The NSE ($-\infty$ to 1) illustrates how well a plot of observed vs. estimated runoff fits a 1:1 line (i.e., a perfect fit) [39]. The PB (optimum = 0) describes the average tendency of estimated values to be larger or smaller than their observed ones. Positive (negative) values indicate underestimation (overestimation) bias [44]. It is notable that perfect agreement of the estimated vs. observed data does not essentially indicate a perfect model, because observed data could have uncertainties [39]. However, we are confident about the good quality of the data used in this study. Performance evaluation of different statistical indicators and their suggested ratings [44,45] are given Table 2.

Table 2. Statistical indicators and associated performance ratings [44,45].

Performance Rating	NSE [44]	NSE [45]	PB (%)
Very good	$0.75 < \text{NSE} \leq 1.00$	$0.90 < \text{NSE} \leq 1.00$	$-10 < \text{PB} < +10$
Good	$0.65 < \text{NSE} \leq 0.75$	$0.80 \leq \text{NSE} \leq 0.90$	$\pm 10 \leq \text{PB} < \pm 15$
Satisfactory	$0.50 < \text{NSE} \leq 0.65$	$0.65 \leq \text{NSE} < 0.80$	$\pm 15 \leq \text{PB} < \pm 25$
Unsatisfactory	$\text{NSE} \leq 0.50$	$\text{NSE} \leq 0.65$	$\text{PB} \geq \pm 25$

4. Results and Discussion

The performance evaluation of the existing models (M1–M5) and our proposed approach (M6–M8) was accomplished in two steps. First, the basic statistics of the observed runoff were compared to the models' estimated runoff both for the calibration and validation watersheds. In the second step, commonly used statistical indicators were used to check the model's predictive credibility [20,34,44] in conjunction with a 1:1 plot graphical judgement between the observed and modeled runoff values [46].

4.1. Models' Analysis Based on Descriptive Statistics

The basic descriptive statistics (Table 3) favor the M8 model using the $\text{CN}_{II\alpha}$ and lower $\lambda = 0.01$ followed by the M6 and M5 models. However, the M6 model was preferred over the M5 due to its practically sound $\text{CN}_{II\alpha}$ to follow the CN theoretical bounds (0–100). In estimating runoff, the M2 model was not plausibly different from the M1 model. Therefore, lowering λ from 0.2 to 0.05, along with its corresponding CN adjustment using Equation (3), produced only modest changes in the estimated runoff values. Nonetheless, using $\lambda = 0.05$ and retaining handbook CN values without adjustment can improve the model's runoff predictive capability, which is not shown in the assessment but is reflected in the comparison of the M6 and M7 models. The majority of the existing CN model variants underestimated the runoff in different watersheds. Nevertheless, it can be inferred that the watershed CN was not the only important parameter; selecting the proper λ also played a crucial role in estimating accurate runoff. Additionally, the prominent response of CNs to the rainstorm depth was vital in runoff depth estimation [1].

Table 3. Summary statistic of rainfall (P), observed runoff (Q_o), and modeled runoff (M1–M8) in the calibration and validation watersheds.

Calibration Watersheds (1402 Rainstorm–Runoff Events)						
Parameter/Model	Mean	Minimum	First Quartile (Q1)	Median	Third Quartile (Q3)	Maximum
P	80.96	12.10	39.92	59.09	98.27	519.68
Q_o	38.60	0.17	8.23	19.61	49.04	348.46
M1	25.57	0.00	1.49	6.13	27.03	415.63
M2	23.56	0.00	1.14	7.26	25.79	383.27
M3	28.79	0.00	1.30	7.95	32.94	436.28
M4	26.06	0.00	1.52	6.31	28.33	419.65
M5	30.06	0.00	1.35	8.83	35.39	443.28
M6	30.26	0.00	1.23	9.38	35.34	445.73
M7	28.98	0.00	2.54	10.77	34.57	417.11
M8	39.67	0.53	7.93	20.13	49.30	458.55

Table 3. Cont.

Validation Watersheds (377 Rainstorm–Runoff Events)						
P	75.22	20.52	40.97	57.05	86.95	376.86
Q ₀	35.03	0.24	8.30	19.10	43.20	364.38
M1	22.04	0.00	1.48	6.35	20.35	294.27
M2	19.85	0.00	0.85	5.55	19.93	265.59
M3	24.75	0.00	1.52	6.27	25.99	309.31
M4	22.49	0.00	1.39	6.63	21.48	296.26
M5	26.48	0.00	2.03	7.87	30.12	309.72
M6	26.07	0.00	1.71	6.66	29.04	314.48
M7	24.98	0.00	2.10	9.43	26.71	293.91
M8	34.77	0.87	7.70	17.91	40.12	325.07

Note: The highlighted values show the good agreement between the observed and the estimated runoff.

4.2. Model Performance Evaluation in Watersheds Used for Calibration

We evaluated the runoff predictability performance of the existing CN models (M1 to M5) and the proposed variants (M6 to M8) for the calibration watersheds (Figure 2). Because of minimal difference in the $CN_{li\alpha}$ values proposed by Williams and Izaurralde [23] and Sharpley and Williams [17], we compared only the latter with the other approaches. As mentioned earlier, the RMSE can vary from 0 to ∞ , and a value close to zero indicates a nearly perfect fit [15,20,34]. On the basis of the RMSE (mean, median) values, the M2 (23.90, 21.91) and M3 (24.30, 21.90) models exhibited similar but improved runoff estimation compared to the M1 (26.49, 24.02) model. The mean value for all of the statistical indicators is shown on each box plot through connected lines. The M2 model's enhanced runoff estimation could be attributed to the lower $\lambda = 0.05$ [2], whereas the M3 model's improved predictability could be ascribed to $CN_{li\alpha}$, which was comparatively higher than the tabulated CN [17]. The M4 model (26.08, 23.78) showed almost no improvement compared to the M1 model. Comparatively better runoff prediction was found for the M5 model (23.53, 21.15), and that of the M6 model (23.23, 20.79) was almost equal in the calibration watersheds. However, the runoff predictive capabilities of the M7 model (21.06, 19.29) and M8 model (18.59, 16.87) were better, as was also evident from their overall RMSE values (Figure 2a). It can be inferred that setting a lower λ and a comparatively higher $CN_{li\alpha}$, as was the case in model M8, possibly reduces the infiltration and surface water retention capacity.

Following the model performance ratings shown in Table 2 and the box plot statistics (Figure 2b), the NSE (mean, median) for the M1 model (0.58, 0.63) and the M4 model (0.59, 0.64) were the smallest among the eight variants of the CN model. It must be kept in mind that the Gusosung watershed statistics were excluded, meaning the mean and median values were calculated for the remaining 30 calibration watersheds. In that particular watershed, only the M8 model showed a reasonable runoff prediction, whereas the rest of the models' performance indicators ratings were unsatisfactory. The M3 model (0.64, 0.68) results showed modest improvement, followed by the M2 (0.66, 0.71) and M5 (0.66, 0.71) models. However, the M6 (0.67, 0.72) and M7 (0.74, 0.77) models exhibited significantly improved results compared to the M1 model. In addition, the M8 model (0.80, 0.82) outperformed all the other models in the majority of the watersheds. The best performance of the M8 model is also evident from Figure 2b, followed by the M7 and M6 models, in that order. The lack of effectiveness of the M1 and M4 models could be attributed to the fixed and higher $\lambda = 0.2$ and inconsistent watershed tabulated CN values [10,15]. Similarly, on the basis of the PB performance ratings (Table 2), the accuracy runoff predictability of the different CN model variants is shown in Figure 2c. Using PB (mean, median), the order for accurately estimating runoff was M8 (−2.43, 0.67) > M7 (19.47, 18.06) > M6 (22.37, 22.51) > M5 (23.22, 21.93) > M3 (25.93, 24.46) > M2 (31.86, 31.26) > M4 (32.93, 32.41) > M1 (34.19, 33.14). In addition, Figure 2c shows that the PB values obtained from the M8 model in estimating runoff in the study area, except for two watersheds, were rated either very good, good, or at least satisfactory.

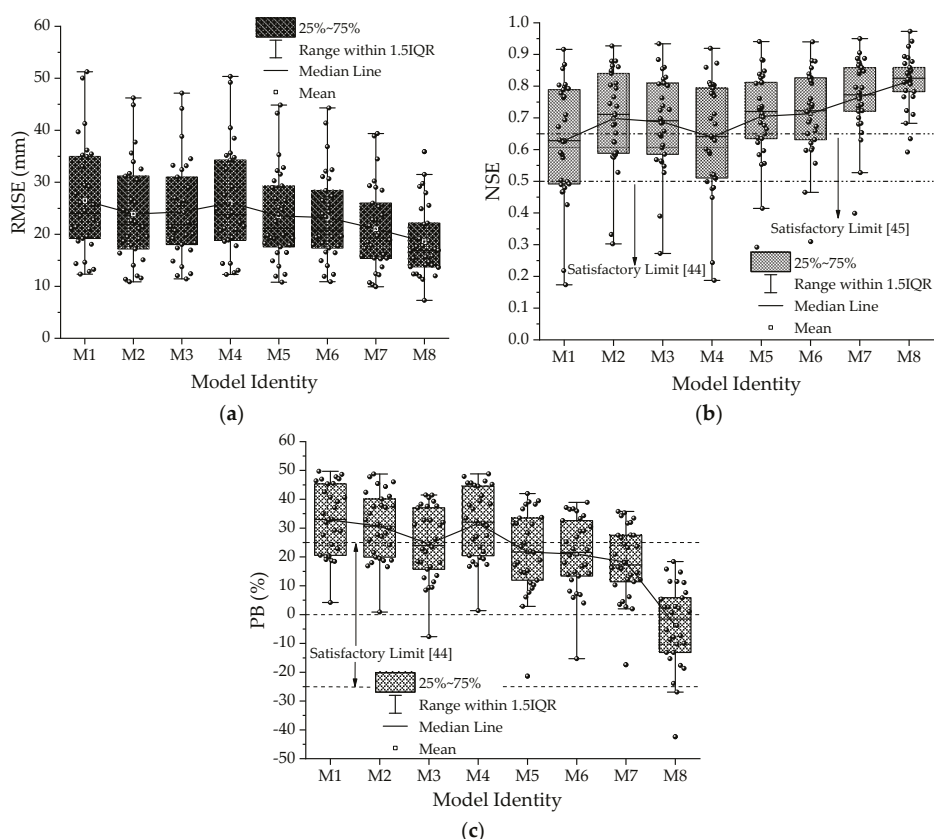


Figure 2. (a) Root mean square error (RMSE), (b) Nash–Sutcliffe efficiency (NSE), and (c) percent bias (PB) for eight variants of the CN model using data of 30 out of 31 calibration watersheds.

4.3. Models' Performance Evaluation in Watersheds Used for Validation

The performance of the CN model variants in the validation watersheds using the RMSE, NSE, and PB is shown in Figure 3. The superior performance of the M8 model is evident, whereas the least efficient was the M1 model with its RMSE, NSE, and PB (mean, median) values of (24.56, 22.73), (0.57, 0.60), and (36.73, 33.18), respectively. The corresponding best runoff prediction by the M8 model was recorded with RMSE (17.25, 16.07), NSE (0.80, 0.78), and PB (−0.35, −3.35). Similarly, the higher PB positive values by the M1 model in the majority of the watersheds indicated underestimation and were in the unsatisfactory range, as found by other researchers [10,20,34,44]. Nevertheless, the M8 model overestimated runoff in the majority of the watersheds, but, was within the acceptable performance range. In addition, among the remaining six variants of the CN model, the M7 model predicted more accurate runoff, followed by the M5, M6, M2, M3, and M4 models, in that order. On the basis of the PB values (Figure 3), the M8 model predicted runoff well in all the watersheds except one.

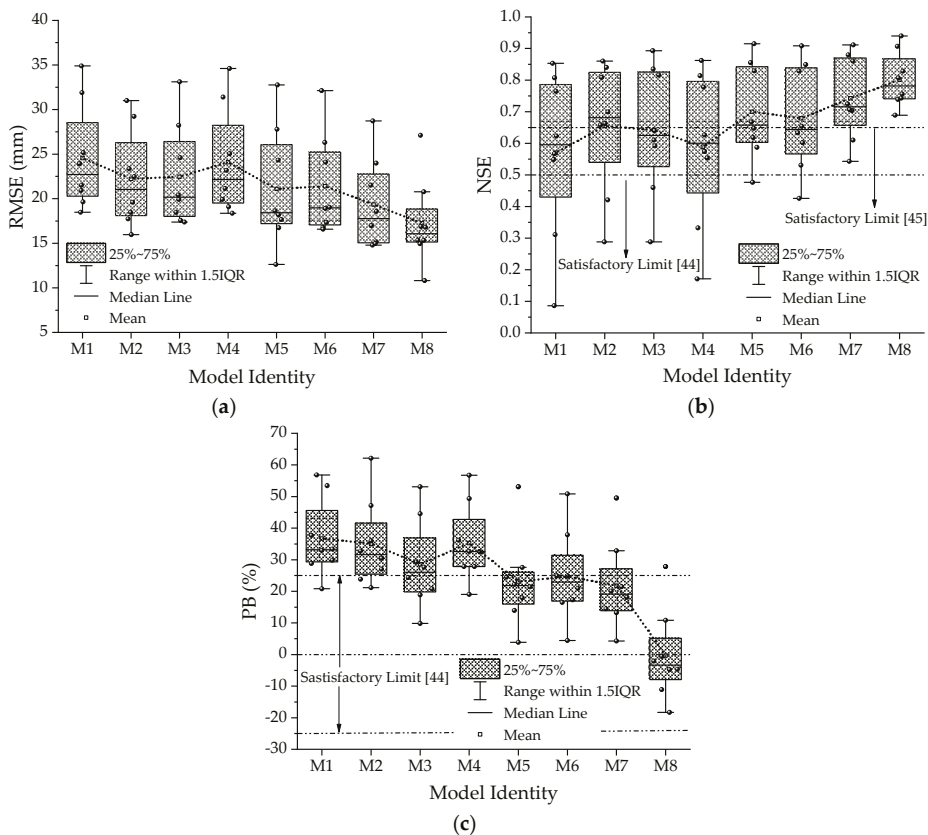


Figure 3. (a) RMSE, (b) NSE, and (c) PB for eight variants of the CN model using data of eight validation watersheds.

4.4. Overall Performance of Models and Comparison Based on 1:1 Plot

Table 4 summarizes the credibility of the eight variants of the CN model in estimating runoff from rainstorm events in different watersheds. It is obvious that the M8 model exhibited more accurate results for a very good performance rating based on NSE (PB) in 30 (19) out of 39 watersheds. The corresponding goodness-of-fit rating for the M1 model was found only in 14 (1) watershed(s). Applying the model evaluation criteria recommended by Ritter and Muñoz-Carpena [45], the M1 and M4 model predictions were “satisfactorily” to “very good” in only 43.6% of the watersheds, followed by the M3, M5, M2, M6, and M7 models with their corresponding values of 53.9%, 61.5%, 64.1%, 66.7%, and 84.6% of the watersheds, respectively. The more plausible model for efficiently predicting runoff was M8 in 92.3% (36 out of 39) watersheds. It is notable that the majority of the runoff was underestimated by the M1 model, as has also been reported for rangeland and cropland in Montana and Wyoming [47], Mississippi [48], the Loess Plateau of China [19], India [20,22,26,43], South Korea [10,15], and Poland [49]. After M8, the M7 and M6 models predicted runoff more coincident with the observed values. The M4 model’s inferior performance could possibly be linked to very little difference in the $CN_{II\alpha}$ and the handbook CN values ($CN_{II\alpha} - CN$), which varied in the range of 0.73 to 1.46. The corresponding CN differences for the M3, M5, and M6 models were in the range of 1.37 to 6.52, 0.73 to 11.28, and 1.15 to 9.48, respectively. It is notable that the M6 and M8 models used the same $CN_{II\alpha}$ values. The M8 model’s outperformance in predicting runoff was probably because of

its lower $\lambda = 0.01$, as suggested for Korean steep-slope watersheds [10], and its comparatively higher $CN_{II\alpha}$ values.

Table 4. Performance of the CN model and its variants in 39 watersheds in the study area.

	M1	M2	M3	M4	M5	M6	M7	M8
Performance Criteria	NSE [44]							
$0.75 < NSE \leq 1.00$	14	15	14	14	14	14	20	30
$0.65 < NSE \leq 0.75$	3	10	7	3	10	12	13	6
$0.50 < NSE \leq 0.65$	10	9	13	13	11	9	4	2
$NSE \leq 0.50$	12	5	5	9	4	4	2	1
	NSE [45]							
$0.90 < NSE \leq 1.00$	1	1	1	1	2	2	3	5
$0.80 \leq NSE \leq 0.90$	6	12	12	8	11	11	11	20
$0.65 \leq NSE < 0.80$	10	12	8	8	11	13	19	11
$NSE \leq 0.65$	22	14	18	22	15	13	6	3
	PB (%)							
$-10 < PB < +10$	1	1	5	1	5	6	6	19
$\pm 10 \leq PB < \pm 15$	0	0	3	0	6	5	8	9
$\pm 15 \leq PB < \pm 25$	10	11	12	10	13	12	12	7
$PB \geq \pm 25$	28	27	19	28	15	16	13	4

We further compared the different CN model variants on the basis of cumulative observed and estimated runoff from the 39 watersheds using the 1:1 plot and the coefficient of determination, R^2 . The moderately high R^2 value supported better runoff prediction capability of the M2 model compared to the M1 model. However, deviation of the observed–estimated runoff best-fit-regression line from the 1:1 plot shows that both the M1 and M2 models underestimated the majority of the runoff events (Figure 4). Although the M2 model R^2 value was comparatively high, the runoff predictability of the M1, M2, and M4 models was almost indistinguishable. Nevertheless, the closeness of data points around the 1:1 plot and the higher R^2 values of the M5 through M8 models favored these models for comparatively better runoff prediction. The best agreement between the observed and estimated runoff was evidenced by applying the M8 model, as shown in Figure 4. It should be noted that the R^2 statistics used for model evaluation could mislead practitioners. These statistics are oversensitive to extremely high values and insensitive to additive and proportional differences between model predictions and measured data [44]. The overall promising results of the M8 model support its suitability for runoff prediction in the steep-slope watersheds. Therefore, the original CN model and the majority of its variants discussed here do not well represent complex watershed characteristics, and thus the abstraction coefficient, the CN values from watershed, and the CN model itself need to be revised for general application. A very recent and comprehensive review by the NRCS Task Group on Curve Number Hydrology [5] also suggested changes to update the handbook and its associated procedures on the basis of lessons learned from global experiences and additional data analyses. To avoid jumps in runoff estimation, the CN model could be made to be more robust by not fixing the initial abstraction coefficient and considering the effect of rainfall as well as the spatial and temporal variability while estimating the watershed CN values.

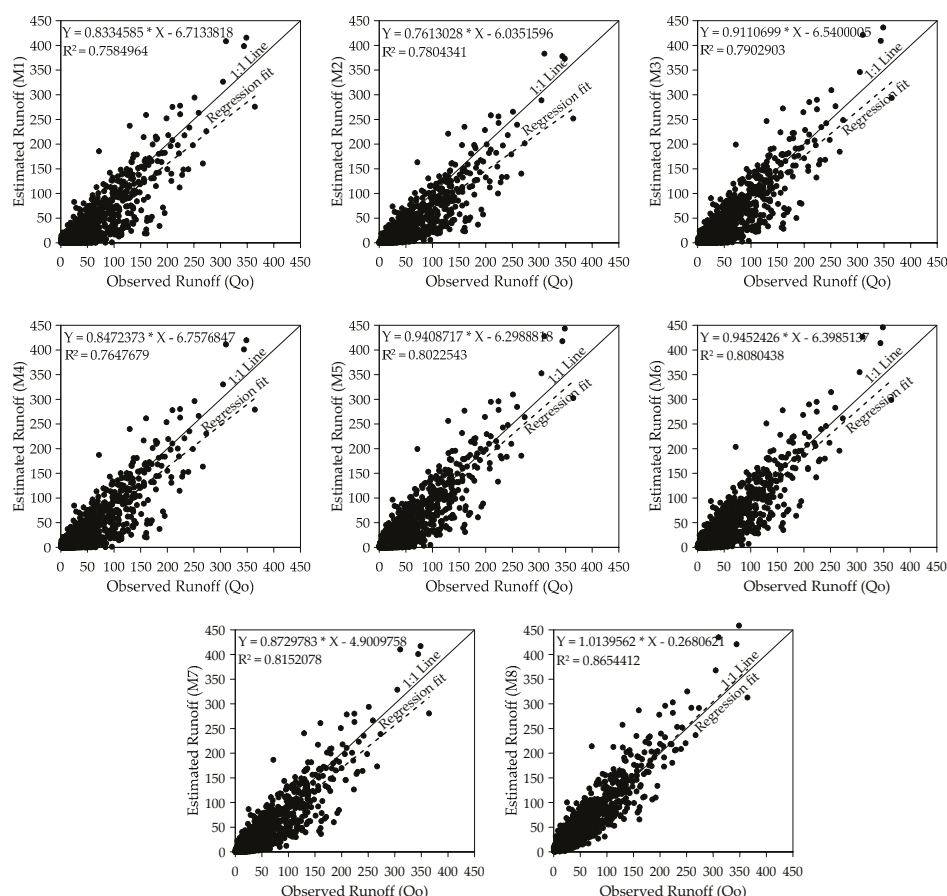


Figure 4. Observed and estimated runoff comparison for eight variants of the CN model using cumulative data of all 39 watersheds.

There is an evidence that the CN tables that were documented a few decades back that were based on soils and land use/cover are often wide of the mark and not supported by real ground data or by critical analyses [10,15,50]. The original CN model response demonstrated in different studies is very sensitive in selecting the watershed-representative CN. Moreover, the runoff response from some watersheds were found to be very erratic, leading to great discrepancies between the modeled data and reality [50]. Like our findings, various studies have reported underestimated runoff in the steep-slope watersheds using the original CN methodology [10,17–23], and slope adjustment for CN was proposed to capture the watershed response in predicting runoff [10,17–19,21–24]. Application of the suggested approach by Sharpley and Williams [17] was criticized for being tested with very limited data in the field [19]. To support the findings of Williams et al. [18], two other slope-adjusted CN approaches were developed by Ajmal et al. [10] and Sharpley and Williams [17], but they were not structurally sound due to incapability to follow the CN theoretical limits. Because of the plausible response in replicating the watershed runoff, the slope-adjusted CN approach proposed in this study was not only structurally sound in terms of following the theoretical bounds of the CN, but also in supporting its application for better runoff prediction. However, the model results could be further improved by introducing the effects of spatial variability in CN for the soil–cover complex along watersheds [51,52].

5. Conclusions and Practical Implications

The CN model is being updated continuously on the basis of new measured rainfall–runoff data and innovation in research. When handbook CN values are used, the inconsistent runoff prediction capability of this model has led researchers to adjust the CN values using the effect of rainfall magnitudes [2,5] and watershed slope [10,17–19,24,26]. However, some researchers agree that the handbook CN values are fit for runoff estimation from watersheds with a maximum 5% average slope. Hence, there is a room for further refinement in determining CN values. This study investigated and proposed a practically sound slope-adjusted CN ($CN_{II\alpha}$) approach to improve the runoff prediction capability of the CN model in steep-slope watersheds in order to reduce possible uncertainties. The proposed $CN_{II\alpha}$ not only followed the theoretical limits (0, 100) [17], but in addition, unlike other existing $CN_{II\alpha}$ approaches [10,19,23], it provided a promising runoff prediction capability in the study area. The use of $\lambda = 0.05$ in place of $\lambda = 0.2$ and their adjusted $CN_{0.05}$ values modestly improved the CN model runoff predictability, but not well enough for runoff estimation from steep-slope watersheds. On the basis of different performance indicators, we found that the proposed $CN_{II\alpha}$ had a positive impact on the CN model runoff prediction. Users of the CN model should know the limitations in its procedures and assumptions because the model produces diverse responses when applied to different land types and watersheds [5]. Assuming a fixed λ value and its associated three fixed values of initial abstraction for dry, normal, and wet conditions are among the major limitations of the original CN model and variants used in this study. The model needs an overhaul for various compelling reasons to circumvent the fixed λ value, as well as unjustified sudden jumps in CN values and its associated estimated runoff. In this era of cutting-edge technology, researchers of different biomes have introduced new parameters in the model to improve its runoff prediction capability. However, inculcating new parameters has increased the model complexity and restricted its application in ungauged watersheds. The CN methodology must be overhauled using experiences from the modern hydrologic engineering without losing the simplicity rule.

Author Contributions: Conceptualization, methodology, and writing—original draft, M.A.; validation, M.W.; visualization and writing—review and editing, D.K.; project administration and resources, T.-W.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by a grant (2020-MOIS33-006) from the Lower-level and Core Disaster-Safety Technology Development Program funded by the Ministry of Interior and Safety (MOIS, Korea).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Muche, M.E.; Hutchinson, S.L.; Hutchinson, J.S.; Johnston, J.M. Phenology-adjusted dynamic curve number for improved hydrologic modeling. *J. Environ. Manag.* **2019**, *235*, 403–413. [\[CrossRef\]](#) [\[PubMed\]](#)
2. Hawkins, R.H.; Ward, T.J.; Woodward, D.E.; Van Mullem, J.A. *ASCE EWRI Task Committee Report on State of the Practice in Curve Number Hydrology*; ASCE: Reston, VA, USA, 2009; Volume 106.
3. Fan, F.; Deng, Y.; Hu, X.; Weng, Q. Estimating composite curve number using an improved SCS-CN method with remotely sensed variables in Guangzhou, China. *Remote Sens.* **2013**, *5*, 1425–1438. [\[CrossRef\]](#)
4. Beck, H.E.; van Dijk, A.I.; de Roo, A.; Dutra, E.; Fink, G.; Orth, R.; Schellekens, J. Global evaluation of runoff from ten state-of-the-art hydrological models. *Hydrol. Earth Sys. Sci.* **2017**, *21*, 2881–2903. [\[CrossRef\]](#)
5. Hawkins, R.H.; Theurer, F.D.; Rezaeianzadeh, M. Understanding the basis of the curve number method for watershed models and TMDLs. *J. Hydrol. Eng.* **2019**, *24*, 06019003. [\[CrossRef\]](#)
6. Ling, L.; Yusop, Z.; Chow, M.F. Urban flood depth estimate with a new calibrated curve number runoff prediction model. *IEEE Access* **2020**, *8*, 10915–10923. [\[CrossRef\]](#)
7. Pandit, A.; Heck, H.H. Estimations of soil conservation service curve numbers for concrete and asphalt. *J. Hydrol. Eng.* **2009**, *14*, 335–345. [\[CrossRef\]](#)
8. Stewart, D.; Canfield, E.; Hawkins, R. Curve number determination methods and uncertainty in hydrologic soil groups from semiarid watershed data. *J. Hydrol. Eng.* **2012**, *17*, 1180–1187. [\[CrossRef\]](#)

9. Tedela, N.H.; McCutcheon, S.C.; Rasmussen, T.C.; Hawkins, R.H.; Swank, W.T.; Campbell, J.L.; Adams, M.B.; Jackson, C.R.; Tollner, E.W. Runoff curve numbers for 10 small forested watersheds in the mountains of the eastern United States. *J. Hydrol. Eng.* **2012**, *17*, 1188–1198. [\[CrossRef\]](#)
10. Ajmal, M.; Waseem, M.; Ahn, J.-H.; Kim, T.-W. Runoff estimation using the NRCS slope-adjusted curve number in mountainous watersheds. *J. Irrig. Drain. Eng.* **2016**, *142*, 04016002. [\[CrossRef\]](#)
11. Fu, S.; Zhang, G.; Wang, N.; Luo, L. Initial abstraction ratio in the SCS-CN method in the Loess Plateau of China. *Trans. ASABE* **2011**, *54*, 163–169. [\[CrossRef\]](#)
12. D'Asaro, F.; Grillone, G. Empirical investigation of curve number method parameters in the Mediterranean area. *J. Hydrol. Eng.* **2012**, *17*, 1141–1152. [\[CrossRef\]](#)
13. D'Asaro, F.; Grillone, G.; Hawkins, R.H. Curve number: Empirical evaluation and comparison with curve number handbook tables in Sicily. *J. Hydrol. Eng.* **2014**, *19*, 04014035. [\[CrossRef\]](#)
14. Singh, P.K.; Mishra, S.K.; Berndtsson, R.; Jain, M.K.; Pandey, R.P. Development of a modified SMA based MSCS-CN model for runoff estimation. *Water Res. Manag.* **2015**, *29*, 4111–4127. [\[CrossRef\]](#)
15. Ajmal, M.; Kim, T.-W. Quantifying excess stormwater using SCS-CN-based rainfall runoff models and different curve number determination methods. *J. Irrig. Drain. Eng.* **2015**, *141*, 04014058. [\[CrossRef\]](#)
16. Baltas, E.; Dervos, N.; Mimikou, M. Determination of the SCS initial abstraction ratio in an experimental watershed in Greece. *Hydrol. Earth Sys. Sci.* **2007**, *11*, 1825–1829. [\[CrossRef\]](#)
17. Sharpley, A.; Williams, J. *Epic—Erosion/Productivity Impact Calculator: I. Model Documentation. II: User Manual*; Technical Bulletin, No. 1768 1990; United State Department of Agriculture: Washington, DC, USA, 1990.
18. Williams, J.R.; Izaurralde, R.C.; Steglich, E.M. Agricultural policy/environmental extender model. *Theor. Doc. Version* **2008**, *604*, 2008–2017.
19. Huang, M.; Gallichand, J.; Wang, Z.; Goulet, M. A modification to the soil conservation service curve number method for steep slopes in the Loess Plateau of China. *Hydrol. Process.* **2006**, *20*, 579–589. [\[CrossRef\]](#)
20. Deshmukh, D.S.; Chaube, U.C.; Hailu, A.E.; Gudeta, D.A.; Kassa, M.T. Estimation and comparison of curve numbers based on dynamic land use land cover change, observed rainfall-runoff data and land slope. *J. Hydrol.* **2013**, *492*, 89–101. [\[CrossRef\]](#)
21. Ebrahimian, M.; Nuruddin, A.A.B.; Soom, M.A.B.M.; Sood, A.M.; Neng, L.J. Runoff estimation in steep slope watershed with standard and slope-adjusted curve number methods. *Pol. J. Environ. Stud.* **2012**, *21*, 1191–1202.
22. Mishra, S.K.; Chaudhary, A.; Shrestha, R.K.; Pandey, A.; Lal, M. Experimental verification of the effect of slope and land use on scs runoff curve number. *Water Res. Manag.* **2014**, *28*, 3407–3416. [\[CrossRef\]](#)
23. Williams, J.; Izaurralde, R. The APEX model. In *Watershed Models*; CRC Press: Boca Raton, FL, USA, 2005.
24. Williams, J.; Kannan, N.; Wang, X.; Santhi, C.; Arnold, J. Evolution of the SCS runoff curve number method and its application to continuous runoff simulation. *J. Hydrol. Eng.* **2012**, *17*, 1221–1229. [\[CrossRef\]](#)
25. Fang, H.; Cai, Q.; Chen, H.; Li, Q. Effect of rainfall regime and slope on runoff in a gullied loess region on the Loess Plateau in China. *Environ. Manag.* **2008**, *42*, 402–411. [\[CrossRef\]](#) [\[PubMed\]](#)
26. Garg, V.; Nikam, B.R.; Thakur, P.K.; Aggarwal, S. Assessment of the effect of slope on runoff potential of a watershed using NRCS-CN method. *Int. J. Hydrol. Sci.* **2013**, *3*, 141–159. [\[CrossRef\]](#)
27. Slattery, M.C.; Bryan, R.B. Hydraulic conditions for rill incision under simulated rainfall: A laboratory experiment. *Earth Surf. Process. Landf.* **1992**, *17*, 127–146. [\[CrossRef\]](#)
28. Govers, G. A field study on topographical and topsoil effects on runoff generation. *Catena* **1991**, *18*, 91–111. [\[CrossRef\]](#)
29. Fox, D.; Bryan, R.; Price, A. The influence of slope angle on final infiltration rate for interrill conditions. *Geoderma* **1997**, *80*, 181–194. [\[CrossRef\]](#)
30. Van de Giesen, N.; Stomph, T.J.; de Ridder, N. Surface runoff scale effects in west African watersheds: Modeling and management options. *Agric. Water Manag.* **2005**, *72*, 109–130. [\[CrossRef\]](#)
31. Joel, A.; Messing, I.; Seguel, O.; Casanova, M. Measurement of surface water runoff from plots of two different sizes. *Hydrol. Process.* **2002**, *16*, 1467–1478. [\[CrossRef\]](#)
32. Stomph, T.; De Ridder, N.; Steenhuis, T.; Van de Giesen, N. Scale effects of hortonian overland flow and rainfall-runoff dynamics: Laboratory validation of a process-based model. *Earth Surf. Process. Landf.* **2002**, *27*, 847–855. [\[CrossRef\]](#)
33. Esteves, M.; Lapetite, J.M. A multi-scale approach of runoff generation in a sahelian gully catchment: A case study in Niger. *Catena* **2003**, *50*, 255–271. [\[CrossRef\]](#)

34. Lal, M.; Mishra, S.; Pandey, A.; Pandey, R.; Meena, P.; Chaudhary, A.; Jha, R.K.; Shreevastava, A.K.; Kumar, Y. Evaluation of the soil conservation service curve number methodology using data from agricultural plots. *Hydrogeol. J.* **2017**, *25*, 151–167. [[CrossRef](#)]
35. Mah, M.; Douglas, L.; Ringrose-Voase, A. Effects of crust development and surface slope on erosion by rainfall. *Soil Sci.* **1992**, *154*, 37–43. [[CrossRef](#)]
36. Kowalik, T.; Walega, A. Estimation of CN parameter for small agricultural watersheds using asymptotic functions. *Water* **2015**, *7*, 939–955. [[CrossRef](#)]
37. Lian, H.; Yen, H.; Huang, C.; Feng, Q.; Qin, L.; Bashir, M.A.; Wu, S.; Zhu, A.-X.; Luo, J.; Di, H. CN-China: Revised runoff curve number by using rainfall-runoff events data in China. *Water Res.* **2020**, *177*, 115767. [[CrossRef](#)] [[PubMed](#)]
38. Qiu, L.; Im, E.-S.; Hur, J.; Shim, K.-M. Added value of very high resolution climate simulations over South Korea using WRF modeling system. *Clim. Dyn.* **2019**, *54*, 173–189. [[CrossRef](#)]
39. Isik, S.; Kalin, L.; Schoonover, J.E.; Srivastava, P.; Lockaby, B.G. Modeling effects of changing land use/cover on daily streamflow: An artificial neural network and curve number based hybrid approach. *J. Hydrol.* **2013**, *485*, 103–112. [[CrossRef](#)]
40. Mishra, S.K.; Jain, M.K.; Suresh Babu, P.; Venugopal, K.; Kaliappan, S. Comparison of AMC-dependent CN-conversion formulae. *Water Res. Manag.* **2008**, *22*, 1409–1420. [[CrossRef](#)]
41. McCutcheon, S.; Tedela, N.; Adams, M.; Swank, W.; Campbell, J.; Hawkins, R.; Dye, C. *Rainfall-Runoff Relationships for Selected Eastern us Forested Mountain Watersheds: Testing of the Curve Number Method for Flood Analysis*; West Virginia Division of Forestry: Charleston, WV, USA, 2006.
42. NRCS (Natural Resources Conservation Service). *National Engineering Handbook Section-4, Part 630, Hydrology*; NRCS: Washington, DC, USA, 2001.
43. Lal, M.; Mishra, S.K.; Pandey, A. Physical verification of the effect of land features and antecedent moisture on runoff curve number. *Catena* **2015**, *133*, 318–327. [[CrossRef](#)]
44. Moriasi, D.N.; Arnold, J.G.; Van Liew, M.W.; Bingner, R.L.; Harmel, R.D.; Veith, T.L. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. *Trans. ASABE* **2007**, *50*, 885–900. [[CrossRef](#)]
45. Ritter, A.; Muñoz-Carpena, R. Performance evaluation of hydrological models: Statistical significance for reducing subjectivity in goodness-of-fit assessments. *J. Hydrol.* **2013**, *480*, 33–45. [[CrossRef](#)]
46. Harmel, R.; Smith, P.; Migliaccio, K.; Chaubey, I.; Douglas-Mankin, K.; Benham, B.; Shukla, S.; Muñoz-Carpena, R.; Robson, B.J. Evaluating, interpreting, and communicating performance of hydrologic/water quality models considering intended use: A review and recommendations. *Environ. Model. Softw.* **2014**, *57*, 40–51. [[CrossRef](#)]
47. Van Mullem, J. Runoff and peak discharges using Green-Ampt infiltration model. *J. Hydraul. Eng.* **1991**, *117*, 354–370. [[CrossRef](#)]
48. King, K.W.; Arnold, J.; Bingner, R. Comparison of Green-Ampt and curve number methods on Goodwin Creek watershed using SWAT. *Trans. ASAE* **1999**, *42*, 919. [[CrossRef](#)]
49. Walega, A.; Salata, T. Influence of land cover data sources on estimation of direct runoff according to SCS-CN and modified SME methods. *Catena* **2019**, *172*, 232–242. [[CrossRef](#)]
50. Hawkins Richard, H. Curve Number Method: Time to Think Anew? *J. Hydrol. Eng.* **2014**, *19*, 1059. [[CrossRef](#)]
51. Soulis, K.X.; Valiantzas, J.D. Identification of the SCS-CN parameter spatial distribution using rainfall-runoff data in heterogeneous watersheds. *Water Res. Manag.* **2013**, *27*, 1737–1749. [[CrossRef](#)]
52. Soulis, K.X. Estimation of SCS curve number variation following forest fires. *Hydrol. Sci. J.* **2018**, *63*, 1332–1346. [[CrossRef](#)]



Description

A sediment basin is a temporary pond built on a construction site to capture eroded or disturbed soil transported in storm runoff prior to discharge from the site. Sediment basins are designed to capture site runoff and slowly release it to allow time for settling of sediment prior to discharge. Sediment basins are often constructed in locations that will later be modified to serve as post-construction stormwater basins.



Photograph SB-1. Sediment basin at the toe of a slope. Photo courtesy of WWE.

Appropriate Uses

Most large construction sites (typically greater than 2 acres) will require one or more sediment basins for effective management of construction site runoff. On linear construction projects, sediment basins may be impractical; instead, sediment traps or other combinations of BMPs may be more appropriate.

Sediment basins should not be used as stand-alone sediment controls. Erosion and other sediment controls should also be implemented upstream.

When feasible, the sediment basin should be installed in the same location where a permanent post-construction detention pond will be located.

Design and Installation

The design procedure for a sediment basin includes these steps:

- **Basin Storage Volume:** Provide a storage volume of at least 3,600 cubic feet per acre of drainage area. To the extent practical, undisturbed and/or off-site areas should be diverted around sediment basins to prevent “clean” runoff from mixing with runoff from disturbed areas. For undisturbed areas (both on-site and off-site) that cannot be diverted around the sediment basin, provide a minimum of 500 ft³/acre of storage for undeveloped (but stable) off-site areas in addition to the 3,600 ft³/acre for disturbed areas. For stable, developed areas that cannot be diverted around the sediment basin, storage volume requirements are summarized in Table SB-1.
- **Basin Geometry:** Design basin with a minimum length-to-width ratio of 2:1 (L:W). If this cannot be achieved because of site space constraints, baffling may be required to extend the effective distance between the inflow point(s) and the outlet to minimize short-circuiting.
- **Dam Embankment:** It is recommended that embankment slopes be 4:1 (H:V) or flatter and no steeper than 3:1 (H:V) in any location.

Sediment Basins	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

- **Inflow Structure:** For concentrated flow entering the basin, provide energy dissipation at the point of inflow.

Table SB-1. Additional Volume Requirements for Undisturbed and Developed Tributary Areas Draining through Sediment Basins

Imperviousness (%)	Additional Storage Volume (ft³) Per Acre of Tributary Area
Undeveloped	500
10	800
20	1230
30	1600
40	2030
50	2470
60	2980
70	3560
80	4360
90	5300
100	6460

- **Outlet Works:** The outlet pipe shall extend through the embankment at a minimum slope of 0.5 percent. Outlet works can be designed using one of the following approaches:
 - **Riser Pipe (Simplified Detail):** Detail SB-1 provides a simplified design for basins treating no more than 15 acres.
 - **Orifice Plate or Riser Pipe:** Follow the design criteria for Full Spectrum Detention outlets in the EDB Fact Sheet provided in Chapter 4 of this manual for sizing of outlet perforations with an emptying time of approximately 72 hours. In lieu of the trash rack, pack uniformly sized 1½ - to 2-inch gravel in front of the plate or surrounding the riser pipe. This gravel will need to be cleaned out frequently during the construction period as sediment accumulates within it. The gravel pack will need to be removed and disposed of following construction to reclaim the basin for use as a permanent detention facility. If the basin will be used as a permanent extended detention basin for the site, a trash rack will need to be installed once contributing drainage areas have been stabilized and the gravel pack and accumulated sediment have been removed.
 - **Floating Skimmer:** If a floating skimmer is used, install it using manufacturer's recommendations. Illustration SB-1 provides an illustration of a Faircloth Skimmer Floating Outlet™, one of the more commonly used floating skimmer outlets. A skimmer should be designed to release the design volume in no less than 48 hours. The use of a floating skimmer outlet can increase the sediment capture efficiency of a basin significantly. A floating outlet continually decants cleanest water off the surface of the pond and releases cleaner water than would discharge from a perforated riser pipe or plate.

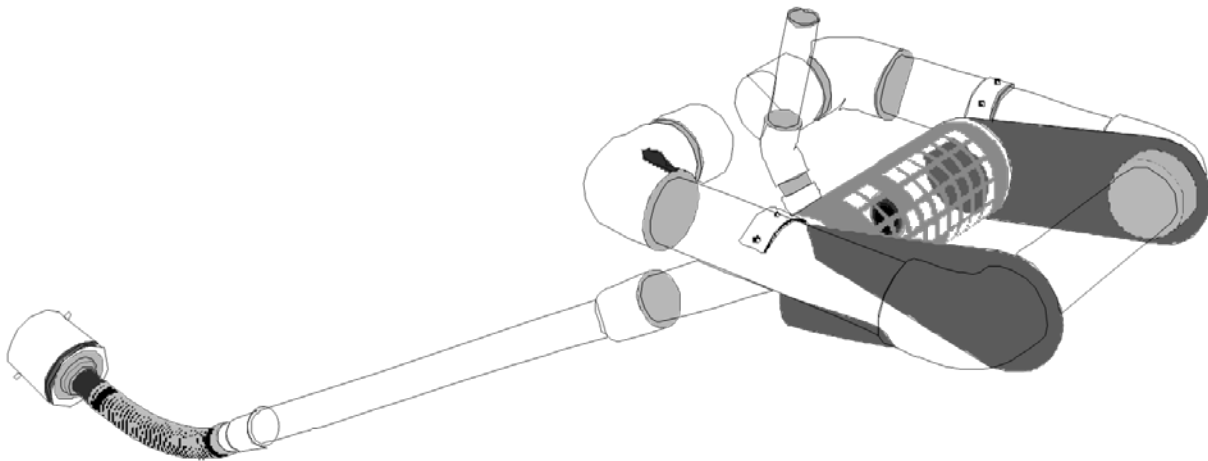


Illustration SB-1. Outlet structure for a temporary sediment basin - Faircloth Skimmer Floating Outlet. Illustration courtesy of J. W. Faircloth & Sons, Inc., FairclothSkimmer.com.

- **Outlet Protection and Spillway:** Consider all flow paths for runoff leaving the basin, including protection at the typical point of discharge as well as overtopping.
 - **Outlet Protection:** Outlet protection should be provided where the velocity of flow will exceed the maximum permissible velocity of the material of the waterway into which discharge occurs. This may require the use of a riprap apron at the outlet location and/or other measures to keep the waterway from eroding.
 - **Emergency Spillway:** Provide a stabilized emergency overflow spillway for rainstorms that exceed the capacity of the sediment basin volume and its outlet. Protect basin embankments from erosion and overtopping. If the sediment basin will be converted to a permanent detention basin, design and construct the emergency spillway(s) as required for the permanent facility. If the sediment basin will not become a permanent detention basin, it may be possible to substitute a heavy polyvinyl membrane or properly bedded rock cover to line the spillway and downstream embankment, depending on the height, slope, and width of the embankments.

Maintenance and Removal

Maintenance activities include the following:

- Dredge sediment from the basin, as needed to maintain BMP effectiveness, typically when the design storage volume is no more than one-third filled with sediment.
- Inspect the sediment basin embankments for stability and seepage.
- Inspect the inlet and outlet of the basin, repair damage, and remove debris. Remove, clean and replace the gravel around the outlet on a regular basis to remove the accumulated sediment within it and keep the outlet functioning.
- Be aware that removal of a sediment basin may require dewatering and associated permit requirements.
- Do not remove a sediment basin until the upstream area has been stabilized with vegetation.

Final disposition of the sediment basin depends on whether the basin will be converted to a permanent post-construction stormwater basin or whether the basin area will be returned to grade. For basins being converted to permanent detention basins, remove accumulated sediment and reconfigure the basin and outlet to meet the requirements of the final design for the detention facility. If the sediment basin is not to be used as a permanent detention facility, fill the excavated area with soil and stabilize with vegetation.

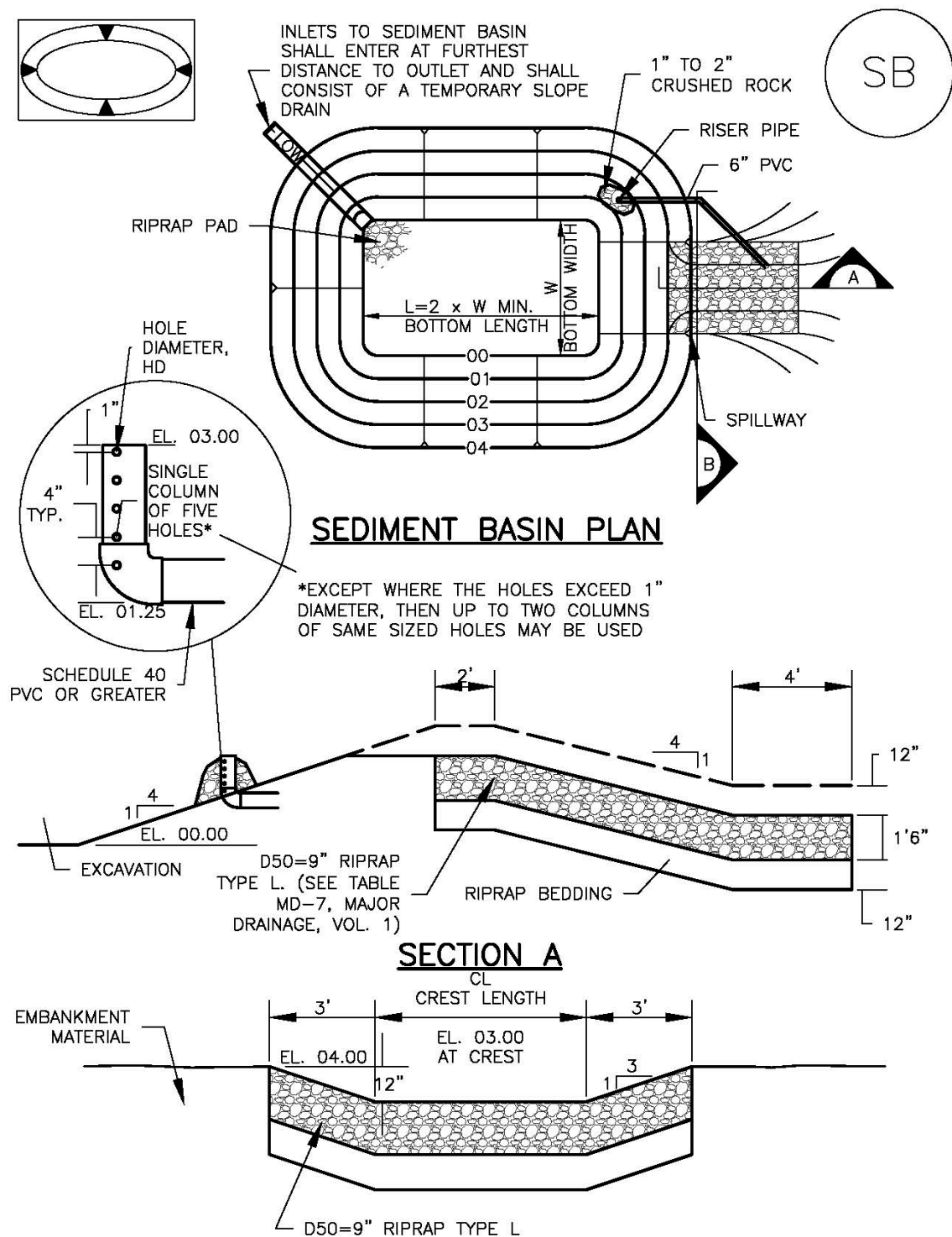


TABLE SB-1. SIZING INFORMATION FOR STANDARD SEDIMENT BASIN			
Upstream Drainage Area (rounded to nearest acre), (ac)	Basin Bottom Width (W), (ft)	Spillway Crest Length (CL), (ft)	Hole Diameter (HD), (in)
1	12 ½	2	9/32
2	21	3	13/16
3	28	5	½
4	33 ½	6	9/8
5	38 ½	8	2 1/32
6	43	9	2 1/32
7	47 ¼	11	2 5/32
8	51	12	2 7/32
9	55	13	7/8
10	58 ¼	15	1 5/16
11	61	16	3 1/32
12	64	18	1
13	67 ½	19	1 1/16
14	70 ½	21	1 1/8
15	73 ¼	22	1 3/16

SEDIMENT BASIN INSTALLATION NOTES

- SEE PLAN VIEW FOR:
 - LOCATION OF SEDIMENT BASIN.
 - TYPE OF BASIN (STANDARD BASIN OR NONSTANDARD BASIN).
 - FOR STANDARD BASIN, BOTTOM WIDTH W, CREST LENGTH CL, AND HOLE DIAMETER, HD.
 - FOR NONSTANDARD BASIN, SEE CONSTRUCTION DRAWINGS FOR DESIGN OF BASIN INCLUDING RISER HEIGHT H, NUMBER OF COLUMNS N, HOLE DIAMETER HD AND PIPE DIAMETER D.
- FOR STANDARD BASIN, BOTTOM DIMENSION MAY BE MODIFIED AS LONG AS BOTTOM AREA IS NOT REDUCED.
- SEDIMENT BASINS SHALL BE INSTALLED PRIOR TO ANY OTHER LAND-DISTURBING ACTIVITY THAT RELIES ON ON BASINS AS AS A STORMWATER CONTROL.
- EMBANKMENT MATERIAL SHALL CONSIST OF SOIL FREE OF DEBRIS, ORGANIC MATERIAL, AND ROCKS OR CONCRETE GREATER THAN 3 INCHES AND SHALL HAVE A MINIMUM OF 15 PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE.
- EMBANKMENT MATERIAL SHALL BE COMPACTED TO AT LEAST 95 PERCENT OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698.
- PIPE SCH 40 OR GREATER SHALL BE USED.
- THE DETAILS SHOWN ON THESE SHEETS PERTAIN TO STANDARD SEDIMENT BASIN(S) FOR DRAINAGE AREAS LESS THAN 15 ACRES. SEE CONSTRUCTION DRAWINGS FOR EMBANKMENT, STORAGE VOLUME, SPILLWAY, OUTLET, AND OUTLET PROTECTION DETAILS FOR ANY SEDIMENT BASIN(S) THAT HAVE BEEN INDIVIDUALLY DESIGNED FOR DRAINAGE AREAS LARGER THAN 15 ACRES.

SEDIMENT BASIN MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.
2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.
3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.
4. SEDIMENT ACCUMULATED IN BASIN SHALL BE REMOVED AS NEEDED TO MAINTAIN BMP EFFECTIVENESS, TYPICALLY WHEN SEDIMENT DEPTH REACHES ONE FOOT (I.E., TWO FEET BELOW THE SPILLWAY CREST).
5. SEDIMENT BASINS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS ACCEPTED BY THE LOCAL JURISDICTION.
6. WHEN SEDIMENT BASINS ARE REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

APPENDIX F

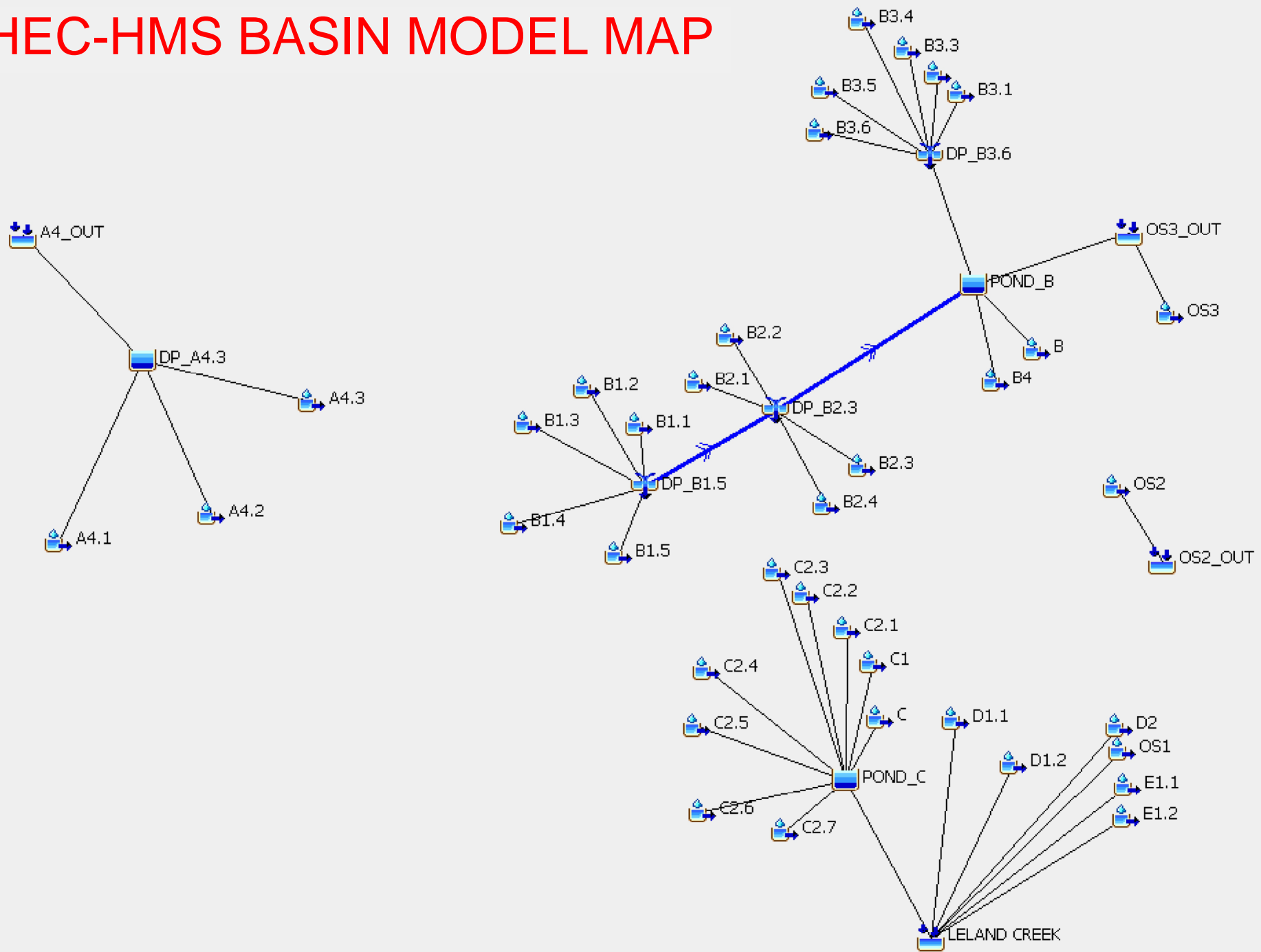
DRAINAGE MAPS

HEC-HMS Basin Model Map

HEC-HMS Map

Proposed Drainage Map

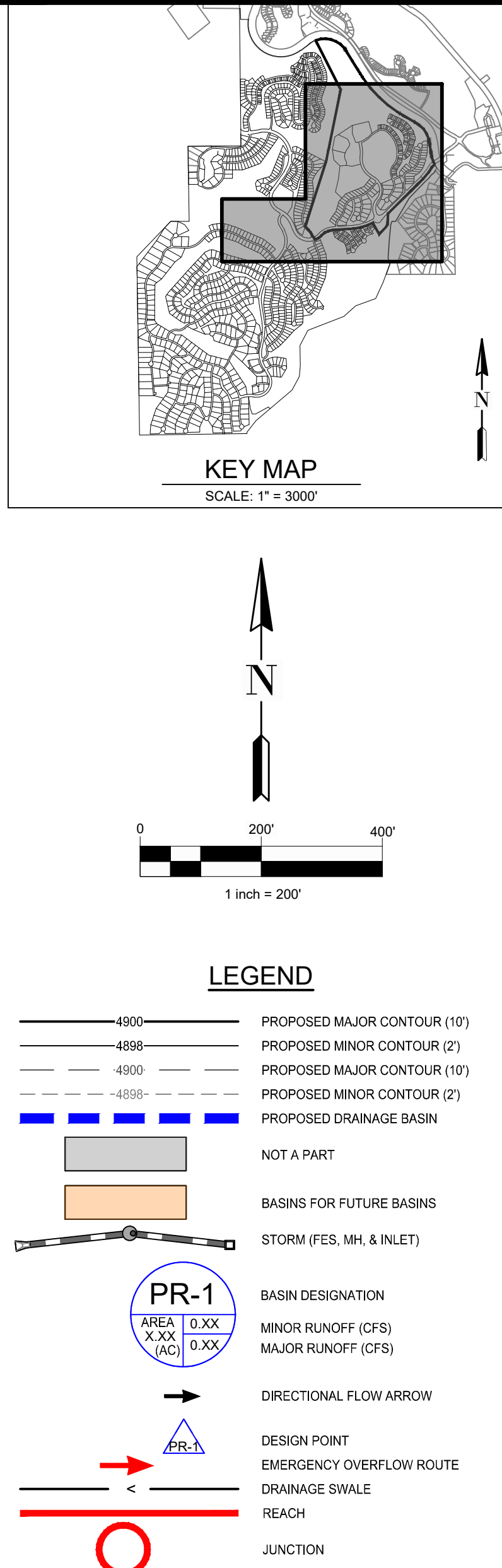
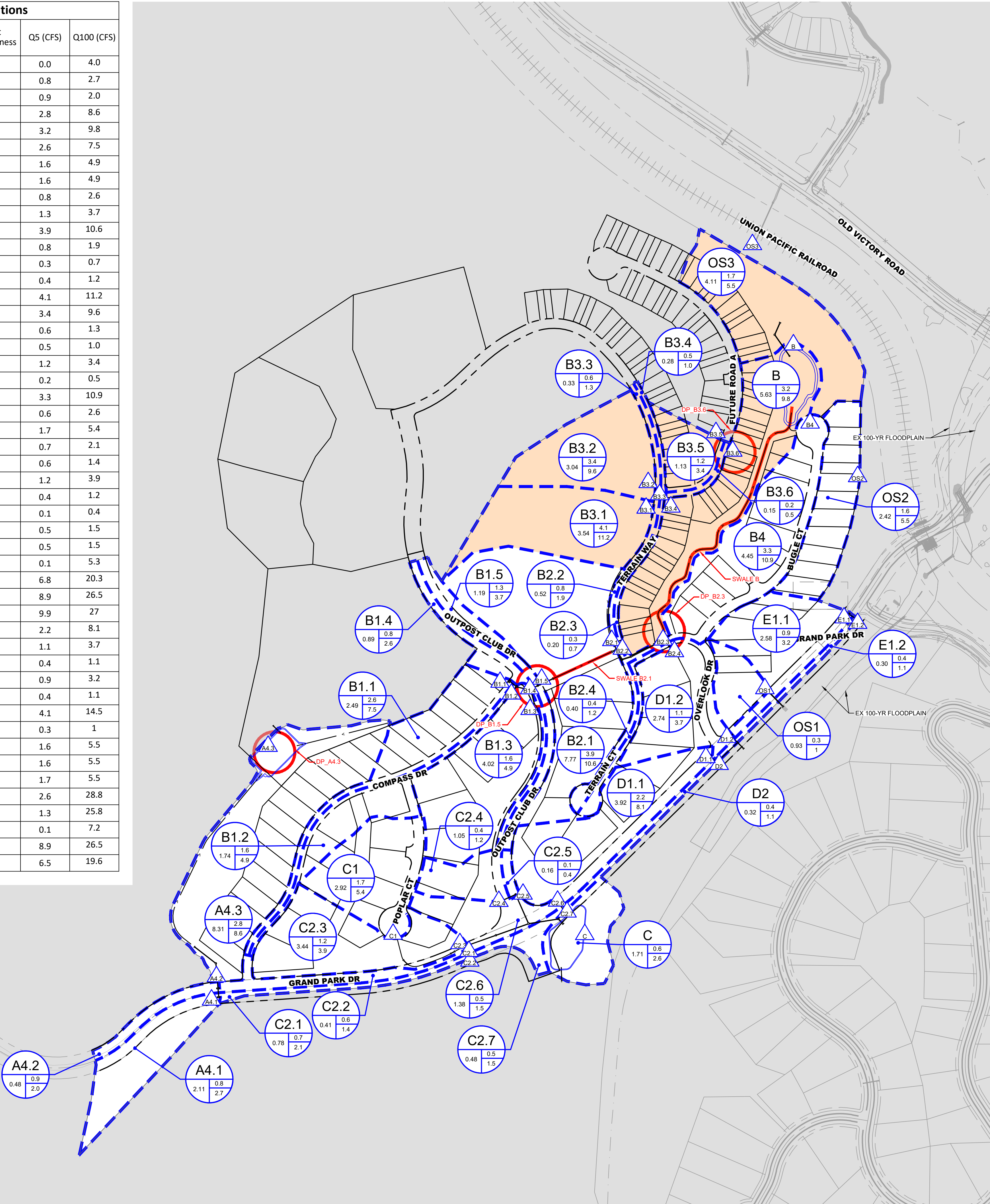
HEC-HMS BASIN MODEL MAP



1/3/2026 3:01 PM, X:\GRAND PARK\DOCUMENTS\REPORTS\DRAINAGE\1611-FILING 1-SWIF-DRAINAGE MAPS-PROPOSED HEC-HMS MAP.DWG 1

Existing Conditions				
Element	Area (Ac)	Percent Imperviousness	Q5 (CFS)	Q100 (CFS)
A4_OUT	-	-	2.8	9.3
A4.1	2.11	5%	0.5	1.9
A4.2	0.48	5%	0.2	0.9
A4.3	7.33	5%	2.2	7.2
B	5.63	5%	2.1	7.4
B1.1	2.49	5%	1.2	4.7
B1.2	1.74	5%	0.7	3.0
B1.3	4.02	5%	1.1	3.8
B1.4	0.89	5%	0.4	1.6
B1.5	1.19	5%	0.5	2.0
B2.1	7.77	5%	1.9	6.4
B2.2	0.52	5%	0.2	0.8
B2.3	0.20	5%	0.1	0.3
B2.4	0.40	5%	0.1	0.6
B3.1	3.54	5%	1.6	6.3
B3.2	3.04	5%	1.3	5.2
B3.3	0.33	5%	0.2	0.6
B3.4	0.28	5%	0.1	0.5
B3.5	1.13	5%	0.7	2.5
B3.6	0.15	5%	0.1	0.3
B4	4.45	5%	1.6	6.9
C	1.71	5%	0.6	2.6
C1	2.92	5%	1.0	3.6
C2.1	0.78	5%	0.3	1.3
C2.2	0.41	5%	0.2	0.7
C2.3	3.44	5%	0.9	3.0
C2.4	1.05	5%	0.3	0.9
C2.5	0.16	5%	0.0	0.2
C2.6	1.38	5%	0.3	1.1
C2.7	0.48	5%	0.2	0.8
DP_A4.3	-	-	3.3	11.4
DP_B1.5	-	-	3.1	12.4
DP_B2.3	-	-	5.0	15.1
DP_B3.6	-	-	3.9	15.4
D1.1	3.92	5%	1.4	5.9
D1.2	2.74	5%	0.6	2.5
D2	0.32	5%	0.1	0.5
E1.1	2.58	5%	0.6	2.3
E1.2	0.30	5%	0.1	0.5
LELAND CREEK	-	-	5.6	20
OS1	0.93	5%	0.2	0.9
OS2	2.42	5%	0.8	3.4
OS2_OUT	-	-	0.8	3.4
OS3	4.11	5%	1.5	4.9
OS3_OUT	-	-	11.5	40.8
POND_B	-	-	10.1	37
POND_C	-	-	3.1	10.6
SWALE B	-	-	5.0	15.1
SWALE B2.1	-	-	2.9	11.8

Proposed Conditions				
Element	Area (Ac)	Percent Imperviousness	Q5 (CFS)	Q100 (CFS)
A4_OUT	-	-	0.0	4.0
A4.1	2.11	42.8%	0.8	2.7
A4.2	0.48	95.0%	0.9	2.0
A4.3	7.33	32.0%	2.8	8.6
B	5.63	47.0%	3.2	9.8
B1.1	2.49	64.8%	2.6	7.5
B1.2	1.74	51.6%	1.6	4.9
B1.3	4.02	25.6%	1.6	4.9
B1.4	0.89	61.6%	0.8	2.6
B1.5	1.19	70.6%	1.3	3.7
B2.1	7.77	55.7%	3.9	10.6
B2.2	0.52	87.3%	0.8	1.9
B2.3	0.20	86.0%	0.3	0.7
B2.4	0.40	77.0%	0.4	1.2
B3.1	3.54	70.0%	4.1	11.2
B3.2	3.04	70.0%	3.4	9.6
B3.3	0.33	95.0%	0.6	1.3
B3.4	0.28	95.0%	0.5	1.0
B3.5	1.13	52.0%	1.2	3.4
B3.6	0.15	95.0%	0.2	0.5
B4	4.45	54.7%	3.3	10.9
C	1.71	11.7%	0.6	2.6
C1	2.92	39.7%	1.7	5.4
C2.1	0.78	57.8%	0.7	2.1
C2.2	0.41	84.7%	0.6	1.4
C2.3	3.44	25.4%	1.2	3.9
C2.4	1.05	30.1%	0.4	1.2
C2.5	0.16	75.4%	0.1	0.4
C2.6	1.38	34.5%	0.5	1.5
C2.7	0.48	70.3%	0.5	1.5
DP_A4.3	-	-	0.1	5.3
DP_B1.5	-	-	6.8	20.3
DP_B2.3	-	-	8.9	26.5
DP_B3.6	-	-	9.9	27
D1.1	3.92	30.2%	2.2	8.1
D1.2	2.74	36.5%	1.1	3.7
D2	0.32	79.4%	0.4	1.1
E1.1	2.58	40.3%	0.9	3.2
E1.2	0.30	79.1%	0.4	1.1
LELAND CREEK	-	-	4.1	14.5
OS1	0.93	19.5%	0.3	1
OS2	2.42	55.0%	1.6	5.5
OS2_OUT	-	-	1.6	5.5
OS3	4.11	22.6%	1.7	5.5
OS3_OUT	-	-	2.6	28.8
POND_B	-	-	1.3	25.8
POND_C	-	-	0.1	7.2
SWALE B	-	-	8.9	26.5
SWALE B2.1	-	-	6.5	19.6



terraccina
design

td

10200 E. Grand Ave. A-314
Denver, CO 80231
PH: 303.652.8667

BY

DATE

1

01/16/2026

1ST SUBMITTAL

#

REVISION DESCRIPTION

1

1ST SUBMITTAL

NOT FOR
CONSTRUCTION

GRAND PARK - WEST MOUNTAIN - FILING 1 - 10W

TOWN OF FRASER, COLORADO

PHASE III DRAINAGE REPORT

HEC-HMS DRAINAGE MAP

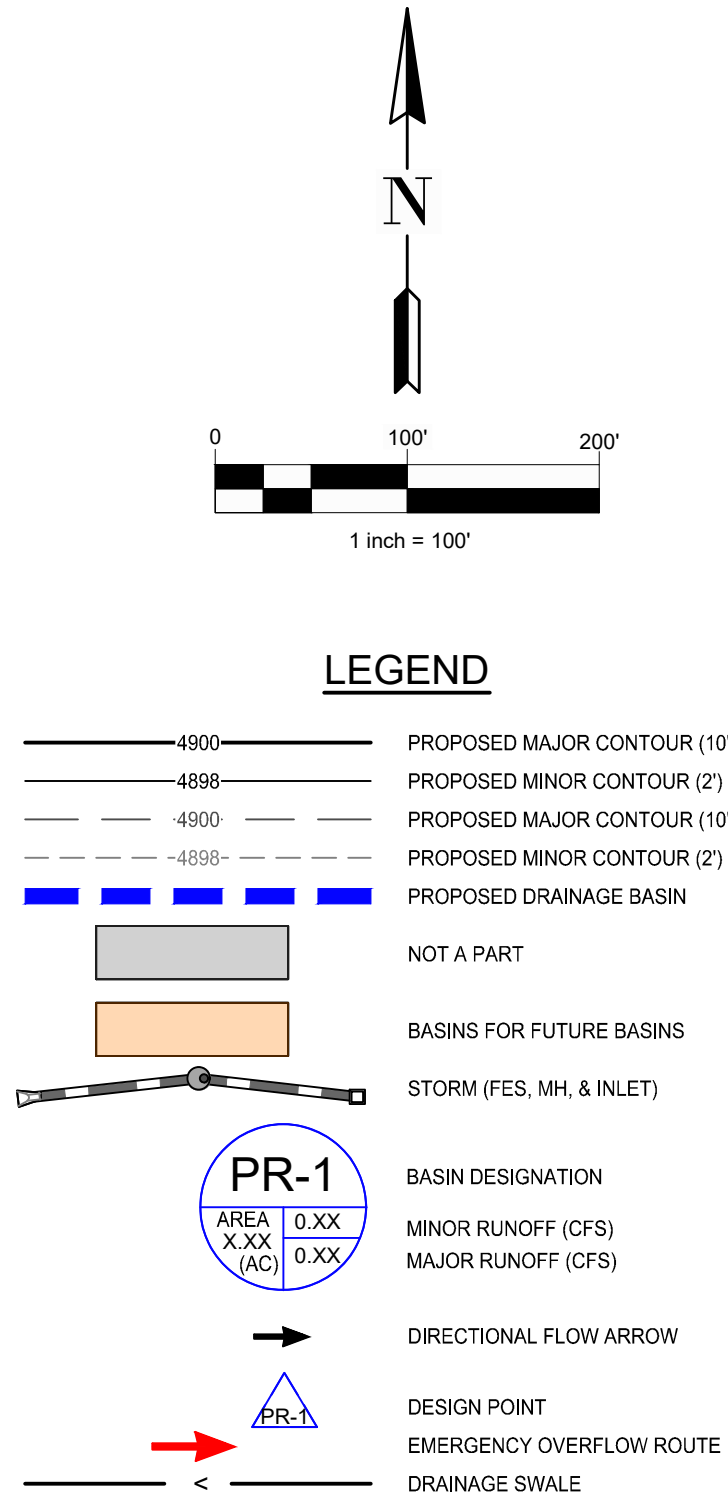
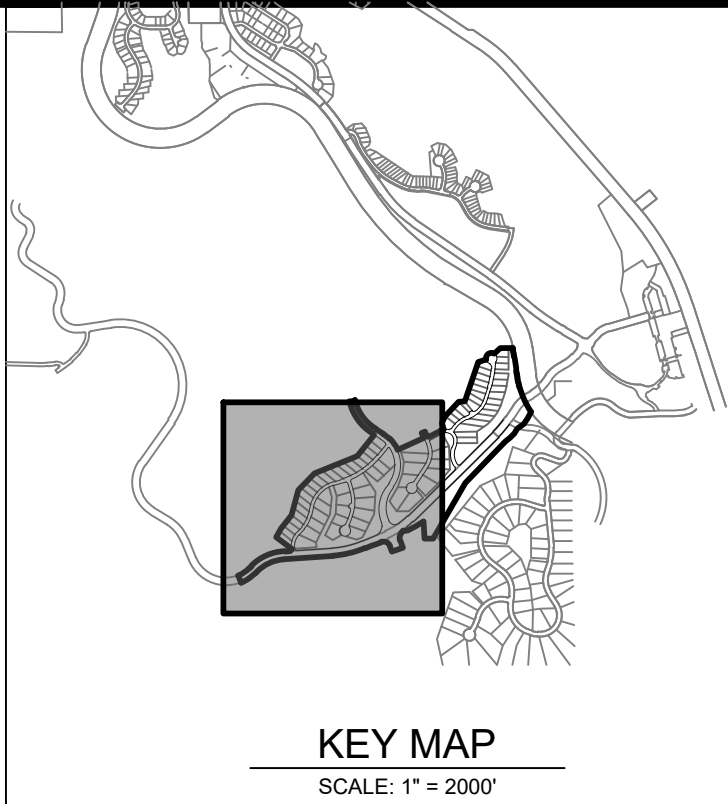
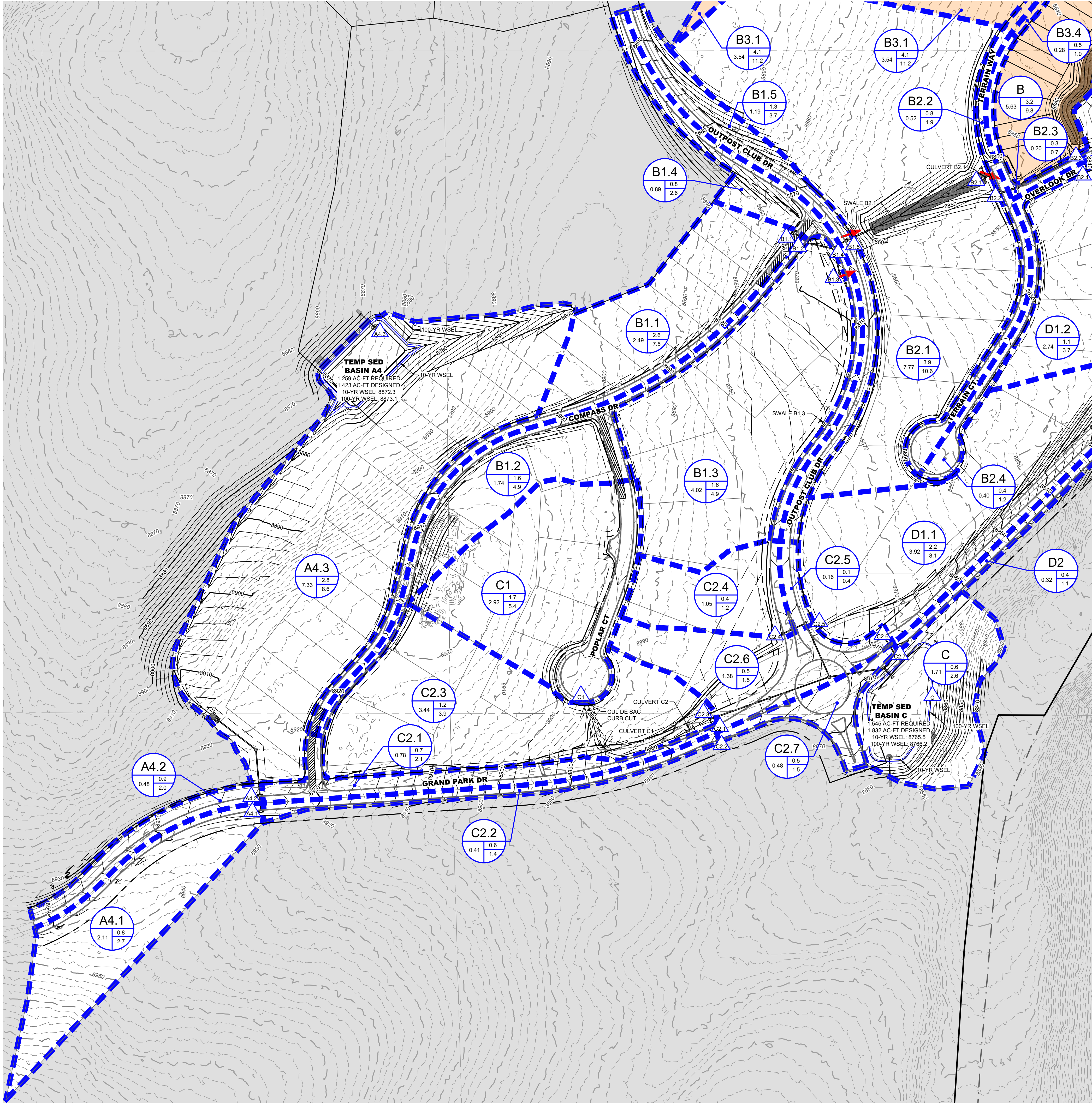
Know what's below.
Call before you dig.

811

1/3/2026 3:02 PM, X:\GRAND PARK\DOCUMENTS\REPORTS\DRAINAGE\16-1- FILING 1- SWF- DRNAGE MAPS, PROPOSED DRAINAGE MAP DWG 2

EXISTING RUNOFF SUMMARY TABLE					
BASIN ID	DESIGN POINT	BASIN AREA (AC)	IMPERVIOUSNESS (%)	5-YEAR RUNOFF (CFS)	100-YEAR RUNOFF (CFS)
A4.1	A4.1	2.11	5.0%	0.5	1.9
A4.2	A4.2	0.48	5.0%	0.2	0.9
A4.3	A4.3	7.33	5.0%	2.2	7.2
B	B	5.63	5.0%	2.1	7.4
B1.1	B1.1	2.49	5.0%	1.2	4.7
B1.2	B1.2	1.74	5.0%	0.7	3.0
B1.3	B1.3	4.02	5.0%	1.1	3.8
B1.4	B1.4	0.89	5.0%	0.4	1.6
B1.5	B1.5	1.19	5.0%	0.5	2.0
B2.1	B2.1	7.77	5.0%	1.9	6.4
B2.2	B2.2	0.52	5.0%	0.2	0.8
B2.3	B2.3	0.20	5.0%	0.1	0.3
B2.4	B2.4	0.40	5.0%	0.1	0.6
B3.1	B3.1	3.54	5.0%	1.6	6.3
B3.3	B3.3	0.33	5.0%	0.2	0.6
B3.4	B3.4	0.28	5.0%	0.1	0.5
B4	B4	4.45	5.0%	1.6	6.9
C	C	1.71	5.0%	0.6	2.6
C1	C1	2.92	5.0%	1.0	3.6
C2.1	C2.1	0.78	5.0%	0.3	1.3
C2.2	C2.2	0.41	5.0%	0.2	0.7
C2.3	C2.3	3.44	5.0%	0.9	3.0
C2.4	C2.4	1.05	5.0%	0.3	0.9
C2.5	C2.5	0.16	5.0%	0.0	0.2
C2.6	C2.6	1.38	5.0%	0.3	1.1
C2.7	C2.7	0.48	5.0%	0.2	0.8
D1.1	D1.1	3.92	5.0%	1.4	5.9
D1.2	D1.2	2.74	5.0%	0.6	2.5

PROPOSED RUNOFF SUMMARY TABLE					
BASIN ID	DESIGN POINT	BASIN AREA (AC)	IMPERVIOUSNESS (%)	5-YEAR RUNOFF (CFS)	100-YEAR RUNOFF (CFS)
A4.1	A4.1	2.11	42.8%	0.8	2.7
A4.2	A4.2	0.48	95.0%	0.9	2.0
A4.3	A4.3	7.33	32.0%	2.8	8.6
B	B	5.63	47.0%	3.2	9.8
B1.1	B1.1	2.49	64.8%	2.6	7.5
B1.2	B1.2	1.74	51.6%	1.6	4.9
B1.3	B1.3	4.02	25.6%	1.6	4.9
B1.4	B1.4	0.89	61.6%	0.8	2.6
B1.5	B1.5	1.19	70.6%	1.3	3.7
B2.1	B2.1	7.77	55.7%	3.9	10.6
B2.2	B2.2	0.52	87.3%	0.8	1.9
B2.3	B2.3	0.20	86.0%	0.3	0.7
B2.4	B2.4	0.40	77.0%	0.4	1.2
B3.1	B3.1	3.54	70.0%	4.1	11.2
B3.3	B3.3	0.33	95.0%	0.6	1.3
B3.4	B3.4	0.28	95.0%	0.5	1.0
B4	B4	4.45	54.7%	3.3	10.9
C	C	1.71	11.7%	0.6	2.6
C1	C1	2.92	39.7%	1.7	5.4
C2.1	C2.1	0.78	57.8%	0.7	2.1
C2.2	C2.2	0.41	84.7%	0.6	1.4
C2.3	C2.3	3.44	25.4%	1.2	3.9
C2.4	C2.4	1.05	30.1%	0.4	1.2
C2.5	C2.5	0.16	75.4%	0.1	0.4
C2.6	C2.6	1.38	34.5%	0.5	1.5
C2.7	C2.7	0.48	70.3%	0.5	1.5
D1.1	D1.1	3.92	30.2%	2.2	8.1
D1.2	D1.2	2.74	36.5%	1.1	3.7



1/30/2026 3:04 PM, X:\GRAND PARK\DOCUMENTS\REPORTS\DRAINAGE\16-1 - FILING 1 - SWF - 10W - 11\PHASE 3 - 10WF - DRAINAGE MAPS - PROPOSED DRAINAGE MAP.DWG 3

EXISTING RUNOFF SUMMARY TABLE					
BASIN ID	DESIGN POINT	BASIN AREA (AC)	IMPERVIOUSNESS (%)	5-YEAR RUNOFF (CFS)	100-YEAR RUNOFF (CFS)
A4.3	A4.3	7.33	5.0%	2.2	7.2
B	B	5.63	5.0%	2.1	7.4
B1.1	B1.1	2.49	5.0%	1.2	4.7
B1.2	B1.2	1.74	5.0%	0.7	3.0
B1.3	B1.3	4.02	5.0%	1.1	3.8
B1.4	B1.4	0.89	5.0%	0.4	1.6
B1.5	B1.5	1.19	5.0%	0.5	2.0
B2.1	B2.1	7.77	5.0%	1.9	6.4
B2.2	B2.2	0.52	5.0%	0.2	0.8
B2.3	B2.3	0.20	5.0%	0.1	0.3
B2.4	B2.4	0.40	5.0%	0.1	0.6
B3.1	B3.1	3.54	5.0%	1.6	6.3
B3.2	B3.2	3.04	5.0%	1.3	5.2
B3.3	B3.3	0.33	5.0%	0.2	0.6
B3.4	B3.4	0.28	5.0%	0.1	0.5
B3.5	B3.5	1.13	5.0%	0.7	2.5
B3.6	B3.6	0.15	5.0%	0.1	0.3
B4	B4	4.45	5.0%	1.6	6.9
D1.1	D1.1	3.92	5.0%	1.4	5.9
D1.2	D1.2	2.74	5.0%	0.6	2.5
D2	D2	0.32	5.0%	0.1	0.5
E1.1	E1.1	2.58	5.0%	0.6	2.3
E1.2	E1.2	0.30	5.0%	0.1	0.5
OS1	OS1	0.93	5.0%	0.2	0.9
OS2	OS2	2.42	5.0%	0.8	3.4
OS3	OS3	4.11	5.0%	1.5	4.9

PROPOSED RUNOFF SUMMARY TABLE					
BASIN ID	DESIGN POINT	BASIN AREA (AC)	IMPERVIOUSNESS (%)	5-YEAR RUNOFF (CFS)	100-YEAR RUNOFF (CFS)
A4.3	A4.3	7.33	32.0%	2.8	8.6
B	B	5.63	47.0%	3.2	9.8
B1.1	B1.1	2.49	64.8%	2.6	7.5
B1.2	B1.2	1.74	51.6%	1.6	4.9
B1.3	B1.3	4.02	25.6%	1.6	4.9
B1.4	B1.4	0.89	61.6%	0.8	2.6
B1.5	B1.5	1.19	70.6%	1.3	3.7
B2.1	B2.1	7.77	55.7%	3.9	10.6
B2.2	B2.2	0.52	87.3%	0.8	1.9
B2.3	B2.3	0.20	86.0%	0.3	0.7
B2.4	B2.4	0.40	77.0%	0.4	1.2
B3.1	B3.1	3.54	70.0%	4.1	11.2
B3.2	B3.2	3.04	70.0%	3.4	9.6
B3.3	B3.3	0.33	95.0%	0.6	1.3
B3.4	B3.4	0.28	95.0%	0.5	1.0
B3.5	B3.5	1.13	52.0%	1.2	3.4
B3.6	B3.6	0.15	95.0%	0.2	0.5
B4	B4	4.45	54.7%	3.3	10.9
D1.1	D1.1	3.92	30.2%	2.2	8.1
D1.2	D1.2	2.74	36.5%	1.1	3.7
D2	D2	0.32	79.4%	0.4	1.1
E1.1	E1.1	2.58	40.3%	0.9	3.2
E1.2	E1.2	0.30	79.1%	0.4	1.1
OS1	OS1	0.93	19.5%	0.3	1
OS2	OS2	2.42	55.0%	1.6	5.5
OS3	OS3	4.11	22.6%	1.7	5.5

