ATTACHMENT IV – CLOSURE PLAN

CLOSURE PLAN

Bremo Bluff FFCP Management Facility
Solid Waste Permit 627
Fluvanna County, Virginia

Prepared for:

Dominion Energy

Dominion Energy Virginia
120 Tredegar Street
Richmond, Virginia 23219

COMMONWEALTH OF VIRGINIA
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11/15/2024
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Schnabel Reference No. 22130437.031

November 2024

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ATTACHMENTS

CERTIFICATION

This Closure Plan for the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) was prepared by Schnabel Engineering (Schnabel). The document and Certification/Statement of Professional Opinion are based on and limited to information that Schnabel has relied on from Dominion Energy and others, but not independently verified.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements in the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" (CCR Rule, 40 CFR §257 Subpart D) as well as the Virginia Department of Environmental Quality's Virginia Solid Waste Management Regulations (VSWMR, 9VAC20-81).

The use of the word "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

James R. DiFrancesco	Principal / Practice Leader Solid Waste
Name	Title
	November 15, 2024
Signature	Date

1.0 PURPOSE

This Closure Plan (Plan) has been prepared for the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) located in Bremo Bluff, Virginia. The Facility will accept coal combustion residuals (CCR) previously generated at the Bremo Station (Station) and operate as a new, captive industrial landfill (CCR Unit) under the Virginia Department of Environmental Quality (DEQ) Solid Waste Permit (SWP) 627. Schnabel Engineering (Schnabel) has prepared this Plan on behalf of the Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion Energy).

The Facility is subject to the closure requirements in the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" (CCR Rule, 40 CFR §257 Subpart D) as well as the DEQ's Virginia Solid Waste Management Regulations (VSWMR, 9VAC20-81).

1.1 Closure Plan Implementation

The final cover system is designed in accordance with the requirements of both the VSWMR and the CCR Rule to lessen the need for maintenance after closure through adequate implementation of stormwater run-off controls which prevent sloughing and reduce the potential for erosion; prevent the impoundment of water and minimize hydraulic head on the liner system; and prevent exposure of the final cover components and underlying CCR wastes.

The CCR Unit will be developed per Attachment III of the Part B Permit Application (Design Plans). The total capped area of the CCR Unit will be approximately 47 acres and features infiltration barrier and drainage components to prevent water percolation into the CCR Unit and the saturation of cover soils. The maximum CCR Unit sideslope grade is 3H:1V (horizontal to vertical), with stormwater benches and tack-on berms that are designed to intercept sheet flow from the final cover before it can concentrate into an erosive flow. Vegetation will be established and maintained on the protective cover soil layer for all capped areas of the CCR Unit.

2.0 CLOSURE TIMEFRAME

The Facility is anticipated to begin placement of CCR wastes in late 2025. Based on the design capacity of 6.2 million cubic yards of net disposal, and a maximum daily intake rate of 15,000 tons per day, the estimated life of the Facility is approximately 6 years, with final closure anticipated to begin in 2031 and be completed in 2034.

Progressive slope closure activities may occur throughout the life of the CCR Unit. Generally, progressive closure activities can be initiated once a smaller area, approximately 15 to 20 acres, reaches final grades, as determined by an annual aerial or field survey. This process can be repeated until the CCR Unit reaches its final design capacity and the last area is closed with the permitted final cover system. Portions of the CCR Unit at final grades, e.g. sideslope areas, may not be ready to close prior to final closure. Once all CCR wastes from the Station are placed in the CCR Unit, the CCR Unit will be closed, making the largest potential area requiring a final cover the entire permitted disposal area, approximately 47 acres.

The implementation process for closure projects will include the following activities:

- Preparation of closure construction bid documents;

- Selection of the prime contractor and finalization of construction documents;
- Construction of the required final cover system;
- Construction and modification of ditches and drainage controls;
- Submission of the closure certification documents, and;
- Establishment of vegetation on the final cover system.

Prior to initiating final closure activities, and at least 180 days prior to beginning closure of the CCR Unit, the DEQ will be notified of the intent to close. Additionally, prior to initiating final closure activities, a notification, which shall include certification of the design of the final cover system by a qualified professional engineer licensed in the Commonwealth of Virginia, will be placed in the Facility's operating record in accordance with the CCR Rule.

Final cover construction shall be initiated when one of the following conditions apply:

- Within 30 days after the date of the known final receipt of CCR wastes.
- An additional lift of CCR wastes is not to be applied within one year, or a longer period as required by the Facility's development, as described above.
- The CCR Unit attains final elevation and within 90 days after such elevation is reached, or longer if specified in the CCR Unit's approved Closure Plan, as described above.
- Within 90 days of the CCR Unit's permit termination or denial.

Final closure should be initiated after the CCR Unit reaches final grades and be completed in accordance with this Closure Plan.

The Airspace and Life of Site Table provided in Attachment 1 contains a listing of the approximate capacity and life expectancy for the CCR Unit. Based on proposed operating conditions, the life of the CCR Unit is estimated to be 6 years.

3.0 CLOSURE OF SURFACE IMPOUNDMENTS AND LAGOONS

There are no leachate or waste treatment surface impoundments or lagoons at this Facility.

4.0 CLOSURE OF CCR UNIT

4.1 Final Cover Design

Four final cover systems are proposed for the CCR Unit; two final cover systems for the sideslope areas and two final cover systems for the top deck areas. The four proposed final cover systems satisfy the requirements under 9VAC20-81-160.D.2.e and 40 CFR §257.102(d)(3)(ii). The final cover system components for each final cover system are described, from the top down, below.

Sideslope Final Cover System Option 1 – Geomembrane with Geocomposite

- 24-inch-thick erosion layer consisting of a 6-inch-thick vegetative support layer and an 18-inch-thick protective cover soil layer
- 275-mil geocomposite
- 40-mil textured linear low-density polyethylene (LLDPE) or high-density polyethylene (HDPE) geomembrane
- Prepared and compacted subgrade of CCR or 12 inches of soil

Sideslope Final Cover System Option 2 – LLDPE MicroDrain® or Super Gripnet® Geomembrane

- 24-inch-thick erosion layer consisting of a 6-inch-thick vegetative support layer and an 18-inch-thick protective cover soil layer
- 8-ounce per square yard (oz) non-woven, heat-burnished geotextile placed with the heat-burnished side down
- 50-mil Agru MicroDrain® LLDPE geomembrane or Agru Super Gripnet® LLDPE geomembrane
- Prepared and compacted subgrade of CCR or 12 inches of soil

Top Deck Final Cover System Option 1 – Geomembrane with Geocomposite

- 24-inch-thick erosion layer consisting of a 6-inch-thick vegetative support layer and an 18-inch-thick protective cover soil layer
- 275-mil geocomposite
- 40-mil textured LLDPE or HDPE geomembrane
- Geosynthetic clay liner (GCL) with maximum permeability of 5.0×10^{-9} centimeters per second (cm/s)
- Prepared and compacted subgrade of CCR or 12 inches of soil

Top Deck Final Cover System Option 2 – LLDPE MicroDrain® Geomembrane and GCL

- 24-inch-thick erosion layer consisting of a 6-inch-thick vegetative support layer and an 18-inch-thick protective cover soil layer
- 8-oz non-woven, heat-burnished geotextile placed with the heat-burnished side down
- 50-mil Agru MicroDrain® LLDPE geomembrane
- GCL with maximum permeability of 5.0×10^{-9} cm/s
- Prepared and compacted subgrade of CCR or 12 inches of soil

Details for the final cover systems are shown in the Design Plans.

4.2 Components of the Final Cover Systems

The final cover systems consist of the following described components, which shall conform to the requirements presented in Attachment VII of the Part B Permit Application [Construction Quality Assurance (CQA) Plan and Technical Specifications].

4.2.1 Subgrade

The proposed sideslope and top deck final cover systems will be placed directly atop a prepared and compacted subgrade of CCR or 12 inches of soil meeting the requirements outlined in the Technical Specifications. The subgrade shall contain particles no larger than ½-inch in their greatest dimension, unless otherwise approved by the Engineer. The subgrade will be rolled with a smooth-drum roller to flatten out wheel ruts and protrusions that may damage the overlying geosynthetics. If CCR is not used as the subgrade, subgrade materials shall consist of soil having a USCS classification of SC, SM, ML, CL, MH, or CH.

4.2.2 Barrier Layer

The geomembrane serves as the infiltration barrier layer. The geomembranes are constructed from LLDPE or HDPE material and shall conform to the standards contained in the Technical Specifications.

Geomembrane installation shall conform to the practices outlined in the Technical Specifications and the CQA Plan.

Additionally, the top deck final cover systems include a GCL. The GCL consists of bentonite encapsulated between two stitched geosynthetic fabrics. The GCL will have a permeability less than or equal to $5x10^{-9}$ cm/s. Prior to placing the GCL, the prepared and compacted CCR or soil must be certified by the installer and Owner's Representative. Care shall be taken during installation of the GCL to prevent exposure to excessive moisture that may damage the clay material.

4.2.3 Drainage Layer

For areas being capped with the 50-mil LLDPE MicroDrain® or Super Gripnet® geomembranes, the drainage layer is incorporated within the structure of the geomembrane. These geomembranes include 130-mil drainage "studs" on the top surface, which provide drainage. The drainage studs are overlain by a heat-burnished geotextile, which provides separation and filtration from the protective cover soil layer. The geomembrane will drain into perforated drainage pipes at each bench to control the head build-up on the geomembrane liner. This collected water will not be exposed to the CCR wastes and will be collected and treated as ordinary stormwater.

Areas using the 40-mil LLDPE or HDPE geomembrane will use a 275-mil double-sided geocomposite as the drainage layer. This geocomposite will be installed on top of the textured geomembrane layer to provide drainage for the protective cover soil, as specified in the Technical Specifications. The geocomposite will prevent the cover soils from becoming saturated, which will help prevent slope failure. The geocomposite will drain into either the perimeter channel at the toe of the slope or on the drainage benches, as necessary, to control the head build-up on the geomembrane liner. This collected water will not be exposed to the CCR wastes and will be collected and treated as ordinary stormwater.

4.2.4 Erosion Layer

The 24-inch-thick erosion layer will be constructed of on-site soils and will be of a sufficient thickness to protect the underlying geosynthetics from freezing, as the maximum anticipated depth of frost penetration for central Virginia is approximately 20 inches. The bottom 18 inches of protective cover soils will be placed and compacted to at least 90% of its Standard Proctor Density, in accordance with the Technical Specifications. The upper 6 inches comprise the vegetative support layer, which will remain uncompacted to promote root development.

The erosion layer soils will consist of fine-grained loamy soils that generally exhibit some degree of plasticity and are classified as low to moderately erodible by wind and water. The calculated soil loss using the Revised Universal Soil Loss Equation (RUSLE) is 1.5 tons per acre per year for the CCR Unit.

Calculations for the RUSLE are included in Attachment 3.

4.2.5 Vegetative Support Layer

The top 6 inches of the 24-inch-thick erosion layer will be vegetative support layer soil consisting of on-site soils. This soil will be placed, but not compacted, then seeded in accordance with the Technical Specifications or with a site-specific mixture based on recommendations from a soils report. In either case, the seed mixture will consist mainly of turf-type grasses and nurse crops that will lend themselves to quickly establishing a healthy stand of grass. Woody vegetation is not allowed on the final cover system.

Established vegetation will be maintained by mowing and application of fertilizer as required to maintain a healthy stand of vegetation.

4.2.6 Erosion and Sediment Control

Erosion and Sediment Control will be performed in accordance with the current edition of the Virginia Erosion and Sediment Control Handbook (VESCH). Typically, this will involve the construction and maintenance of stormwater diversions, temporary and permanent seeding, and stone outlet protection, as shown in the Design Plans.

Vegetation will be established in accordance with the Technical Specifications to provide protection from direct raindrop erosion. Prior to seeding, the vegetative support layer will be roughened by tracking a bulldozer along the slopes providing a surface of small depressions that will aid in establishing vegetative cover and reducing run-off velocity. Until vegetation is established, mulch or temporary erosion matting, as appropriate, will be installed over the seeded surface.

Calculations for the stormwater diversion and collection system are included in Attachment 4. Erosion and sediment control details are included in the Design Plans.

4.3 Final Slopes

The maximum final design slope for the CCR Unit is 3H:1V. The minimum final grade on the top deck per the closure design is 6.5%. Stormwater diversion channels and tack-on berms are located on the sideslopes to intercept and collect sheet flow run-off before it concentrates into erosive shallow concentrated flow. The Design Plans show the proposed final grades for the CCR Unit and the design details for the stormwater management system.

Stability of the proposed slope liner system was analyzed for short- and long-term static and seismic conditions. To maintain the prescribed factors of safety, the minimum peak interface friction angle between the protective cover soils and underlying geosynthetics, as well as any material interface of the final cover system, must be at least 25.9 degrees, or equivalent shear strength as approved by the ENGINEER, as determined by ASTM D5321 at normal stresses of 500 pounds per square foot (psf), 1,000 psf, and 2,000 psf. Calculations for the veneer stability of the final cover system are provided in Attachment 2.

Staged construction may be required if the interface friction angle testing prior to construction shows any of the interfaces to be less than the required minimum and/or equivalent strength with the addition of adhesion is used as appropriate for the construction material.

4.4 Settlement, Subsidence, and Displacement

The final cover has been designed to account for settlement and subsidence. A settlement analysis, included in Attachment 2 to the Design Report, was completed to estimate the potential post-development settlement of the foundation soils below the CCR Unit. The CCR Unit cap may experience some settlement relative to base grade settlement and potential consolidation of CCR wastes. Settlement associated with base grade settlement is not anticipated to adversely affect the final cover system. Settlement associated with the consolidation of CCR wastes is expected to be minimal given the inorganic nature of compacted CCR.

Non-uniform settlement may warrant occasional regrading and/or repair to the soil layer above the cap to maintain drainage. The overall effectiveness of the geomembrane liner at minimizing liquid infiltration will not be jeopardized by non-uniform differential settlement.

4.5 Run-Off Controls

4.5.1 Stormwater Management

The stormwater control measures include drainage channels, drainage benches, slope drains, culverts, and sediment basins. Sheet flow from the final cover surface will be collected in a series of drainage benches. These benches will be constructed with soil and sized to convey the run-off from at least the 100-year, 24-hour storm event. The drainage benches will be lined with erosion control matting to resist erosion and support vegetative growth. The minimum longitudinal slope of the drainage benches is two percent. The benches will transport stormwater to slope drainpipes. The slope drains carry the stormwater to the perimeter stormwater channel, which drains through culverts to the Facility's sediment basins for attenuation and eventual discharge. Attachment 4 includes a stormwater analysis that demonstrates the capacity of the proposed stormwater drainage systems to adequately handle post-development stormwater events.

4.5.1.1 Drainage Structure Maintenance

Maintenance of the Facility's drainage structures will include routine inspections as per the Operations Plan to identify areas of erosion, undercutting, or other maintenance needs. Additional inspections may be required after large storm events to check for damage. Specific items to be inspected include:

- Culvert inlets for accumulated sediment or debris;
- Diversion benches for erosion, sediment buildup, and establishment of vegetation;
- Slope drainpipes for proper anchorage, leaking joints, undercutting;
- Vegetation in other areas for proper establishment, need of mowing;
- Perimeter stormwater channels for signs of deterioration;
- Drop inlet structures for integrity and accumulated sediment; and,
- Other temporary controls (e.g., silt fence) for proper function and sediment control.

Activities to correct or repair identified deficiencies will be initiated as soon as practicable by site operations. Additional time may be required to correct larger deficiencies or if additional drainage structure construction is required. Sediment removed from the sediment basins during maintenance or repair activities will be dewatered and used as cover soil on the CCR Unit. The level of accumulated sediment will be monitored on a regular basis through visual inspection, and the removal of accumulated sediment will be performed as necessary.

As part of final closure activities, the sediment basins serving the Facility will have accumulated sediment removed and will be removed or transitioned to permanent stormwater management ponds. Converted ponds will be left in place to provide stormwater control for the Facility after closure.

4.5.2 Contact Stormwater Management

Contact stormwater, i.e., stormwater that comes in contact with CCR wastes, will be managed separately from stormwater run-off. A dedicated collection pipe around the perimeter of the CCR Unit will convey contact stormwater run-ff to the Contact Stormwater Pond (CSWP). The CSWP will be used to collect contact stormwater before it is pumped to the Station property for treatment at a proposed, Dominion Energy-owned, permitted wastewater treatment facility prior to discharge. During the life of the CCR Unit, the CSWP will be maintained in a manner similar to the stormwater management structures, as described in the section above.

Once the CCR Unit is closed, the contact stormwater collection pipe will be flushed with non-contact stormwater or other available non-potable water to remove any accumulated CCR in the collection pipe. After flushing, the inlets to the contact stormwater collection pipe will be capped with bolted blind flanges to prohibit further use, as the collection pipe will remain in-place.

Accumulated sediments within the CSWP will be removed through a combination of using lightweight excavation equipment and a vacuum truck. Accumulated sediment will be dewatered during the excavation process and the dewatering water pumped to the Station for treatment prior to discharge. The use of absorbents and desiccant materials may be required to facilitate the removal and loading process and to ensure the removed material can be transported without release of liquids. Removed sediments will be loaded into a transfer truck and disposed of at a permitted, Dominion Energy-approved, off-site disposal facility.

After bulk accumulated sediment removal, the exposed concrete liner will be power washed with non-contact stormwater or other available non-potable water to remove residual CCR material. The wash water will be removed through pumping to the Station for treatment prior to discharge or by vacuum truck for transport and disposal off site. Additional absorbent materials may be used in the final washing of the CSWP to facilitate the final removal of residual CCR and contact water.

The CSWP will then be converted to a permanent stormwater management pond as part of final closure activities.

4.6 Inventory Removal and Disposal

Facility equipment and temporary structures used during normal operations will be removed after their usefulness ends. Lubricants, fuel, waste oil, and other residues used or generated as part of Facility operations will be managed and disposed of appropriately. Operational equipment should not require decontamination, and routine equipment maintenance will be performed to minimize the risk of contamination from lubricants or fuel oil used at the Facility.

5.0 SCHEDULE FOR CLOSURE

Final closure activities will be initiated as described in Section 2.0 of this Plan. The DEQ may approve a longer closure period if it is demonstrated that the required or planned closure activities will take longer than the regulatory 180 days to complete and that steps have been taken to eliminate any significant threat to human health and the environment. A 36-month closure period is requested under this Plan.

It is estimated that once closure activities begin, it will take two full construction seasons to complete final cover placement, with an additional construction season for any remaining decommissioning (e.g., contact water system) and site stabilization work that may need to be completed before the facility can be certified as closed. These three continuous closure construction seasons will span a total of 36 months.

A progressive closure phase may be initiated once an approximately 15- to 20-acre area reaches final permitted grades, as determined by either an annual aerial or field survey. The progressive closure construction activity for each cycle of closure is anticipated to take approximately 9 to 12 months to complete based on construction experience of similarly sized closure projects. Minimizing the exposure of CCR wastes during closure cap construction to prevent erosion from rain and wind will be accomplished by methods such as:

- Installing stormwater run-off and run-on controls such as temporary diversion berms, silt fencing, slope drains, and sediment trapping measures as required by the specific construction activity.
- Sequencing the stripping of cover and fine grading for cap construction such that it occurs during periods of favorable weather.
- Limiting exposed areas to those that can be covered with geosynthetics in a short amount of time.

6.0 CLOSURE IMPLEMENTATION

6.1 Closure Posting

One sign will be posted at the site entrance to the Facility notifying all persons of the final closure of the Facility and prohibition against further receipt of CCR wastes. Unauthorized access to the Facility will be controlled by fencing and lockable gates across the access roads.

6.2 Notification

Fluvanna County, Virginia will be notified upon the completion of closure of the Facility. The survey plat will be prepared showing the final closure grades, as well as the locations of the groundwater monitoring wells. The survey plat and deed will have the following notification language:

> **This property has been used for the management and disposal of CCR wastes. Any future use of the site shall not disturb the integrity of the final cover, liners, or any other components of the containment systems, or the function of the monitoring system unless necessary to comply with the CCR Rule, Virginia Solid Waste Management Regulations, or approved by the Department of Environmental Quality.**

Within 30 days of recording a notation on the deed to the property, a notification of the notation being recorded will be sent to the DEQ, posted on Dominion Energy's publicly accessible internet site, and placed in the Facility's operating record.

6.3 Certification

Within 30 days of the completion of closure construction, a Professional Engineer licensed in the Commonwealth of Virginia and representing the Facility will provide the DEQ with certification of closure in accordance with this Plan, along with the results of the CQA Plan. The certification statement should generally read as follows:

> **I certify that closure has been completed in accordance with the Closure Plan dated [DATE] for permit number 627 issued to Dominion Energy, with the exception of the following discrepancies:**

> **In addition, a sign(s) was (were) posted on [DATE] at the facility entrance notifying all persons of the closing [and state other notification procedures if applicable] and barriers [indicate type] were installed at [location] to prevent new waste from being deposited.**
>
> **A survey plat prepared by [NAME] was submitted to Fluvanna County, Virginia on [DATE]. A copy of the survey plat is included with this certification.**
>
> **A notation was recorded on the deed to the property on [DATE]. A copy of the revised deed is attached to this certification.**
>
> **[Signature, date and stamp of Professional Engineer]**

The certification will be posted on Dominion Energy's publicly accessible internet site and placed in the Facility's operating record.

7.0 COST ESTIMATE

The estimated cost for closure of the CCR Unit is $14,475,934. A construction contractor will be hired to provide closure construction services. Calculations for the closure cost estimate are included in Attachment 5 of this Closure Plan.

ATTACHMENT 1

AIRSPACE AND LIFE OF SITE TABLE

Bremo Bluff FFCP Management Facility
Airspace and Life of Site Table

FILL PHASE	PHASE LINER AREA (AT LIMITS OF WASTE) (AC)	PHASE FINAL COVER AREA (AT LIMITS OF WASTE) (AC)	GROSS AIRSPACE (CY)	LINER SYSTEM (CY)	INTERMEDIATE COVER (CY)	FINAL COVER SYSTEM (CY)	NET AIRSPACE (CCR) (CY)	PHASE LIFE (YEARS)
1	46.5	46.5	6,540,500	112,530	75,020	150,040	6,202,910	6.0
TOTALS	**46.5**	**46.5**	**6,540,500**	**112,530**	**75,020**	**150,040**	**6,202,910**	**6.0**

Notes

Liner Thickness:	1.5 ft.	
Intermediate Cover Thickness:	1.0 ft.	
Cap Thickness:	2.0 ft.	
Phase Life (avg. tons per day):	5100	
Phase Life (days / year):	301	6 days per week minus 11 holidays
Phase Life (tons per year):	1,535,100	
Phase Life (waste density):	1.485	tons/CY
Phase Life (CY per year):	1,033,737	

ATTACHMENT 2

VENEER STABILITY ANALYSIS

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Calculations

PROJECT: Bremo Bluff FFCP Management Facility	**REFERENCE NO:** 22130437.031
SUBJECT: Veneer Stability Analysis – Cap	**DATE:** 02/01/2024

1.0 OBJECTIVE

The objective of this analysis is to evaluate the veneer stability of the final cover system for the proposed Coal Combustion Residuals (CCR) Unit at the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) and determine the factors of safety of the various analyzed conditions.

2.0 METHODOLOGY

The analysis was performed using spreadsheet analyses of the selected interfaces using the "finite slope model analysis" method outlined in Reference 1. The portions of the CCR Unit most sensitive to veneer failure are the sideslope areas; therefore, the sideslope angle of 3H:1V (horizontal to vertical), or 18.4 degrees, was used for these calculations.

The minimum allowable interface friction angle was determined by setting the factor of safety (FS) equal to the minimum required FS value for the Long-Term Veneer Stability condition, as shown in the table below. Using the minimum allowable interface friction angle, factors of safety for the final cover system in the Short-Term Veneer Stability, Parallel Seepage, and Seismic conditions were determined.

3.0 ASSUMPTIONS

Veneer stability calculations were based on the following assumptions and input parameters:

- The final cover soils were assigned a unit weight of 112 pounds per cubic foot (pcf) and an estimated strength of 33.6 degrees, which is consistent with the United States Department of Interior Bureau of Reclamation's Design of Small Dams Unified Soil Classification System for the silty sands or sand-silt mixtures (SM) on-site.
- The cohesion and saturated unit weight of the final cover soils were conservatively assumed to be 0 pounds per square foot (psf) and 135 pcf, respectively.
- Based on the CCR Unit design grades, shown in Attachment III of the Part B Permit Application (Design Plans), the maximum slope length for the CCR Unit cap is approximately 193 feet with a cap thickness of approximately 2 feet.
- The final closure HELP model analysis demonstrates all anticipated seepage flows are contained within the thickness of the drainage layer, preventing saturation of the overlying soils. Depth of Seepage was therefore assumed to be zero.

4.0 CALCULATIONS

Based on the spreadsheet calculations (Attachment 1), the minimum allowable friction angle for any interface in the final cover system was determined to be 25.9 degrees. The table below summarizes the required and calculated factors of safety for each of the conditions based on a calculated interface friction angle of 25.9 degrees.

Table 1: FS Results Summary

Condition	Minimum Required FS	Calculated FS
Long-Term Veneer Stability	1.5	1.50
Short-Term Veneer Stability	1.3	1.50
Parallel Seepage	1.3	1.50
Seismic	1.0	1.12

5.0 CONCLUSION

The on-site soils, combined with the proposed geosynthetics, will provide a final cover system that meets the required factors of safety given a minimum allowable interface friction angle 25.9 degrees.

Attachments:

(1) Veneer Stability Calculations Spreadsheets

References:

(1) Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003

(2) Das, Braja M. "Principles of Geotechnical Engineering, 3rd Edition".

(3) United States Department of Interiors Bureau of Reclamation. Design of Small Dams, Third Edition, 1987.

Veneer Stability Analysis Attachment 1

Veneer Stability Calculations Spreadsheets

Schnabel ENGINEERING

Calculations

Project:	Bremo Bluff FFCP Management Facility	**Made by:**	ERR
Subject:	Veneer Slope Stability Analysis - Cap, Long-Term Static	**Checked by:**	SDRM
Reference No.:	22130437.031	**Reviewed by:**	JRD
Date:	2/1/2024		

Objective

Determine the ***long-term*** *veneer slope stability by means of a factor of safety of the static condition for the* ***3:1 slope areas****.*

Method

Where:

a = $(W_a - N_a \cos\beta)(\cos\beta)$

b = $-\{(W_a - N_a\cos\beta)\sin\beta\tan\varphi + (N_a\tan\beta + Ca)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\varphi)\}$

c = $(N_a\tan\delta + C_a)\sin^2\beta\tan\varphi$

$$FS = \frac{-b + (b^2 - 4ac)^{0.5}}{2a}$$

Assumptions

β =	slope angle	=	18.4 °	(3:1)
φ =	internal friction angle cover soil	=	33.6 °	
δ =	interface friction angle	=	25.9 °	
c_a =	adhesion along interface	=	0.0 psf	
c =	cohesion of cover soil	=	0.0 psf	
L =	slope length	=	193.0 ft	
h =	cap thickness	=	2.0 ft	assumed placement of 12" soil lift
γ =	unit weight of cover soil	=	112 pcf	

Calculations

$W_a = \gamma h^2(L/h - 1/\sin\beta - (\tan\beta/2))$	=	41740.63 lb/ft
$N_a = W_a\cos\beta$	=	39598.64 lb/ft
$C_a = c_a(L - h/\sin\beta)$	=	0.00 psf
$W_p = \gamma h^2/\sin2\beta$	=	746.67 lb/ft
$C = ch/\sin\beta$	=	0.00 lb/ft

Static Conditions

a = $(W_a - N_a \cos\beta)(\cos\beta)$ = 3959.86

b = $-\{(W_a - N_a\cos\beta)\sin\beta\tan\varphi + (N_a\tan\beta + Ca)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\varphi)\}$ = -6789.60

c = $(N_a\tan\delta + C_a)\sin^2\beta\tan\varphi$ = 1274.70

$$\mathbf{FS = \frac{-b + (b^2 - 4ac)^{0.5}}{2a} = 1.50}$$

References

1. Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003
2. Das, Braja M. "Principles of Geotechnical Enginering, 3rd Edition".

Schnabel ENGINEERING

Calculations

Project:	Bremo Bluff FFCP Management Facility	**Made by:**	ERR
Subject:	Veneer Slope Stability Analysis - Cap**,** Short-Term Static	**Checked by:**	SDRM
Reference No.:	22130437.031	**Reviewed by:**	JRD
Date:	2/1/2024		

Objective

Determine the ***short-term*** *veneer slope stability by means of a factor of safety of the static condition for the* ***3:1 slope areas*** *.*

Method

Where:

a = $(W_{a+e} – N_{a+e} \cos\beta)(\cos\beta)$

b = $-\{(W_{a+e} – N_{a+e}\cos\beta)\sin\beta\tan\varphi + (N_{a+e}\tan\beta + C_a)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\varphi)\}$

c = $(N_{a+e}\tan\delta + C_a)\sin^2\beta\tan\varphi$

$$FS = \frac{-b + (b^2-4ac)^{0.5}}{2a}$$

Assumptions

β =	slope angle	=	18.4 °	(3:1)
φ =	internal friction angle cover soil	=	33.6 °	
δ =	interface friction angle	=	25.9 °	
c_a =	adhesion along interface	=	0.0 psf	
c =	cohesion of cover soil	=	0.0 psf	
L =	slope length	=	193.0 ft	
h =	cap thickness	=	2.0 ft	assumed placement of 12" soil lift
γ =	unit weight of cover soil	=	112 pcf	

Calculations

$W_a = \gamma h^2(L/h – 1/\sin\beta – (\tan\beta/2))$	=	41,740.63 lb/ft
Width of Dozer Track	=	3.00 ft
Contact Area	=	64.26 sq.ft.
Ground Pressure	=	4.8 psi
Influence factor (I)	=	0.95 (obtained from Figure 13.7, page 493, ref. 1
Ground Pressure at Geosynthetics	=	652.4 psf
Length of Dozer Track	=	10.7 ft
W_e	=	**6987 lb/ft**
W_{a+e}	=	48728.04 lb/ft
$N_{a+e} = W_{a+e}\cos\beta$	=	46227.48 lb/ft
$C_a = c_a(L – h/\sin\beta)$	=	0.00 psf
$W_p = (\gamma h^{2)}/\sin 2\beta$	=	746.67 lb/ft
$C = ch/\sin\beta$	=	0.00 lb/ft

Static Conditions

a = $(W_{a+e} – N_{a+e} \cos\beta)(\cos\beta)$ = 4622.75

b = $-\{(W_{a+e} – N_{a+e}\cos\beta)\sin\beta\tan\varphi + (N_{a+e}\tan\beta + C_a)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\varphi)\}$ = -7914.72

c = $(N_{a+e}\tan\delta + C_a)\sin^2\beta\tan\varphi$ = 1491.37

$$\mathbf{FS} = \frac{-b + (b^2-4ac)^{0.5}}{2a} = \mathbf{1.50}$$

References

1. Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003
2. Das, Braja M. "Principles of Geotechnical Enginering, 3rd Edition".

Schnabel ENGINEERING

Calculations

Project:	Bremo Bluff FFCP Management Facility	**Made by:**	ERR
Subject:	Veneer Slope Stability Analysis - Cap, Parallel Seepage	**Checked by:**	SDRM
Reference No.:	22130437.031	**Reviewed by:**	JRD
Date:	2/1/2024		

Objective

Determine the veneer slope stability ***allowing for seepage parallel to the slope*** *by means of a factor of safety of the static condition for the* ***3:1 slope areas***.

Method

Where:

$a = W_A\sin\beta\cos\beta + U_H(1-\cos^2\beta)$

$b = -[W_P\tan\varphi + W_A(\sin^2\beta\tan\varphi\cos^2\beta\tan\delta) - U_{AN}\cos\beta\tan\delta - U_{PN}\tan\varphi + U_H\sin\beta\cos\beta(\tan\varphi-\tan\delta)]$

$c = (W_A\cos\beta - U_{AN} + U_H\sin\beta)\sin\beta\tan\delta\tan\varphi$

$$FS = \frac{-b + (b^2-4ac)^{0.5}}{2a}$$

Assumptions

β =	slope angle	=	18.4	°	(3:1)
φ =	internal friction angle cover soil	=	33.6	°	
δ =	interface friction angle	=	25.9	°	
c_a =	adhesion along interface	=	0.0	psf	
c =	cohesion of cover soil	=	0.0	psf	
L =	slope length between benches	=	193.0	ft	
h =	cap thickness	=	2.0	ft	assumed placement of 12" soil lift
γ =	unit weight of cover soil	=	112	pcf	
γ_w=	Unit weight of water	=	62.4	psf	
γ_{sat}=	Saturated unit weight of cover soil	=	140	psf	
H =	Height of slope	=	61	ft	
h_w=	Depth of seepage in soil	=	0.00	ft	

Calculations

$W_A = 0.5[\gamma(h-h_w)(2H\cos\beta-h-h_w)+\gamma_{sat}h_w(2H\cos\beta-h_w)]/(\sin\beta\cos\beta)$	=	42,462.70
$U_{AN}=\gamma_w h_w(H-0.5h_w\cos\beta)/\tan\beta$	=	0.00
$U_H=0.5\gamma_w h_w^2$	=	0.00
$W_p = 0.5[\gamma(h^2-h_w^2)+\gamma_{sat}h_w^2]/(\sin\beta\cos\beta)$	=	746.67
$U_{PN}=0.5\gamma_w h_w^2/\tan\beta$	=	0.00

Static Conditions

$a = W_A\sin\beta\cos\beta + U_H(1-\cos^2\beta)$ = 12,738.81

$b = -\{W_P\tan\varphi + W_A(\sin^2\beta\tan\varphi\cos^2\beta\tan\delta) - U_{AN}\cos\beta\tan\delta - U_{PN}\tan\varphi + U_H\sin\beta\cos\beta(\tan\varphi-\tan\delta)\}$ = -21,874.20

$c = (W_A\cos\beta - U_{AN} + U_H\sin\beta)\sin\beta\tan\delta\tan\varphi$ = 4,109.72

$$\mathbf{FS} = \frac{-b + (b^2-4ac)^{0.5}}{2a} = \mathbf{1.50}$$

References

1. Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003
2. Das, Braja M. "Principles of Geotechnical Enginering, 3rd Edition".

Calculations

Project:	Bremo Bluff FFCP Management Facility	**Made by:**	ERR
Subject:	Veneer Slope Stability Analysis - Cap, Seismic	**Checked by:**	SDRM
Reference No.:	22130437.031	**Reviewed by:**	JRD
Date:	2/1/2024		

Objective

Determine the veneer slope stability by means of a factor of safety of the ***seismic condition*** *for the* ***3:1 slope areas*** *.*

Method

Where:

a = $(C_sW_a + N_a\sin\beta)\cos\beta + C_sW_p\cos\beta$

b = $-\{(C_sW_a + N_a\sin\beta)\sin\beta\tan\varphi + (N_a\tan\delta + C_a)\cos^2\beta + (C + W_p\tan\varphi)\cos\beta\}$

c = $(N_a\tan\delta + C_a)\cos\beta\sin\beta\tan\varphi$

$$FS = \frac{-b + (b^2-4ac)^{0.5}}{2a}$$

Assumptions

β =	slope angle	=	18.4 °	(3:1)
φ =	internal friction angle cover soil	=	33.6 °	
δ =	interface friction angle	=	25.9 °	
c_a =	adhesion along interface	=	0.0 psf	
c =	cohesion of cover soil	=	0.0 psf	
L =	slope length	=	193.0 ft	
h =	cap thickness	=	2.0 ft	assumed placement of 12" soil lift
γ =	unit weight of cover soil	=	112 pcf	
C_s =	seismic coefficient	=	0.10 g	(1/2 peak ground acceleration)

Calculations

$W_a = \gamma h^2(L/h - 1/\sin\beta - (\tan\beta/2)$	=	41740.63 lb/ft
$N_a = W_a\cos\beta$	=	39598.64 lb/ft
$C_a = c_a(L - h/\sin\beta)$	=	0.00 psf
$W_p = \gamma h^2/\sin2\beta$	=	746.67 lb/ft
$C = ch/\sin\beta$	=	0.00 lb/ft

Seismic Conditions

a = $(C_sW_a + N_a\sin\beta)\cos\beta + C_sW_p\cos\beta$ = 15910.29

b = $-\{(C_sW_a + N_a\sin\beta)\sin\beta\tan\varphi + (N_a\tan\delta + C_a)\cos^2\beta + (C + W_p\tan\varphi)\cos\beta\}$ = -21283.79

c = $(N_a\tan\delta + C_a)\cos\beta\sin\beta\tan\varphi$ = 3832.53

$$\mathbf{FS = \frac{-b + (b^2-4ac)^{0.5}}{2a} = 1.12}$$

References

1. Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003
2. Das, Braja M. "Principles of Geotechnical Enginering, 3rd Edition".

ATTACHMENT 3

RUSLE CALCULATIONS

9800 JEB Stuart Parkway, Suite 100
Glen Allen, VA 23059
T: 804-649-7035

Calculations

PROJECT: Bremo Bluff FFCP Management Facility	**REFERENCE NO:** 22130437.031
SUBJECT: RUSLE Calculations	**DATE:** 02/01/2024

1.0 OBJECTIVE

The objective of this calculation is to determine the average annual soil loss for the proposed Coal Combustion Residuals (CCR) Unit at the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility). According to the Virginia Department of Environment Quality (DEQ) Solid Waste Permitting Submission Instruction No. 6 (SI-6), the average annual soil loss must be less than 2 tons per acre per year.

2.0 METHODOLOGY AND ASSUMPTIONS

The average annual soil loss was calculated using the United States Department of Agriculture's (USDA) Revised Universal Soil Loss Equation (RUSLE):

$$A = R \times K \times L \times S \times C \times P$$

Where A is the average soil loss per acre, R is the rainfall runoff erosivity factor, K is the soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is the cover management factor, and P is the support practice factor. Each variable was determined from the guidance contained in the USDA Agriculture Handbook 703 (AH 703) and the IPAA Guidance Document.

3.0 CALCULATIONS

3.1 Rainfall Runoff Erosivity Factor (R)

The R factor was obtained from the IPAA Guidance Document. The R factor for Fluvanna County is approximately 181.

3.2 Soil Erodibility Factor (K)

The K factor was determined from the nomograph in Figure 3-1 in AH-703, included in Attachment 1. The final cover soil composition was based upon a representative sample from the project site, included in Attachment 2, and is expected to have 25% silt and fine sand with 67% sand and some organic material. The silty sands or sand-silt mixtures (Unified Soil Classification System SM) on-site have a fine granular soil structure, and moderate to rapid permeability. Based on these assumptions, the K factor is 0.15.

3.3 Slope Length Factor (L)

The L factor was calculated from the following equation:

$$L = (\lambda/72.6)^m$$

Where λ is the slope length (193 feet for the proposed CCR Unit) and m is determined by the following equation:

$$m = \beta/(1 + \beta)$$

Where β is the ratio of rill to inter-rill erosion, and is determined by the following equation:

$$\beta = \frac{\left(\frac{\sin\theta}{0.0896}\right)}{3.0(\sin\theta)^{0.8} + 0.56}$$

Θ is the slope angle, which was calculated to be 18.4 degrees. Using these equations, β is 2.01, m is 0.67, and L is 1.92.

3.4 Slope Steepness Factor (S)

The slope steepness factor is determined by one of two equations, depending on the slope steepness.

$$S = 10.8\sin\theta + 0.03 \qquad \text{s} < 9\%$$

$$S = 16.8\sin\theta - 0.50 \qquad \text{s} > 9\%$$

Using the slope of 18.4, the S factor is 4.8.

3.5 Cover Management Factor (C)

The cover management factor was determined from the NRCS Field Office Technical Guide, included in Attachment 1. Based on the C Factor for Permanent Pasture, and assuming 60 to 70 percent ground cover and 10 to 20 percent canopy cover, the C factor was determined to be 0.006.

3.6 Support Practice Factor (P)

The P factor was assumed to be 1 because no support practice factors will be used.

4.0 CONCLUSION

Based on these calculations, the average annual soil loss is expected to be 1.5 tons per acre per year for the capped area of the CCR Unit, which satisfies the DEQ criterion.

Attachments:

(1) R, K, and C Factor Sources
(2) Soil Sample

References:

(1) USDA Agricultural Handbook 703. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). 1997
(2) IPAA Guidance Document. Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites.

RUSLE Calculations Attachment 1

R, K, and C Factor Sources

APPENDIX A. EROSIVITY (R-VALUE TABLES)

State Name	County	R Factor US	State Name	County	R Factor US
UTAH			**VIRGINIA**		
Utah	Piute	42.55	Virginia	Chesterfield	208.96
Utah	Rich	26.75	Virginia	Clarke	145.41
Utah	SaltLake	50.29	Virginia	Craig	156.54
Utah	SanJuan	34.09	Virginia	Culpeper	179.01
Utah	Sanpete	30.36	Virginia	Cumberland	185.48
Utah	Sevier	34.96	Virginia	Dickenson	186.19
Utah	Summit	37.56	Virginia	Dinwiddie	219.80
Utah	Tooele	45.99	Virginia	Essex	204.28
Utah	Uintah	28.02	Virginia	Fairfax	168.12
Utah	Utah	42.11	Virginia	Fauquier	164.51
Utah	Wasatch	37.37	Virginia	Floyd	195.63
Utah	Washington	40.70	Virginia	Fluvanna	180.24
Utah	Wayne	26.79	Virginia	Franklin	203.31
Utah	Weber	46.28	Virginia	Frederick	135.55
VERMONT			Virginia	Giles	150.31
Vermont	Addison	93.46	Virginia	Gloucester	220.34
Vermont	Bennington	131.23	Virginia	Goochland	195.01
Vermont	Caledonia	98.81	Virginia	Grayson	190.46
Vermont	Chittenden	90.99	Virginia	Greene	186.90
Vermont	Essex	100.77	Virginia	Greensville	235.45
Vermont	Franklin	95.97	Virginia	Halifax	209.27
Vermont	Grand Isle	72.13	Virginia	Hanover	197.19
Vermont	Lamoille	105.65	Virginia	Henrico	206.66
Vermont	Orange	91.71	Virginia	Henry	221.25
Vermont	Orleans	97.62	Virginia	Highland	138.78
Vermont	Rutland	108.38	Virginia	Isle of Wight	258.17
Vermont	Washington	99.42	Virginia	James City	231.64
Vermont	Windham	126.56	Virginia	King and Queen	212.59
Vermont	Windsor	103.12	Virginia	King George	185.08
VIRGINIA			Virginia	King William	210.25
Virginia	Accomack	205.76	Virginia	Lancaster	208.33
Virginia	Albemarle	189.88	Virginia	Lee	224.99
Virginia	Alleghany	145.02	Virginia	Loudoun	157.35
Virginia	Amelia	202.67	Virginia	Louisa	191.89
Virginia	Amherst	178.84	Virginia	Lunenburg	215.60
Virginia	Appomattox	189.90	Virginia	Madison	178.60
Virginia	Arlington	177.60	Virginia	Mathews	226.68
Virginia	Augusta	151.24	Virginia	Mecklenburg	219.46
Virginia	Bath	151.25	Virginia	Middlesex	215.65
Virginia	Bedford	177.86	Virginia	Montgomery	158.62
Virginia	Bland	148.06	Virginia	Nelson	190.35
Virginia	Botetourt	160.76	Virginia	New Kent	214.39
Virginia	Brunswick	224.15	Virginia	Northampton	209.81
Virginia	Buchanan	174.53	Virginia	Northumberland	202.31
Virginia	Buckingham	185.34	Virginia	Nottoway	208.94
Virginia	Campbell	193.77	Virginia	Orange	187.86
Virginia	Caroline	189.79	Virginia	Page	151.42
Virginia	Carroll	194.45	Virginia	Patrick	229.82
Virginia	Charles City	220.14	Virginia	Pittsylvania	203.01
Virginia	Charlotte	202.68	Virginia	Powhatan	193.85

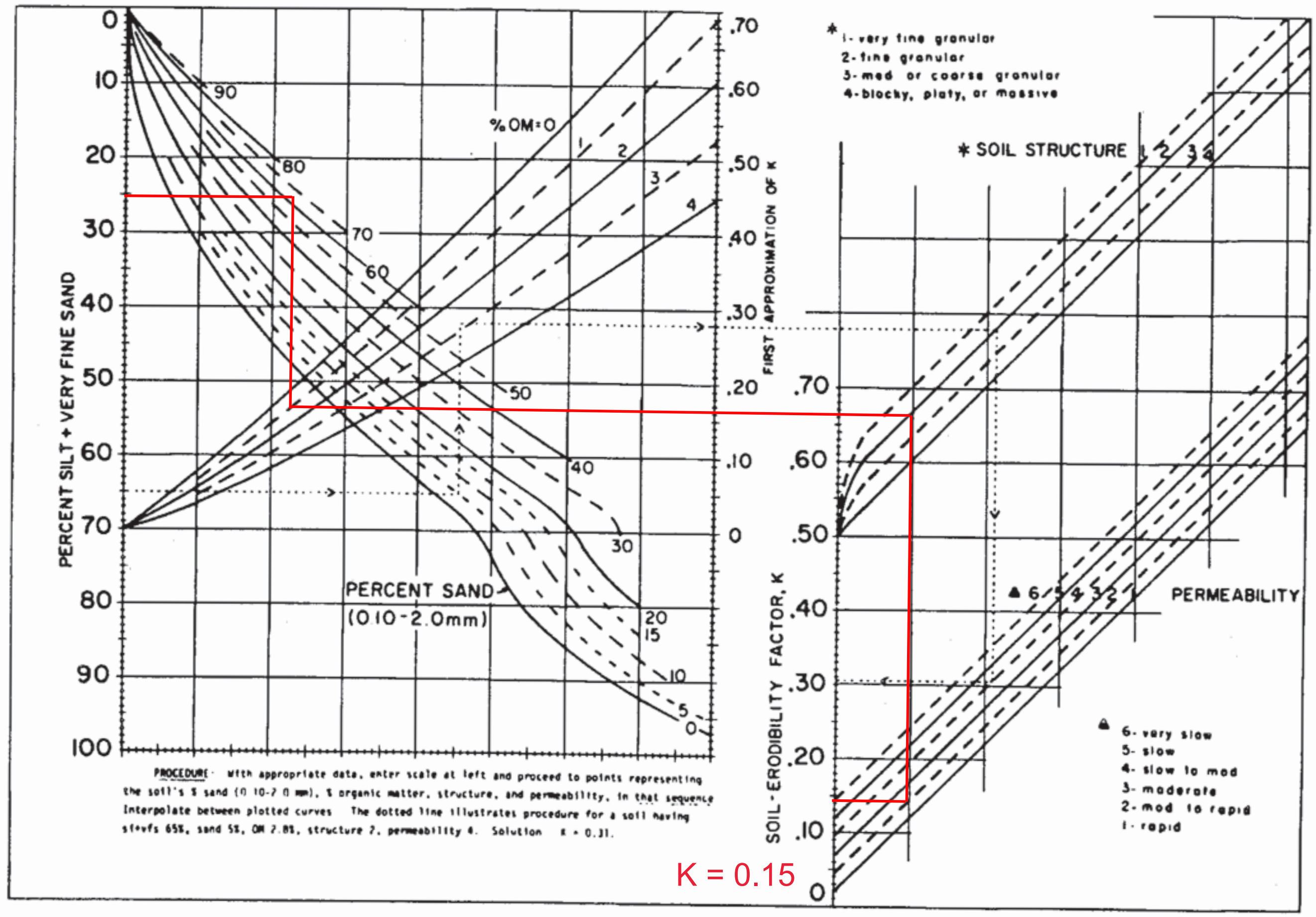


Figure 3-1. Soil-erodibility nomograph (after Wischmeier and Smith 1978). For conversion to SI divide K values of this nomograph by 7.59. K is in U.S. customary units.

Table 6.2 C Factors for Permanent Pasture

Percent Cover – Ground + Canopy			C Factor Vigor / Fertility / Productivity		
Ground Cover	**Canopy Cover**	**Total Cover**	**High**	**Medium**	**Low**
80-90	10-20	100	.001		
10-70	30-90	100	.002		
50-80	10-40	90	.002	.006	
10-40	50-80	90	.003	.01	
60-70	10-20	80	.002	.006	.018
30-50	30-50	80	.003	.006	.018
10-20	60-70	80	.005	.014	.042
40-60	10-30	70	.003	.009	.029
10-30	40-60	70	.006	.017	.052
40-50	10-20	60		.012	.036
30	30	60		.017	.05
10-20	40-50	60		.022	.068
40	10	50			.045
30	20	50			.057
20	30	50			.072
10	40	50			.088
30	10	40			.064
20	20	40			.081
10	30	40			.102
20	10	30			.091
10	20	30			.116
20	0	20			.101
10	10	20			.129
0	20	20			.164

RUSLE Calculations Attachment 2

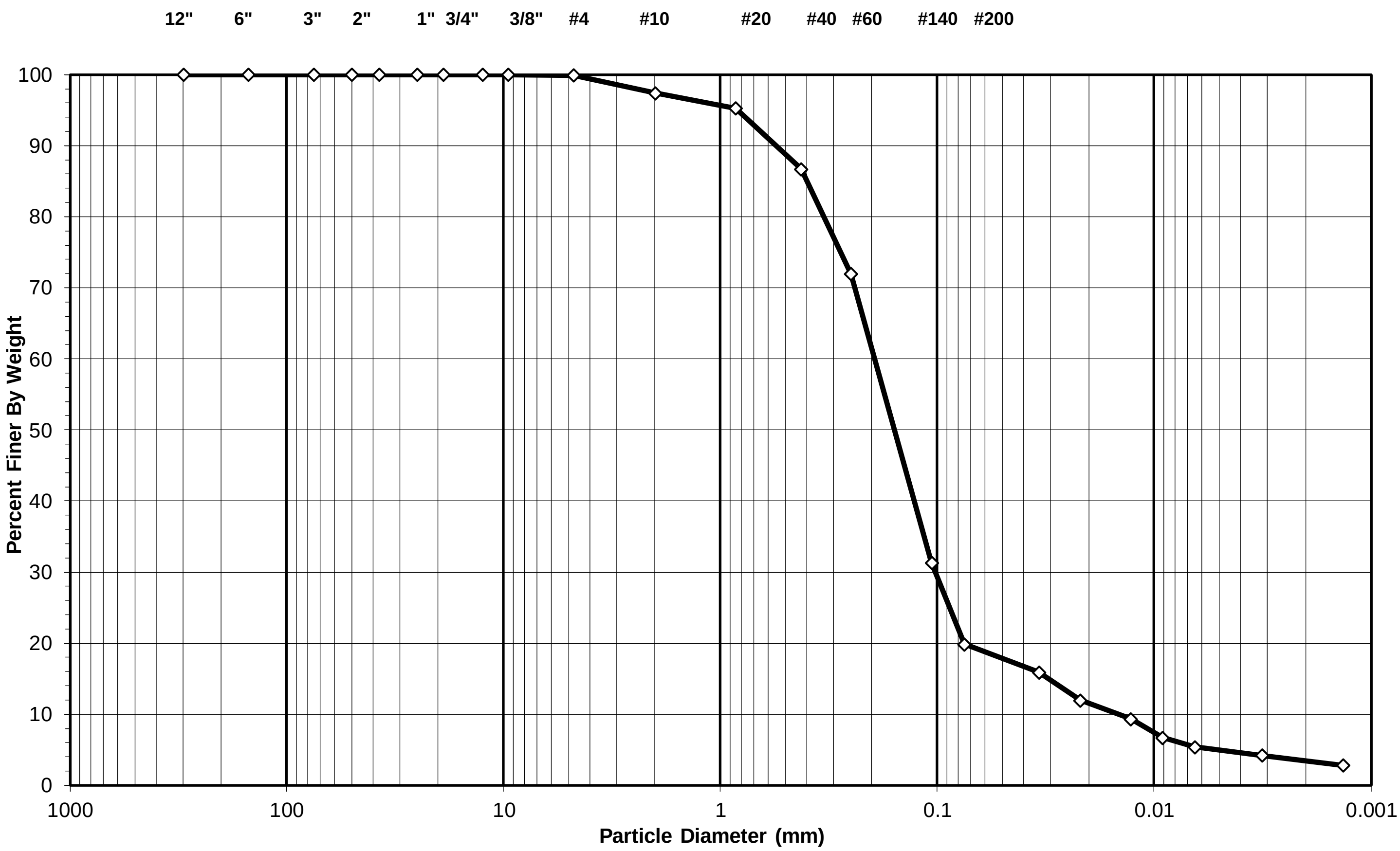
Soil Sample

SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client	AECOM	Boring No.	PZ-20
Client Reference	Dominion - Bremo	Depth (ft)	28-30
Project No.	R-2020-043-001	Sample No.	SS-9
Lab ID	R-2020-043-001-006	Soil Color	Brown

	SIEVE ANALYSIS			***HYDROMETER***	
USCS	**cobbles**	**gravel**	**sand**	**silt and clay fraction**	
USDA	**cobbles**	**gravel**	**sand**	**silt**	**clay**



USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	0.10
#4 To #200	*Sand*	80.05
Finer Than #200	*Silt & Clay*	19.85
#200 To .005mm	*Silt*	14.98
Finer .005mm	Clay	4.87

USCS Symbol ***SM, TESTED***
(Non-Plastic Fines)

USCS Classification ***SILTY SAND***

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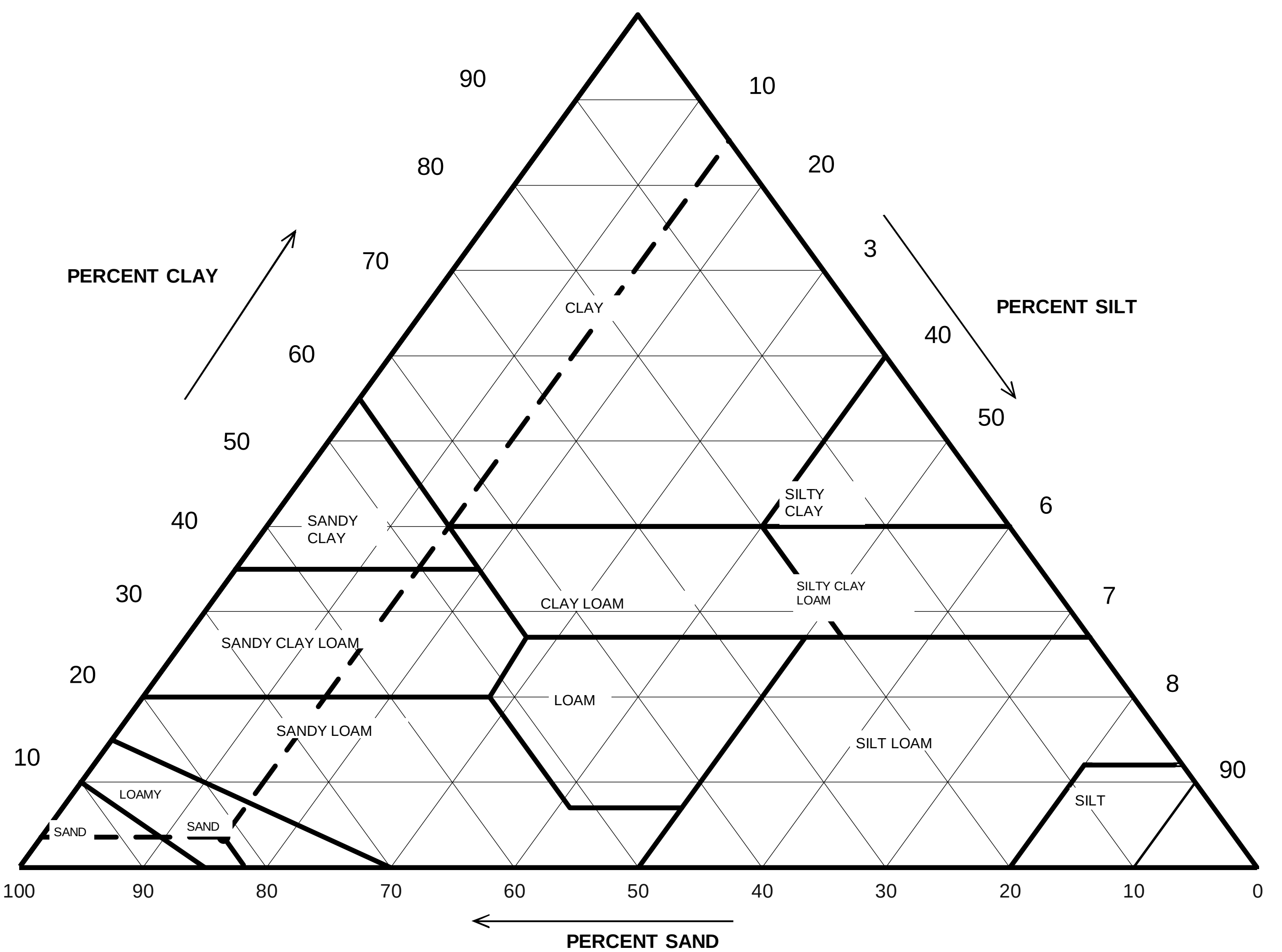
USDA CLASSIFICATION CHART

Client	AECOM	Boring No.	PZ-20
Client Reference	Dominion - Bremo	Depth (ft)	28-30
Project No.	R-2020-043-001	Sample No.	SS-9
Lab ID	R-2020-043-001-006	Soil Color	Brown



Particle Size (mm)	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
		Gravel	2.58	**0.00**
2	97.42	*Sand*	79.59	**81.70**
0.05	17.83	*Silt*	14.37	**14.75**
0.002	3.46	*Clay*	3.46	**3.55**

USDA Classification: ***LOAMY SAND***

DCN: CT-S3OR DATE: 7/26/2020 REVISION: 8 \AECOM\2020-043 AECOM - Dominion - Bremo\2020-043-001\[2020-043-001-006 Grain Sieve Hyd10 SILT&CLAY.xls]Sheet1

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client	AECOM	Boring No.	PZ-20
Client Reference	Dominion - Bremo	Depth (ft)	28-30
Project No.	R-2020-043-001	Sample No.	SS-9
Lab ID	R-2020-043-001-006	Soil Color	**Brown**

Minus #10 for Hygroscopic Moisture Content		**Hydrometer Specimen Data**	
Tare No.	U	Air Dried - #10 Hydrometer Material (g)	73.76
Wgt.Tare + Wet Soil (g)	32.94	Corrected Dry Wt. of - #10 Material (g)	73.43
Wgt.Tare + Dry Soil (g)	32.86		
Weight of Tare (g)	15.11	Weight of - #200 Material (g)	14.96
Weight of Water (g)	0.08	Weight of - #10 ; + #200 Material (g)	58.47
Weight of Dry Soil (g)	17.75		
Moisture Content (%)	**0.5**	**J-FACTOR (%FINER THAN #10)**	**0.9742**
Soil Specimen Data			
Tare No.	720		
Wgt.Tare + Air Dry Soil (g)	282.57		
Weight of Tare (g)	90.08		
Air Dried Wgt. Total Sample (g)	192.49	Dry Weight of Material Retained on #10 (g)	4.94
Total Dry Sample Weight (g)	191.65	Corrected Dry Sample Wt - #10 (g)	186.71

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.0	0.0	100.0	**100.0**
6"	150	0.00	0.0	0.0	100.0	**100.0**
3"	75	0.00	0.0	0.0	100.0	**100.0**
2"	50	0.00	0.0	0.0	100.0	**100.0**
1 1/2"	37.5	0.00	0.0	0.0	100.0	**100.0**
1"	25.0	0.00	0.0	0.0	100.0	**100.0**
3/4"	19.0	0.00	0.0	0.0	100.0	**100.0**
1/2"	12.5	0.00	0.0	0.0	100.0	**100.0**
3/8"	9.50	0.00	0.0	0.0	100.0	**100.0**
#4	4.75	0.19	0.1	0.1	99.9	**99.9**
#10	2.00	4.75	2.5	2.6	97.4	**97.4**
#20	0.85	1.63	2.2	2.2	97.8	**95.3**
#40	0.425	6.43	8.8	11.0	89.0	**86.7**
#60	0.250	11.12	15.1	26.1	73.9	**72.0**
#140	0.106	30.62	41.7	67.8	32.2	**31.3**
#200	0.075	8.67	11.8	79.6	20.4	**19.8**
Pan	-	14.96	20.4	100.0	-	**-**

Notes :

Tested By	TB	Date	3/19/20	Checked By	GEM	Date	3/24/20

DCN: CT-S3OR DATE: 7/26/13 REVISION: 8 CTS\AECOM\2020-043 AECOM - Dominion - Bremo\2020-043-001\[2020-043-001-006 Grain Sieve Hyd10 SILT&CLAY.xls]Sheet1

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HYDROMETER ANALYSIS
ASTM D 422-63 (2007)

Client	AECOM	Boring No.	PZ-20
Client Reference	Dominion - Bremo	Depth (ft)	28-30
Project No.	R-2020-043-001	Sample No.	SS-9
Lab ID	R-2020-043-001-006	Soil Color	**Brown**

Elapsed Time (min)	R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0	NA	NA	NA	NA	NA	NA	NA	NA
2	16.0	22.7	3.88	12.1	16.3	0.01302	0.0340	**15.9**
5	13.0	22.7	3.88	9.1	12.3	0.01302	0.0219	**12.0**
15	11.0	22.7	3.88	7.1	9.6	0.01302	0.0128	**9.3**
30	9.0	22.7	3.88	5.1	6.9	0.01302	0.0092	**6.7**
60	8.0	22.7	3.88	4.1	5.5	0.01302	0.0065	**5.4**
250	7.0	23.3	3.78	3.2	4.3	0.01293	0.0032	**4.2**
1440	6.0	22.8	3.87	2.1	2.9	0.01300	0.0013	**2.8**

Soil Specimen Data		**Other Corrections**	
Wgt. of Dry Material (g)	73.43	Hygroscopic Moisture Factor	0.996
Weight of Deflocculant (g)	5.0		
		a - Factor	0.99
		Percent Finer than # 10	97.42
		Specific Gravity	2.70 Assumed

Notes:

Tested By	RFF	Date	3/18/20	Checked By	GEM	Date	3/24/20

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ATTERBERG LIMITS

ASTM D 4318-17

Client:	AECOM	Boring No.:	PZ-20
Client Reference:	Dominion - Bremo	Depth (ft):	28-30
Project No.:	R-2020-043-001	Sample No.:	SS-9
Lab ID:	R-2020-043-001-006	Color:	Brown
			(MInus No. 40 sieve material)

As Received
Water Content

Tare Number	B1
Wt. of Tare & Wet Sample (g)	32.49
Wt. of Tare & Dry Sample (g)	30.68
Weight of Tare (g)	15.63
Weight of Water (g)	1.81
Weight of Dry Sample (g)	15.05
Water Content (%)	**12.0**

NON - PLASTIC MATERIAL

Tested By	*SS*	*Date*	*3/18/20*	*Checked By*	*GEM*	*Date*	*3/19/20*

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ATTACHMENT 4

STORMWATER ANALYSIS

Schnabel ENGINEERING

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Calculations

PROJECT: Bremo Bluff FFCP Management Facility	**REFERENCE NO:** 22130437.031
SUBJECT: Stormwater Analysis	**DATE:** 02/01/2024

1.0 OBJECTIVE

The objective of this analysis is to demonstrate the adequacy of the proposed stormwater management systems to convey flow from the 25-year, 24-hour storm event in accordance with the Virginia Solid Waste Management Regulations (VSWMR) for the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility).

2.0 BACKGROUND

During filling operations, contact stormwater, i.e., stormwater that contacts CCR, will be managed separately from leachate and stormwater run-off. Contact stormwater run-off from the face of the active area of the proposed Coal Combustion Residuals (CCR) Unit will be routed through dedicated temporary slope drains into collection piping around the perimeter of the CCR Unit and conveyed to a dedicated stormwater management structure, the Contact Stormwater Pond (CSWP). Contact stormwater collected in the CSWP will be pumped directly to a proposed Dominion Energy-owned, permitted wastewater treatment facility, which is further discussed in Attachment VIII of the Part B Permit Application (Leachate Management Plan).

Stormwater run-on to the Facility will be collected in outer perimeter run-on control channels, which will drain to the stormwater ponds at the southern edge of the Facility for attenuation prior to release.

After closure of the CCR Unit, stormwater run-off from the final cover system will be collected in a series of drainage benches and permanent slope drains, which convey flow to the perimeter stormwater channels that will drain to the stormwater ponds at the southern edge of the Facility for attenuation prior to release.

3.0 METHODOLOGY

The site was modeled in the U.S. Army Corps of Engineers Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) using calculation methodology from the Natural Resources Conservation Service's (NRCS) Technical Release 55 (TR-55). The HEC-HMS model was used to determine flow rates and volumes to the various stormwater structures, which were analyzed to demonstrate compliance with the VSWMR; Title 9 Virginia Administration Code (VAC) Agency 20, Chapter 81, Section 130, Subsection H (9VAC20-81-130.H). Additionally, channel capacities and velocities were analyzed to demonstrate compliance with Virginia Erosion and Sediment Control Regulations Minimum Standard No. 19 (9VAC25-840-40).

Existing topography was based on the aerial survey completed by McKenzie Snyder, Inc. on March 24, 2019, and existing landcover conditions were determined from ESRI's Geographic Information System (GIS) aerial imagery for the Bremo Bluff area, data October 3rd, 2022.

Meteorological data was obtained from the National Ocean and Atmospheric Administration (NOAA) Atlas 14 Precipitation Frequency Data Server and was used to model the design frequency storms. The Facility is located in Bremo Bluff, Virginia and detailed precipitation data is provided in Attachment 1.

Information on site soil types and corresponding hydrologic soil groups (HSG) was obtained from the NRCS' Web

Soil Survey. Existing soils within the proposed Facility footprint are predominantly HSG Type A soils. For modeling, all disturbed areas were assumed to be HSG Type B soils in the post-development condition. Web Soil Survey data is included in Attachment 2.

Each drainage area was assigned an area-weighted runoff curve number (CN) based on the existing and proposed land covers and HSGs found within the delineated areas.

3.1 HEC-HMS Model

The site was divided into drainage areas, reaches, and ponds for modeling in HEC-HMS. Drainage areas were delineated by hand based on the existing topography, proposed grading, and proposed stormwater conveyance structures and are shown on the Drainage Area Map included in Attachment 3. Travel times and lag times for each drainage area were calculated using the methodology described in TR-55. HEC-HMS Model inputs and outputs are included in Attachments 4 and 5, respectively.

3.2 Stormwater Conveyance

3.2.1 Benches and Channels

In accordance with 9VAC25-840-40 MS-19, stormwater conveyance benches and channels shall be non-erosive during the 2-year, 24-hour storm event and contain the 10-year, 24-hour storm event. Per the VSWMR, stormwater controls systems are to be designed to contain the flow from the 25-year, 24-hour storm event, which exceed the 10-year, 24-hour capacity requirements from MS-19. The benches and channels were designed to contain flows up to the 100-year, 24-hour storm event, exceeding the design requirements of the VSWMR. Per NOAA Atlas 14, the 25-year, 24-hour storm event and the 100-year, 24-hour storm event at the Facility results in 5.93 inches and 7.91 inches of precipitation, respectively.

Bench and channel flow depth was calculated using Manning's Equation for open channel flow:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

Q = Flowrate [cubic feet per second (cfs)]
n = Manning's roughness coefficient
A = Cross Sectional Flow Area [square feet (sf)]
R = Hydraulic Radius (ft)
S = Longitudinal Slope [feet per foot (ft/ft)]

The shear stress in each bench and channel was calculated using the following equation:

$$T_o = \gamma d S$$

Where:

T_o = Mean Boundary Shear Stress [pounds per square foot (psf)]
γ = Unit Weight of Water, 62.4 [pounds per cubic foot (pcf)]
d = Maximum Depth of Channel Flow (ft)

Grass lining erodibility was evaluated based on the guidance in the Virginia Erosion and Sediment Control Handbook (VESCH) (Chapter 3.17 and Table 5-14). None of the disturbed soils were identified as having a high erosive tendency, i.e., a k factor greater than 0.35; therefore, no correction was required for the VESCH-supplied permissible velocities. The grass seed blend is assumed to be a grass-legume mixture.

Riprap lining erodibility was evaluated using guidance from the Federal Highway Administration's (FHWA) Hydraulic Engineering Circular No. 15 (HEC-15) Design of Roadside Channels with Flexible Linings. Calculated depths, velocities, and additional details are included in Section 4.1, Table 1.

HydroTurf erodibility was evaluated using manufacturer's data, which states it can handle flows up to 40 feet per second with no instability or damage.

In accordance with the FHWA HEC-15, rigid linings such as concrete are considered non-erodible. Calculated depths, velocities, and additional details are included in Section 4.1, Table 1.

3.2.2 Slope Drains

Non-contact stormwater run-off from the CCR Unit will be collected in a series of drainage benches and conveyed through final cover slope drains to the perimeter stormwater conveyance channel. The slope drains will be constructed in the final cover system and are proposed to be 24-inch diameter Advanced Drainage System (ADS) N-12 piping with a 24-inch diameter drop inlet tee collecting flow from each drainage bench. Flows from the largest contributing drainage area to a drain, as determined from HEC-HMS, were used to verify pipe capacity is not exceeded. The slope drain inlets were evaluated using the weir and orifice equations, shown in Section 3.2.5, and the flow rate from the drainage bench with the largest contributing area.

The hydraulic grade line (HGL) was calculated to verify that the HGL will not exceed the overtopping elevation (i.e., drop inlet rim elevations plus 2-feet) at any point in the final cover slope drain. The HGL was calculated using Autodesk Storm and Sanitary Analysis for the longest proposed slope drain with the largest contributing flow.

Inlet capacity and HGL calculations are included in Attachment 6.

3.2.3 Culverts

The stormwater run-off collected from the perimeter drainage channels is conveyed to the stormwater ponds via concrete culverts and the storm sewer system described in the section below. The culverts were designed to convey the anticipated flows from the 100-year, 24-hour storm event without creating an overtopping headwater condition. Each culvert was analyzed using the FHWA's HY-8 culvert analysis program. Culvert calculations comparing the maximum available flow capacity with the design flows resulting from the 25-year and 100-year, 24-hour storm events are included in Attachment 7.

3.2.4 Storm Sewer System

Stormwater from the western portion of the Facility is conveyed through a storm sewer system comprised of a series of drop inlets, concrete pipes, and concrete manholes. This system is shown in Attachment III of the Part B Permit Application (Design Plans) as Storm Sewer Profiles A and B.

The HGL of the storm sewer system was calculated using Autodesk Storm and Sanitary Analysis to verify that the HGL will not exceed the drop inlet or manhole rim elevations. These calculations are included in Attachment 8.

3.2.5 Stormwater Ponds

The stormwater ponds were evaluated using discharge structure rating tables with flowrates and water levels calculated through HEC-HMS. Each pond's discharge structure consists of a combination of orifices and weirs that control the discharge rate based on the impounded water elevation. Discharge from orifices, such as the dewatering devices, were calculated using the orifice equation, shown below, assuming an orifice discharge coefficient of 0.61.

$$Q = C_d A_o \sqrt{2gh}$$

Discharge from weirs, such as the flow over the principal riser structure at low heads, were calculated using the rectangular weir equation, shown below, with a weir coefficient of 3.33 for a sharp-crested weir.

$$Q = C_w L h^{1.5}$$

Where:

C_d = Orifice Discharge Coefficient
C_w = Weir Discharge Coefficient
A_o = Orifice Area (sf)
g = Gravitational Constant [feet per square second (ft/s^2)]
h = head (ft)
L = Weir Crest Length (ft)

Depending on the head on the structure, the principal spillway may function as either an orifice or a weir. This effect was included in the riser structure calculations by limiting flow through the structure to the lesser of the calculated discharges. Flows from the riser structure outlet pipe were calculated using a culvert hydraulic spreadsheet developed by the Urban Drainage and Flood Control District in Denver, Colorado. (UD Culvert). The stage-storage, discharge rating curves, and details for the stormwater ponds are included in Attachment 9.

3.2.6 Cap Drainage Layer

The final cover system for the closed CCR Unit will include a drainage layer to manage stormwater infiltrating through the cover soil. The drainage layer consists of a 250-mil geocomposite which outlets to a network of cap drainpipes and returns the infiltrated stormwater to the main stormwater conveyance systems. To demonstrate this additional flow quantity is adequately managed, the drainage layer discharge is included as an additional flow quantity in the stormwater calculations. Infiltration into the landfill cover system was modeled as baseflow and routed through the stormwater conveyance systems using the linear reservoir method in HEC-HMS. This method accounts for nearly 100 percent of infiltration volume and simulates the recession of flow through the drainage layer after a storm event. Hydrographs from the final cover area subbasins in HEC-HMS resulting from the 25-year storm event are included in Attachment 12.

3.3 Contact Stormwater Conveyance

3.3.1 Contact Stormwater Pipes

Contact stormwater from the active area of the CCR Unit will be routed through dedicated temporary slope drains to the perimeter contact water pipes. The slope drains will be constructed down the side slopes of the CCR Unit and are proposed to be 24-inch diameter SDR-17 high-density polyethylene (HDPE) piping with a 24-inch by 36-inch tee conveying flow to the perimeter 36-inch diameter SDR-11 HDPE contact stormwater piping.

The contact stormwater slope drains and perimeter pipes were modeled using Manning's equation, shown in Section 3.2.1, with a Manning's coefficient of 0.013 to determine capacity at the minimum slopes. Flows from the largest contributing active area were used to verify pipe capacity is not exceeded. Pipe capacity calculations for the contact stormwater slope drains and perimeter pipes are included as Attachment 10.

3.3.2 Contact Stormwater Pond

The contact stormwater pipes discharge to the proposed CSWP, which is lined with geosynthetics and concrete armoring. The CSWP is pumped directly to a proposed Dominion Energy-owned, permitted wastewater treatment facility. The HEC-HMS model results and stage-storage of the CSWP are included in Attachment 5 and Attachment 9, respectively. Post capping, the CSWP will be converted to a permanent stormwater management pond (Basin 3).

4.0 CALCULATIONS

4.1 Stormwater Conveyance

4.1.1 Benches and Channels

Using the flows determined from HEC-HMS (Attachment 4), the various proposed sideslope drainage benches and perimeter drainage channels were sized and modeled in AutoCAD's Hydraflow Express. The drainage bench flows were determined from the drainage bench with the largest contributing drainage area. Calculated values for each channel are summarized in the table below.

Table 1: Summary of Calculated Channel Values

Channel ID	Slope (%)	Channel Lining	Erodibility				Capacity			
			2-Year, 24-Hour Flow Rate (cfs[1])	Flow Depth (ft[2])	Velocity (ft/s[3])	Shear Stress (psf[4])	100-Year, 24-Hour Flow Rate (cfs)	Flow Depth (ft)	Channel Depth (ft)	Freeboard (ft)
C.AR1	6.0%	Hydro Turf	6.27	0.55	8.29	2.06	21.38	0.86	2	1.14
C.E1	1.5%	Concrete	4.06	0.14	3.50	0.13	14.21	0.29	4	3.71
C.E2	1.5%	Concrete	9.32	0.23	4.79	0.22	36.80	0.51	4	3.49
C.E3	1.5%	Concrete	2.21	0.10	2.70	0.09	5.46	0.17	4	3.83
C.PE1	1.5%	Grass	2.01	0.24	1.82	0.22	23.58	0.95	3.6	2.65
C.PW1	2.5%	Grass	0..87	0.13	1.55	0.20	11.49	0.56	3.6	3.04
C.W1	2.5%	Concrete	4.80	0.13	4.47	0.20	18.57	0.29	4	3.71
C.W2	8.0%	Concrete	0.31	0.03	1.28	0.05	0.95	0.05	4	3.95
C.W3	1.5%	Concrete	6.47	0.18	4.30	0.17	22.19	0.38	4	3.62
C.W4	1.5%	Concrete	2.74	0.11	3.03	0.10	9.10	0.23	4	3.77
C.W5	1.5%	Concrete	3.25	0.12	3.29	0.11	10.64	0.25	4	3.75
C.RR1	13.5%	Grouted RR[5]/Gabion	13.35	0.28	7.12	2.36	73.68	0.75	2	1.25
C.RR2	12.5%	Riprap	4.42	0.26	3.66	2.03	24.14	0.66	2	1.34
C.RR3	7.0%	Grouted RR/Gabion	17.70	0.40	6.32	1.75	97.15	1.04	2	0.96
C.RR4	8.0%	Riprap	6.52	0.29	3.34	1.45	39.45	0.81	2	1.19
Drainage Bench (maximum)	2.0%	Grass	1.38	0.35	1.73	0.44	10.38	0.73	2	1.27

Notes: [1] Cubic feet per second (cfs).
[2] Feet (ft).
[3] Feet per second (ft/s).
[4] Pounds per square foot (psf).
[5] Riprap (RR).

The maximum permissible flow velocities for a grass-lined channel with a grass and legume seed mixture are presented in the VESCH (Chapter 3.17 and Table 5-14) and are 4.00 feet per second (ft/s) for slopes less than 5 percent and 3.00 ft/s for slopes between 5 and 10 percent. The 100-year, 24-hour storm event was analyzed to determine the maximum flow depth in each channel, exceeding the VSWMR 25-year, 24-hour storm event requirement.

As shown in Table 2.3 of the FHWA's HEC-15, the permissible shear stress for rock riprap with a d_{50} of 1.0 ft (approximately Class I) is 4.8 psf.

Based on the values shown in the table above, the drainage benches and receiving perimeter channels will not exceed the permissible criteria for flow depth or erodibility during the 2-year, 24-hour storm event and 100-year, 24-hour storm event, respectively.

4.1.2 Slope Drains

The most critical slope drain collects flow from approximately 12.9 acres and results in a maximum inflow rate of 36.14 cfs during the 100-year, 24-hour storm event. The slope drain was analyzed using Autodesk Storm and Sanitary Analysis to demonstrate capacity of the system to safely convey the design flows. Calculation results are included in Attachment 8,

As shown in Section 4.1.1, during the 100-year, 24-hour storm, the most critical drainage bench has an inflow rate of 10.07 cfs and a peak flow depth of 0.72 ft. The 24-inch diameter slope drain inlet tee with 0.72 ft of head has an inflow capacity of approximately 10.49 cfs, thus exceeding the inflow received from the channel.

To determine the HGL of the slope drain flowing at its maximum inflow rate, the slope drain was divided into different stations for each drop inlet. The slope drain is designed so that the water levels will not overtop the drop inlets drainage berm (rim elevation plus 2-foot channel depth). A table summarizing the station inverts, overtopping elevations, and 100-year, 24-hour storm HGL is shown below.

Table 2: Summary of Slope Drain Capacity

Station Location	Invert (ft-amsl[1])	Overtopping Elevation (ft-amsl)	HGL from the 100-year, 24-hour Storm Event (ft-amsl)
Inlet S.1.5	375.35	381.35	379.92
Inlet S.1.4	404.79	411.29	409.30
Inlet S.1.3	434.87	441.37	436.70
Inlet S.1.2	464.96	471.46	466.17
Inlet S.1.1	501.60	508.1	501.90

Notes: [1] Feet above mean sea level (ft-amsl).

4.1.3 Culverts

Using the flows determined from HEC-HMS (Attachment 4), the various proposed culverts were sized and modeled using the FHWA's HY-8 culvert analysis program, based on the maximum flow capacity without overtopping the associated channel section during the 100-year, 24-hour storm event. Calculated values for each culvert are summarized in the table below.

Table 3: Summary of Culvert Capacity

Culvert Name/No.	Diameter (in[1])	Type	Maximum Capacity (cfs)	100-year, 24-hour Design Flow (cfs)
C1A	36	2x Class IV RCP, with Headwall and Endwall	100.7	22.2
C2A	18	1x Class III RCP, with Headwall	15.4	3.2
C2B	36	1x Class III RCP, with Headwall	53.1	39.5
C2C	36	2x Class III RCP, with Headwall	169.2	97.2
C2D	36	2x Class III RCP, with Headwall and Endwall	103.2	97.2
C2E	36	2x Class III RCP, with Headwall and Endwall	102.0	73.7

C2F	24	1x Class III RCP, Drop Inlet	40.0	24.1

Notes: [1] Inch (in).

Based on the values shown in the table above, the proposed culverts convey flow up to the 100-year, 24-hour storm event, exceeding the VSWMR 25-year, 24-hour storm event requirement.

4.1.4 Stormwater Ponds

Using HEC-HMS, inflows to the stormwater ponds under proposed conditions were modeled. The calculated values for the stormwater ponds are summarized in the table below.

Table 4: Summary of Stormwater Pond Values

Pond ID	Drainage Area (ac)	100-Year, 24-Hour Inflow Rate (cfs)	Maximum Pool Elevation (ft-amsl)	Freeboard to Emergency Spillway (ft)	Peak Discharge (cfs)
Basin 1	45.74	160.75	328.23	1.77	49.90
Basin 2	59.66	136.65	303.73	2.27	50.13
Basin 3	12.13	45.79	285.64	4.36	0.69

Based on the values shown in the table above, the proposed ponds convey flows up to the 100-year, 24-hour storm event, exceeding the VSWMR 25-year, 24-hour storm event requirement.

4.2 Contact Stormwater Conveyance

4.2.1 Contact Stormwater Pipes

The maximum active area draining to the contact stormwater system will be 28 acres and results in a peak discharge of approximately 145 cfs during the 100-year, 24-hour storm event. The discharge from the active area will be divided between the western and eastern contact stormwater systems located along the perimeter of the CCR Unit. A table summarizing the systems' maximum capacities is shown below.

Table 5: Summary of Contact Stormwater Pipes

System Control	Typical Slope (%)	Maximum Capacity (cfs)
24-in HDPE Slope Drain	33.3	130.96
24-in HDPE Slope Drain	5.0	50.72
Eastern 36-in HDPE Contact Stormwater Pipe	1.5	81.91
Western 36-in HDPE Contact Stormwater Pipe	1.5	81.91

Based on the values shown in the table above, the active CCR area is to be divided between the two contact stormwater pipes.

4.2.2 Contact Stormwater Pond

Using HEC-HMS, inflows to the CSWP under proposed conditions were modeled. The calculated values for the CSWP are summarized in the table below.

Table 6: Summary of CSWP Values

Pond ID	Drainage Area (ac)	100-Year, 24-Hour Inflow Rate (cfs)	Maximum Pool Elevation (ft-amsl)	Freeboard to Emergency Spillway (ft)	Peak Discharge (cfs)
CSWP	40.13	205.36	293.97	4.03	3.34[1]

Notes: [1] CSWP will have pumped discharge of 1500 gallons per minute (3.34 cfs)

Based on the values shown in the table above, the proposed pond conveys flow up to the 100-year, 24-hour storm event, exceeding the VSWMR 25-year, 24-hour storm event requirement.

5.0 Conclusion

The proposed stormwater management systems for the Facility are adequately sized and designed for anticipated conditions. The systems satisfy the minimum requirements set forth by MS-19 and the VSWMR.

Attachments:

(1) NOAA Atlas 14 Precipitation Data
(2) Web Soil Survey
(3) Post-Development Drainage Area Map (SWM-1)
(4) HEC-HMS Model and Inputs
(5) HEC-HMS Results
(6) Slope Drains
(7) Culvert Calculations
(8) Storm Sewer System Profiles
(9) Pond Stage-Storage and Rating Curve
(10) Contact Stormwater Pipes
(11) Basin Hydrographs
(12) Final Cover Area Subbasin Hydrographs

Stormwater Analysis Attachment 1

NOAA Atlas 14 Precipitation Data

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NOAA Atlas 14, Volume 2, Version 3
Location name: Bremo Bluff, Virginia, USA*
Latitude: 37.7113°, Longitude: -78.284°
Elevation: 291 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

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	**0.341** (0.306-0.380)	**0.389** (0.350-0.432)	**0.435** (0.391-0.483	**0.512** (0.459-0.568)	**0.574** (0.515-0.635)	**0.633** (0.564-0.699)	**0.681** (0.605-0.752)	**0.724** (0.639-0.799)	**0.767** (0.673-0.848)	**0.813** (0.707-0.899)
10-min	**0.545** (0.490-0.607)	**0.621** (0.560-0.691)	) **0.696** (0.627-0.774)	**0.818** (0.735-0.908)	**0.914** (0.820-1.01)	**1.01** (0.899-1.11)	**1.08** (0.961-1.20)	**1.15** (1.01-1.27)	**1.21** (1.06-1.34)	**1.28** (1.11-1.42)
15-min	**0.682** (0.612-0.758)	**0.781** (0.704-0.869)	**0.881** (0.793-0.979)	**1.04** (0.929-1.15)	**1.16** (1.04-1.28)	**1.28** (1.14-1.41)	**1.37** (1.21-1.51)	**1.45** (1.28-1.60)	**1.53** (1.34-1.69)	**1.61** (1.40-1.78)
30-min	**0.934** (0.839-1.04)	**1.08** (0.972-1.20)	**1.25** (1.13-1.39)	**1.50** (1.35-1.66)	**1.72** (1.54-1.90)	**1.92** (1.71-2.12)	**2.10** (1.86-2.31)	**2.26** (1.99-2.49)	**2.43** (2.13-2.69)	**2.60** (2.26-2.88)
60-min	**1.16** (1.05-1.30)	**1.35** (1.22-1.51)	**1.60** (1.44-1.78)	**1.95** (1.75-2.17)	**2.28** (2.05-2.53)	**2.60** (2.32-2.88)	**2.88** (2.56-3.19)	**3.16** (2.79-3.49)	**3.48** (3.06-3.86)	**3.80** (3.31-4.20)
2-hr	**1.39** (1.24-1.56)	**1.61** (1.44-1.81)	**1.91** (1.71-2.15)	**2.35** (2.10-2.63)	**2.78** (2.47-3.11)	**3.21** (2.83-3.59)	**3.60** (3.15-4.01)	**3.99** (3.48-4.44)	**4.48** (3.86-4.98)	**4.94** (4.23-5.51)
3-hr	**1.50** (1.33-1.69)	**1.74** (1.55-1.96)	**2.06** (1.84-2.33)	**2.53** (2.25-2.85)	**2.99** (2.65-3.37)	**3.45** (3.03-3.87)	**3.86** (3.38-4.34)	**4.29** (3.73-4.81)	**4.80** (4.13-5.38)	**5.30** (4.52-5.94)
6-hr	**1.84** (1.63-2.11)	**2.14** (1.90-2.44)	**2.53** (2.24-2.89)	**3.10** (2.74-3.54)	**3.70** (3.24-4.21)	**4.31** (3.76-4.89)	**4.88** (4.22-5.54)	**5.49** (4.70-6.22)	**6.25** (5.29-7.08)	**7.03** (5.87-7.95)
12-hr	**2.25** (2.00-2.58)	**2.61** (2.32-2.99)	**3.09** (2.74-3.54)	**3.81** (3.36-4.36)	**4.60** (4.02-5.24)	**5.42** (4.70-6.15)	**6.22** (5.34-7.04)	**7.09** (6.00-7.98)	**8.22** (6.86-9.25)	**9.40** (7.72-10.6)
24-hr	**2.64** (2.41-2.92)	**3.19** (2.92-3.54)	**4.08** (3.72-4.52)	**4.82** (4.38-5.34)	**5.93** (5.35-6.54)	**6.87** (6.16-7.57)	**7.91** (7.03-8.69)	**9.05** (7.97-9.91)	**10.7** (9.31-11.7)	**12.1** (10.4-13.3)
2-day	**3.09** (2.81-3.41)	**3.74** (3.40-4.13)	**4.74** (4.31-5.23)	**5.58** (5.06-6.14)	**6.78** (6.12-7.45)	**7.79** (6.99-8.54)	**8.87** (7.91-9.71)	**10.0** (8.89-11.0)	**11.7** (10.3-12.9)	**13.1** (11.4-14.4)
3-day	**3.27** (2.99-3.60)	**3.95** (3.61-4.35)	**5.02** (4.58-5.52)	**5.90** (5.37-6.47)	**7.17** (6.50-7.85)	**8.23** (7.42-9.00)	**9.37** (8.39-10.2)	**10.6** (9.42-11.6)	**12.4** (10.9-13.5)	**13.8** (12.0-15.2)
4-day	**3.45** (3.16-3.78)	**4.17** (3.82-4.58)	**5.30** (4.85-5.80)	**6.22** (5.68-6.80)	**7.56** (6.88-8.25)	**8.67** (7.85-9.46)	**9.86** (8.86-10.8)	**11.2** (9.95-12.2)	**13.0** (11.5-14.2)	**14.5** (12.7-15.9)
7-day	**3.95** (3.65-4.29)	**4.75** (4.39-5.17)	**5.94** (5.47-6.45)	**6.91** (6.35-7.50)	**8.30** (7.60-8.99)	**9.45** (8.61-10.2)	**10.7** (9.66-11.6)	**12.0** (10.8-13.0)	**13.9** (12.3-15.0)	**15.4** (13.5-16.7)
10-day	**4.46** (4.14-4.82)	**5.35** (4.96-5.79)	**6.60** (6.12-7.13)	**7.62** (7.04-8.22)	**9.05** (8.33-9.76)	**10.2** (9.37-11.0)	**11.4** (10.4-12.3)	**12.7** (11.6-13.7)	**14.5** (13.1-15.7)	**16.0** (14.2-17.3)
20-day	**6.01** (5.62-6.43)	**7.17** (6.71-7.67)	**8.66** (8.09-9.26)	**9.83** (9.18-10.5)	**11.4** (10.6-12.2)	**12.7** (11.8-13.5)	**13.9** (12.9-14.9)	**15.2** (14.0-16.3)	**17.0** (15.5-18.2)	**18.3** (16.6-19.6)
30-day	**7.41** (6.97-7.88)	**8.78** (8.27-9.34)	**10.4** (9.77-11.0)	**11.6** (10.9-12.3)	**13.2** (12.4-14.0)	**14.4** (13.5-15.3)	**15.6** (14.5-16.5)	**16.7** (15.5-17.7)	**18.2** (16.8-19.3)	**19.3** (17.7-20.5)
45-day	**9.32** (8.79-9.87)	**11.0** (10.4-11.6)	**12.9** (12.1-13.6)	**14.2** (13.4-15.1)	**16.0** (15.1-16.9)	**17.3** (16.3-18.3)	**18.6** (17.4-19.7)	**19.8** (18.5-20.9)	**21.3** (19.9-22.6)	**22.4** (20.8-23.8)
60-day	**11.1** (10.4-11.7)	**13.0** (12.3-13.7)	**15.0** (14.2-15.8)	**16.5** (15.6-17.4)	**18.4** (17.4-19.4)	**19.8** (18.6-20.9)	**21.1** (19.9-22.3)	**22.4** (21.0-23.6)	**24.0** (22.4-25.3)	**25.1** (23.3-26.6)

[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.

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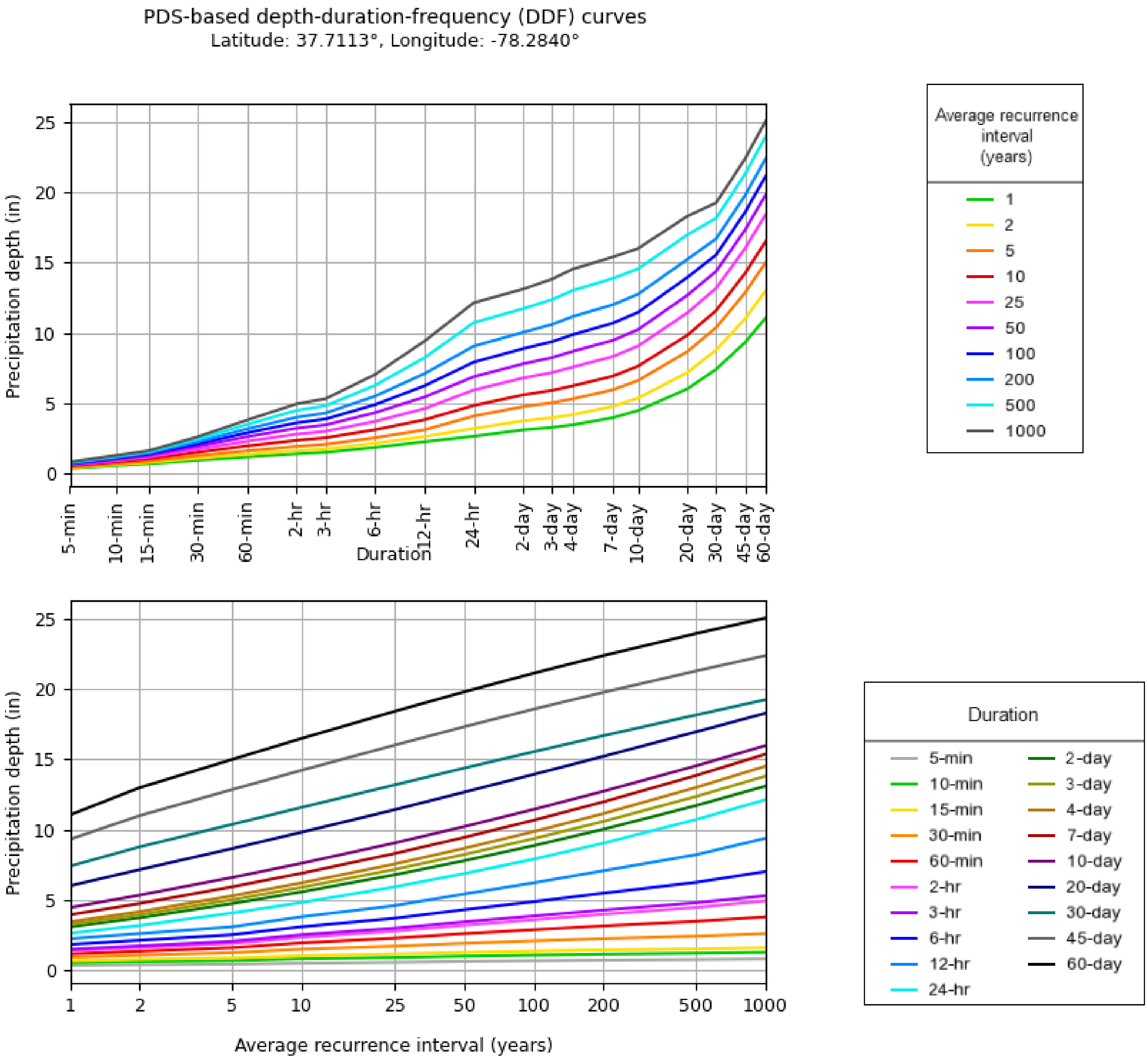
PF graphical



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Created (GMT): Wed Nov 15 22:06:27 2023

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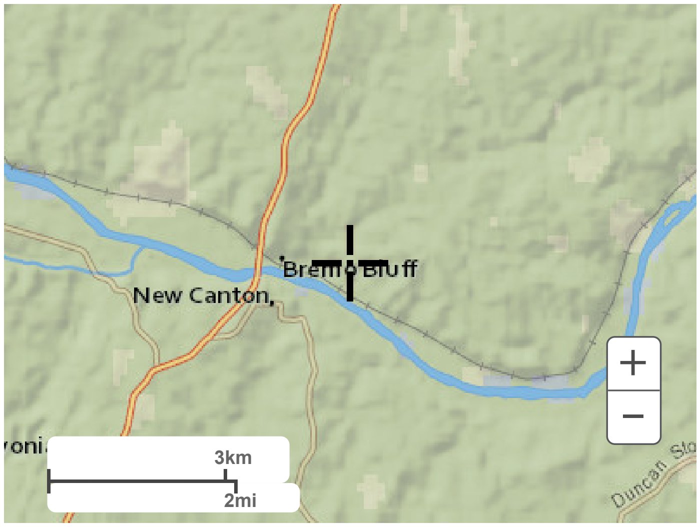
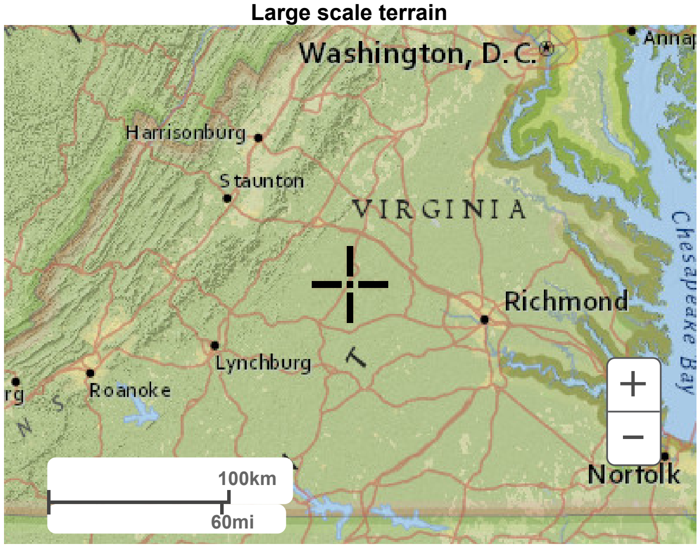
Maps & aerials

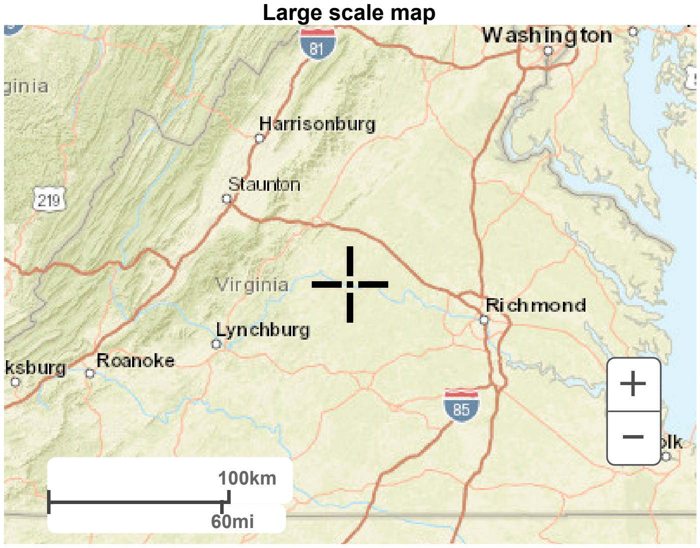
Small scale terrain



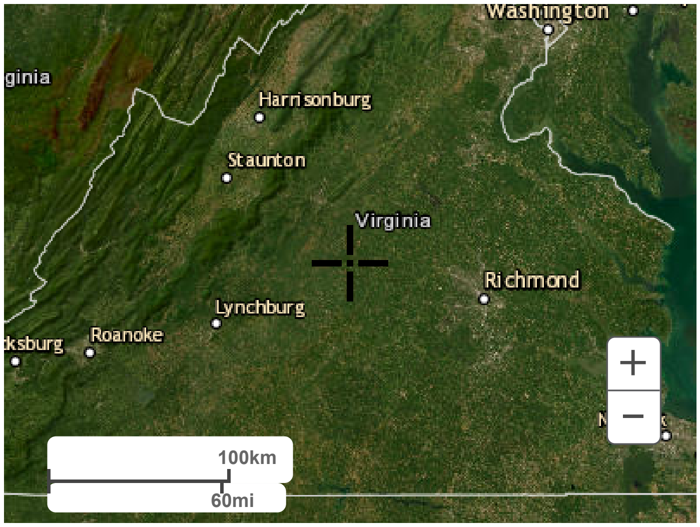
Large scale terrain



Large scale map



Large scale aerial



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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

Stormwater Analysis Attachment 2

Web Soil Survey

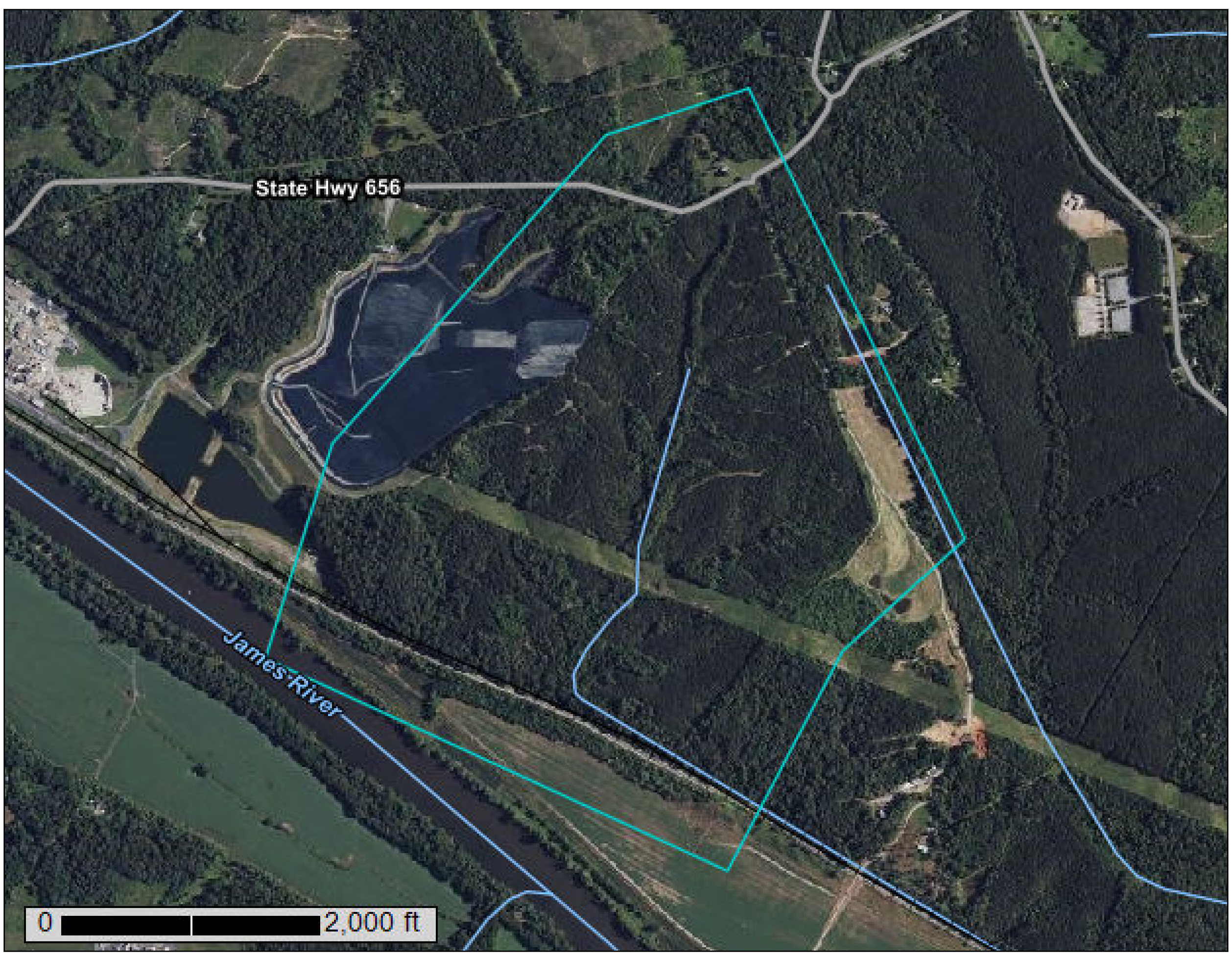
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Buckingham County, Virginia, and Fluvanna County, Virginia



June 22, 2023

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

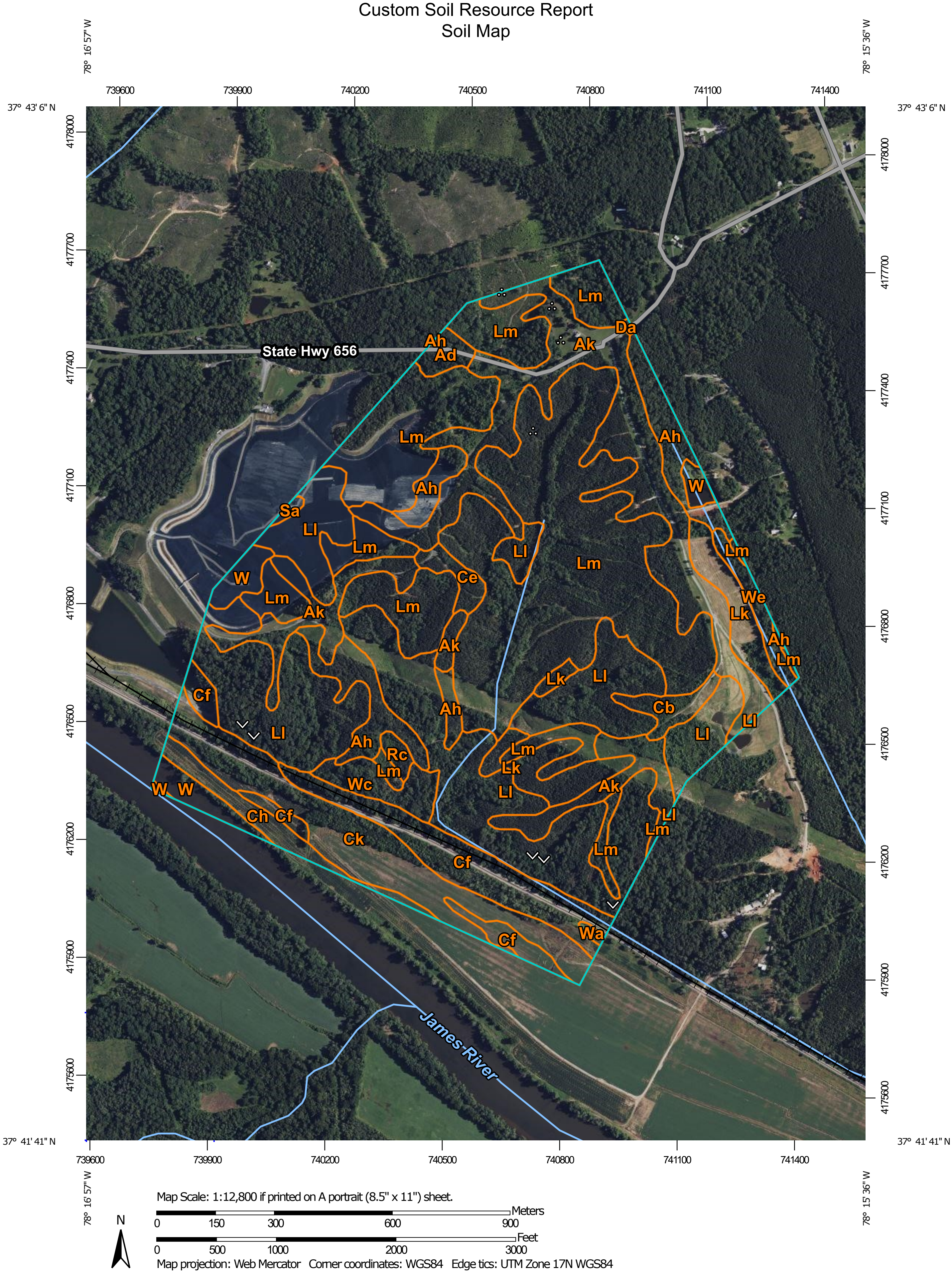
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


78° 16' 57" W
78° 15' 36" W
37° 43' 6" N
37° 41' 41" N
739600
739900
740200
740500
740800
741100
741400
4178000
4177700
4177400
4177100
4176800
4176500
4176200
4175900
4175600
State Hwy 656
James River
Lm
Da
Ah
Ad
Ak
Sa
Ll
W
Ce
Cf
Rc
Wc
Ch
Ck
Lk
We
Cb
Wa
Map Scale: 1:12,800 if printed on A portrait (8.5" x 11") sheet.
Meters
0 150 300 600 900
Feet
0 500 1000 2000 3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

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 scales ranging from 1:15,800 to 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: Buckingham County, Virginia
Survey Area Data: Version 8, Aug 24, 2022

Soil Survey Area: Fluvanna County, Virginia
Survey Area Data: Version 17, Aug 26, 2022

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: May 19, 2022—Jul 1, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
W	Water	0.2	0.0%
Subtotals for Soil Survey Area		**0.2**	**0.0%**
Totals for Area of Interest		**435.3**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ad	Appling fine sandy loam, undulating phase	2.7	0.6%
Ah	Appling sandy loam, rolling phase	21.3	4.9%
Ak	Appling sandy loam, undulating phase	65.3	15.0%
Cb	Cecil clay loam, eroded undulating phase	4.0	0.9%
Ce	Cecil sandy loam, undulating phase	3.1	0.7%
Cf	Chewacla silt loam	24.4	5.6%
Ch	Congaree fine sandy loam	6.6	1.5%
Ck	Congaree silt loam	29.2	6.7%
Da	Durham fine sandy loam, undulating phase	0.2	0.1%
Lk	Louisburg sandy loam, eroded rolling and hilly phases	16.6	3.8%
Ll	Louisburg sandy loam, eroded steep phase	101.2	23.2%
Lm	Louisburg sandy loam, rolling and hilly phases	139.2	32.0%
Rc	Rough gullied land	1.4	0.3%
Sa	Seneca fine sandy loam	0.6	0.1%
W	Water	8.8	2.0%
Wa	Wehadkee silt loam	0.4	0.1%
Wc	Wilkes sandy loam, hilly and steep phases	6.3	1.5%
We	Worsham sandy loam	3.9	0.9%
Subtotals for Soil Survey Area		**435.1**	**100.0%**
Totals for Area of Interest		**435.3**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Buckingham County, Virginia

W—Water

Map Unit Composition

Water: 100 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Fluvanna County, Virginia

Ad—Appling fine sandy loam, undulating phase

Map Unit Setting

National map unit symbol: 42pp
Elevation: 250 to 510 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Appling and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Appling

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 12 inches: fine sandy loam
H2 - 12 to 46 inches: clay
H3 - 46 to 65 inches: sandy clay loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F136XY320VA - Northern inner piedmont acidic upland forest, moist
Hydric soil rating: No

Ah—Appling sandy loam, rolling phase

Map Unit Setting

National map unit symbol: 42pt
Elevation: 210 to 440 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Appling and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Appling

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 9 inches: sandy loam
H2 - 9 to 47 inches: clay
H3 - 47 to 79 inches: sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F136XY320VA - Northern inner piedmont acidic upland forest, moist
Hydric soil rating: No

Ak—Appling sandy loam, undulating phase

Map Unit Setting

National map unit symbol: 42pv
Elevation: 200 to 480 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Appling and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Appling

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 9 inches: sandy loam
H2 - 9 to 47 inches: clay
H3 - 47 to 79 inches: sandy loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F136XY320VA - Northern inner piedmont acidic upland forest, moist
Hydric soil rating: No

Cb—Cecil clay loam, eroded undulating phase

Map Unit Setting

National map unit symbol: 42q2
Elevation: 200 to 1,400 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Cecil and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cecil

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 9 inches: clay loam
H2 - 9 to 60 inches: clay
H3 - 60 to 79 inches: sandy clay loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F136XY320VA - Northern inner piedmont acidic upland forest, moist
Hydric soil rating: No

Ce—Cecil sandy loam, undulating phase

Map Unit Setting

National map unit symbol: 42q5
Elevation: 200 to 1,400 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Cecil and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cecil

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 56 inches: clay
H3 - 56 to 72 inches: loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F136XY320VA - Northern inner piedmont acidic upland forest, moist
Hydric soil rating: No

Cf—Chewacla silt loam

Map Unit Setting

National map unit symbol: 42q6
Elevation: 200 to 430 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Chewacla and similar soils: 85 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Chewacla

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 44 inches: silt loam
H3 - 44 to 79 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 11.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Ecological site: F136XY110VA - Northern inner piedmont flood plain forest, wet
Hydric soil rating: No

Minor Components

Wehadkee

Percent of map unit: 7 percent

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Ch—Congaree fine sandy loam

Map Unit Setting

National map unit symbol: 42q8
Elevation: 100 to 500 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Congaree and similar soils: 85 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Congaree

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 30 inches: sandy clay loam
H3 - 30 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 30 to 48 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C

Ecological site: F136XY120VA - Northern inner piedmont flood plain forest, moist
Hydric soil rating: No

Minor Components

Wehadkee
Percent of map unit: 7 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Ck—Congaree silt loam

Map Unit Setting
National map unit symbol: 42q9
Elevation: 100 to 500 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Congaree and similar soils: 85 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Congaree

Setting
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile
H1 - 0 to 10 inches: silt loam
H2 - 10 to 62 inches: silty clay loam

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 30 to 48 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None

Available water supply, 0 to 60 inches: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Ecological site: F136XY120VA - Northern inner piedmont flood plain forest, moist
Hydric soil rating: No

Minor Components

Wehadkee

Percent of map unit: 7 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Da—Durham fine sandy loam, undulating phase

Map Unit Setting

National map unit symbol: 42qb
Elevation: 280 to 460 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Durham and similar soils: 85 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Durham

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 19 inches: fine sandy loam
H2 - 19 to 23 inches: sandy clay loam
H3 - 23 to 27 inches: sandy clay loam
H4 - 27 to 46 inches: silty clay loam
H5 - 46 to 52 inches: fine sandy loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F136XY320VA - Northern inner piedmont acidic upland forest, moist
Hydric soil rating: No

Minor Components

Worsham

Percent of map unit: 3 percent
Landform: Depressions, hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Lk—Louisburg sandy loam, eroded rolling and hilly phases

Map Unit Setting

National map unit symbol: 42r5
Elevation: 500 to 800 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Louisburg and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Louisburg

Setting

Landform: Hillslopes

Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 7 inches: sandy loam
H2 - 7 to 24 inches: sandy loam
H3 - 24 to 79 inches: bedrock

Properties and qualities

Slope: 8 to 25 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F136XY370VA - Northern inner piedmont acidic woodlands and glades, dry
Hydric soil rating: No

Minor Components

Worsham

Percent of map unit: 5 percent
Landform: Depressions, hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Ll—Louisburg sandy loam, eroded steep phase

Map Unit Setting

National map unit symbol: 42r6
Elevation: 500 to 800 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Louisburg and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Louisburg

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 7 inches: sandy loam
H2 - 7 to 24 inches: sandy loam
H3 - 24 to 79 inches: bedrock

Properties and qualities

Slope: 25 to 40 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F136XY370VA - Northern inner piedmont acidic woodlands and glades, dry
Hydric soil rating: No

Minor Components

Worsham

Percent of map unit: 5 percent
Landform: Depressions, hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Lm—Louisburg sandy loam, rolling and hilly phases

Map Unit Setting

National map unit symbol: 42r7
Elevation: 500 to 800 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Louisburg and similar soils: 85 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Louisburg

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 7 inches: sandy loam
H2 - 7 to 24 inches: sandy loam
H3 - 24 to 79 inches: bedrock

Properties and qualities

Slope: 8 to 25 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F136XY370VA - Northern inner piedmont acidic woodlands and glades, dry
Hydric soil rating: No

Minor Components

Worsham

Percent of map unit: 3 percent
Landform: Depressions, hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Rc—Rough gullied land

Map Unit Setting

National map unit symbol: 42s1
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Rough gullied land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rough Gullied Land

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8e
Hydric soil rating: Unranked

Sa—Seneca fine sandy loam

Map Unit Setting

National map unit symbol: 42s2
Elevation: 200 to 480 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Seneca and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Seneca

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 23 inches: clay loam
H3 - 23 to 30 inches: silty clay loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 1.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F136XY160VA - Northern inner piedmont high-bottomland forest, moist
Hydric soil rating: No

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Wa—Wehadkee silt loam

Map Unit Setting

National map unit symbol: 42sf
Elevation: 180 to 430 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Wehadkee and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wehadkee

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 42 inches: silt loam
H2 - 42 to 54 inches: silt loam
H3 - 54 to 62 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 11.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: F136XY100VA - Northern inner piedmont flood plain swamp forest, hydric soils
Hydric soil rating: Yes

Wc—Wilkes sandy loam, hilly and steep phases

Map Unit Setting

National map unit symbol: 42sh
Elevation: 180 to 390 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Wilkes and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wilkes

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Mixed mafic residuum

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 17 inches: sandy clay loam
H3 - 17 to 27 inches: bedrock

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F136XY230VA - Northern inner piedmont basic upland forest, dry
Hydric soil rating: No

We—Worsham sandy loam

Map Unit Setting

National map unit symbol: 42sk
Elevation: 200 to 480 feet
Mean annual precipitation: 24 to 58 inches
Mean annual air temperature: 55 to 58 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Worsham and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Worsham

Setting

Landform: Depressions, hillslopes

Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from granite and gneiss

Typical profile

H1 - 0 to 18 inches: sandy loam
H2 - 18 to 28 inches: clay
H3 - 28 to 36 inches: sandy loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Ecological site: F136XY300VA - Northern inner piedmont acidic upland depression swamp forest, hydric soils
Hydric soil rating: Yes

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

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.

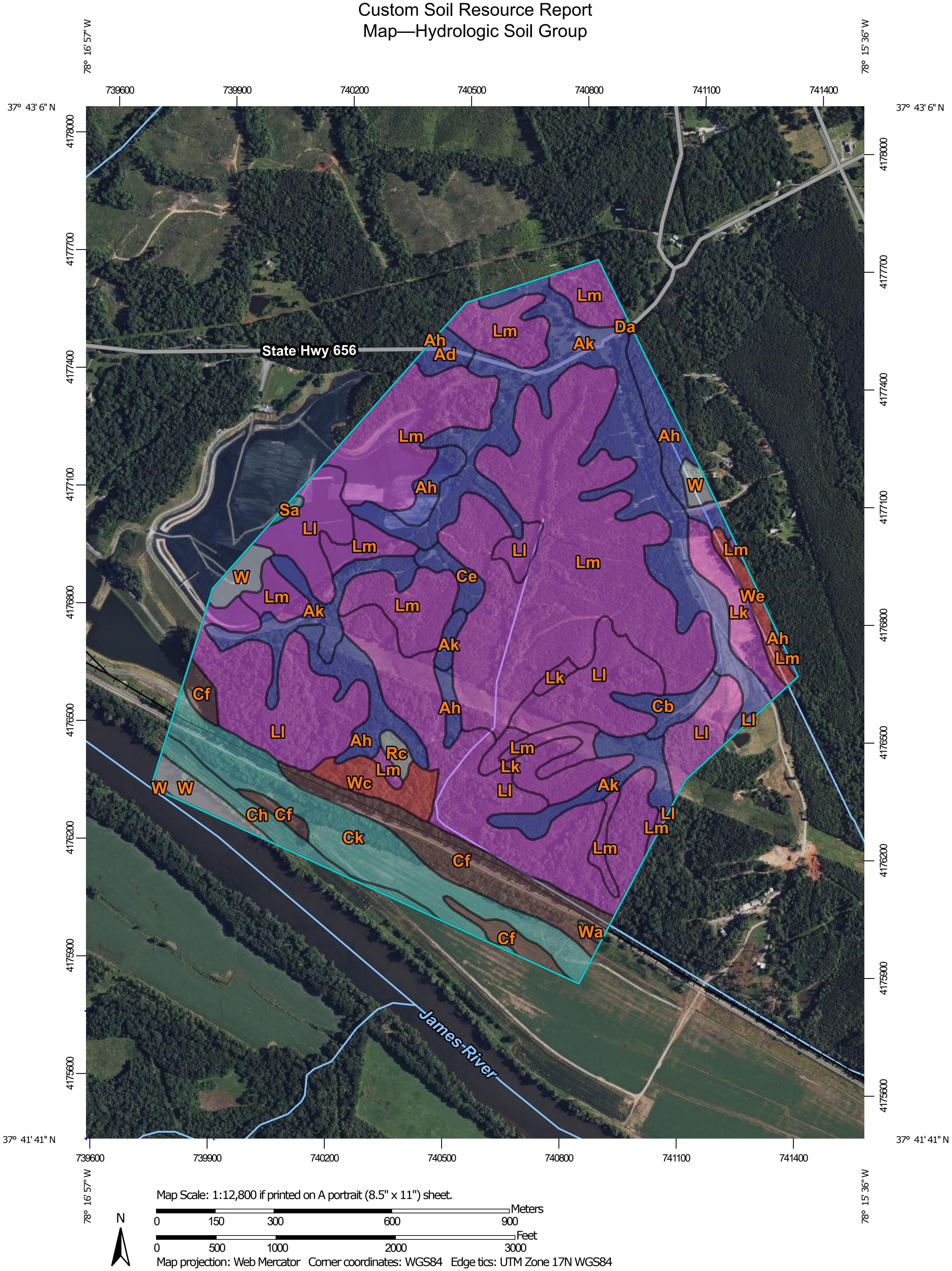
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

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.

Map—Hydrologic Soil Group



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 scales ranging from 1:15,800 to 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: Buckingham County, Virginia
Survey Area Data: Version 8, Aug 24, 2022

Soil Survey Area: Fluvanna County, Virginia
Survey Area Data: Version 17, Aug 26, 2022

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: May 19, 2022—Jul 1, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
W	Water		0.2	0.0%
Subtotals for Soil Survey Area			**0.2**	**0.0%**
Totals for Area of Interest			**435.3**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ad	Appling fine sandy loam, undulating phase	B	2.7	0.6%
Ah	Appling sandy loam, rolling phase	B	21.3	4.9%
Ak	Appling sandy loam, undulating phase	B	65.3	15.0%
Cb	Cecil clay loam, eroded undulating phase	B	4.0	0.9%
Ce	Cecil sandy loam, undulating phase	B	3.1	0.7%
Cf	Chewacla silt loam	B/D	24.4	5.6%
Ch	Congaree fine sandy loam	C	6.6	1.5%
Ck	Congaree silt loam	C	29.2	6.7%
Da	Durham fine sandy loam, undulating phase	C	0.2	0.1%
Lk	Louisburg sandy loam, eroded rolling and hilly phases	A	16.6	3.8%
Ll	Louisburg sandy loam, eroded steep phase	A	101.2	23.2%
Lm	Louisburg sandy loam, rolling and hilly phases	A	139.2	32.0%
Rc	Rough gullied land		1.4	0.3%
Sa	Seneca fine sandy loam	C	0.6	0.1%
W	Water		8.8	2.0%
Wa	Wehadkee silt loam	B/D	0.4	0.1%
Wc	Wilkes sandy loam, hilly and steep phases	D	6.3	1.5%
We	Worsham sandy loam	D	3.9	0.9%
Subtotals for Soil Survey Area			**435.1**	**100.0%**
Totals for Area of Interest			**435.3**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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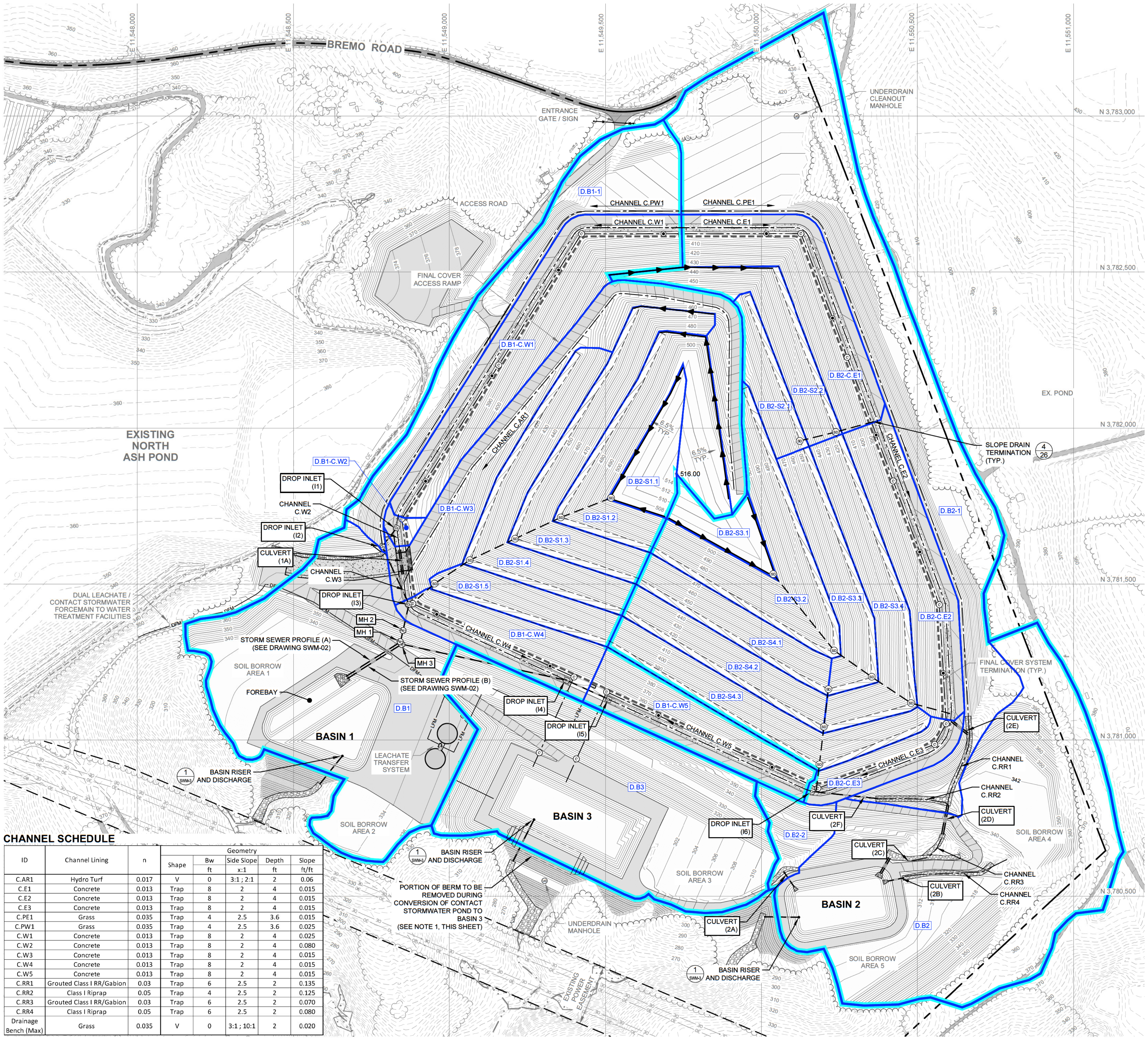
Stormwater Analysis Attachment 3

Post-Development Drainage Area Map



CHANNEL SCHEDULE

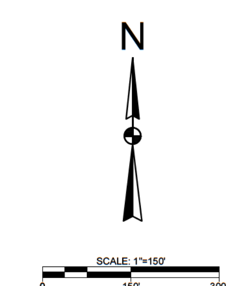
ID	Channel Lining	n	Geometry				
			Shape	Bw ft	Side Slope x:1	Depth ft	Slope ft/ft
C.AR1	Hydro Turf	0.017	V	0	3:1 ; 2:1	2	0.06
C.E1	Concrete	0.013	Trap	8	2	4	0.015
C.E2	Concrete	0.013	Trap	8	2	4	0.015
C.E3	Concrete	0.013	Trap	8	2	4	0.015
C.PE1	Grass	0.035	Trap	4	2.5	3.6	0.015
C.PW1	Grass	0.035	Trap	4	2.5	3.6	0.025
C.W1	Concrete	0.013	Trap	8	2	4	0.025
C.W2	Concrete	0.013	Trap	8	2	4	0.080
C.W3	Concrete	0.013	Trap	8	2	4	0.015
C.W4	Concrete	0.013	Trap	8	2	4	0.015
C.W5	Concrete	0.013	Trap	8	2	4	0.015
C.RR1	Grouted Class I RR/Gabion	0.03	Trap	6	2.5	2	0.135
C.RR2	Class I Riprap	0.05	Trap	4	2.5	2	0.125
C.RR3	Grouted Class I RR/Gabion	0.03	Trap	6	2.5	2	0.070
C.RR4	Class I Riprap	0.05	Trap	6	2.5	2	0.080
Drainage Bench (Max)	Grass	0.035	V	0	3:1 ; 10:1	2	0.020

LEGEND

- PARCEL BOUNDARY
- EX. TOPOGRAPHIC CONTOURS (2' INTERVALS)
- PROP. TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EX. OVERHEAD ELECTRIC LINE
- DISPOSAL UNIT BOUNDARY / BOTTOM LINER ANCHOR TRENCH (3/25)
- PROP. UNDERDRAIN MANHOLE
- PROP. ROAD
- PROP. CONCRETE CHANNEL
- PROP. CONTACT STORMWATER PIPE
- PROP. CONTACT STORMWATER PIPE MANHOLE
- PROP. CONTACT STORMWATER PIPE INLET
- PROP. DRAINAGE BENCH (4/25)
- PROP. SLOPE DRAIN (3/26)
- PROP. SLOPE DRAIN DROP INLET (5/26)
- PROP. TACK-ON DIVERSION BERM (8/25)
- PROP. NON-CONTACT STORMWATER MANHOLE
- PROP. NON-CONTACT STORMWATER DROP INLET
- PROP. NON-CONTACT STORMWATER PIPE / CULVERT
- PROP. LEACHATE FORCEMAIN
- PROP. CLASS I RIP RAP CHANNEL ARMORING
- MAJOR DRAINAGE AREA BOUNDARY
- MINOR DRAINAGE AREA BOUNDARY
- XXXX DRAINAGE AREA IDENTIFICATION

NOTES

1. POST CAPPING, THE CONTACT STORMWATER POND IS TO BE CONVERTED TO A PERMANENT STORMWATER MANAGEMENT POND (BASIN 3).
2. SEE DETAIL 1 ON DRAWING SWM-3 FOR TYPICAL BASIN RISER AND DISCHARGE DETAIL.
3. SEE DETAIL 2 ON DRAWING SWM-3 FOR CULVERT TABLE.



NOTE: SEE STORMWATER MANAGEMENT CALCULATION PACKAGE, PREPARED BY SCHNABEL ENGINEERING, DATED 02/16/24, FOR HYDRAULIC ROUTING INFORMATION AND RESULTS.

REV.	DESCRIPTION	DES. BY	CAD BY	CHK. BY	DATE
1	RESPONSE TO COMMENTS	JRD	BPG	ATN	02/16/24
0	ISSUED FOR PERMIT	JRD	BPG	ATN	07/10/23

COMMONWEALTH OF VIRGINIA
JAMES R. DIFRANCESCO
Lic. No. 025260
02/16/2024
PROFESSIONAL ENGINEER

Schnabel ENGINEERING
9800 JEB Stuart Parkway, Suite 100
Glen Allen, VA 23059
Phone: 804-649-7035
Fax: 804-264-3244
schnabel-eng.com

BREMO BLUFF FFCP MANAGEMENT FACILITY
SOLID WASTE PERMIT No. 627
FLUVANNA COUNTY, VIRGINIA

POST-DEVELOPMENT DRAINAGE AREA MAP

PREPARED FOR: Dominion Energy

PROJECT: 22130437.031
DATE: 02/16/24
DRAWING SWM-1
SHEET 40 OF 42

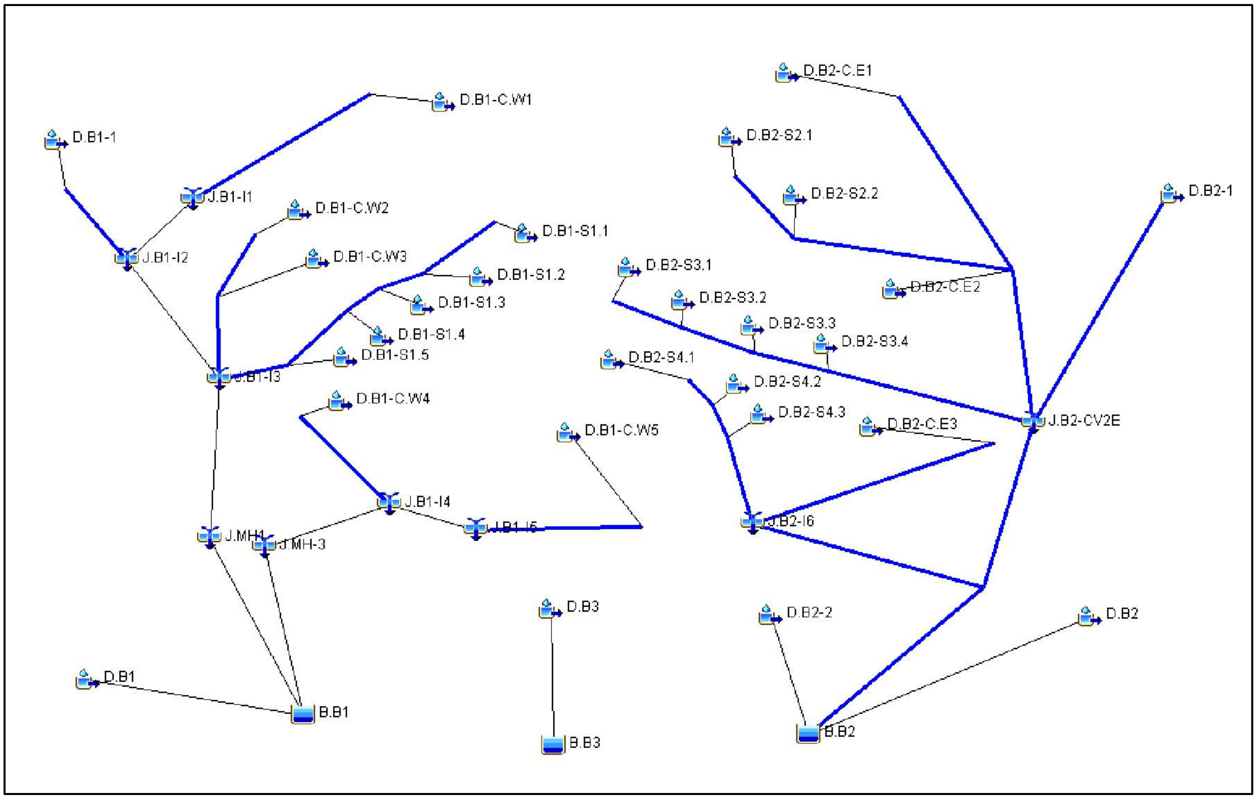
Stormwater Analysis Attachment 4

HEC-HMS Model and Inputs

Schnabel ENGINEERING

Bremo FFCP
Stormwater Analysis
Attachment 4 – HEC-HMS Model Input Data

HEC-HMS Model Setup View:



NOAA Precipitation Data https://hdsc.nws.noaa.gov/hdsc/pfds/	
Design Storm	Rainfall (in)
1-yr, 24-hr	2.64
2-yr, 24-hr	3.19
10-yr, 24-hr	4.83
25-yr, 24-hr	5.93
100-yr, 24-hr	7.91

HEC-HMS Model Inputs

Post Development Conditions	DA Basin-1											
	D.B1	D.B1-1	D.B1-C.W1	D.B1-C.W2	D.B1-C.W3	D.B1-C.W4	D.B1-C.W5	D.B1-S1.1	D.B1-S1.2	D.B1-S1.3	D.B1-S1.4	D.B1-S1.5
Total Drainage Area (ac)	12.57	4.74	5.16	0.22	5.07	2.33	2.71	1.36	3.73	3.28	3.10	1.47
Coefficient Calcs: Woods (Good), HSG A, CN = 30	0.13	0.48										
Coefficient Calcs: Open Space (Good), HSG A, CN = 39	0.00											
Coefficient Calcs: Woods (Good), HSG B, CN = 55	0.06	1.35										
Coefficient Calcs: Open Space (Good), HSG B, CN = 61	5.51	2.79	3.52	0.11	2.37	1.37	1.57	1.36	3.73	3.28	3.10	1.47
Coefficient Calcs: Gravel, HSG B, CN = 85	4.83	0.00	0.99	0.06	2.59	0.46	0.54					
Composite CN	72	56	66	70	74	67	67	61	61	61	61	61
Impervious Area:	2.05	0.13	0.65	0.05	0.11	0.49	0.60					
* Percent Impervious (%):	16%	3%	13%	22%	2%	21%	22%	0%	0%	0%	0%	0%
Sheet Flow: Length (ft) [max. 100 ft] =	85	100	100	85	65	100	100	100	100	100	100	100
Sheet Flow: Slope (ft/ft) =	0.33	0.22	0.33	0.14	0.33	0.33	0.33	0.07	0.33	0.33	0.33	0.33
Sheet Flow: Manning's (n) =	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Sheet Flow: T_t (hr) =	0.07	0.09	0.08	0.10	0.05	0.08	0.08	0.15	0.08	0.08	0.08	0.08
Shallow Concentrated Flow: Land Cover Type	Pasture/Open Space	Pasture/Open Space	Pasture/Open Space			Pasture/Open Space	Pasture/Open Space	Pasture/Open Space	Pasture/Open Space			
Shallow Concentrated Flow: Length (ft) [max. 1000 ft] =	238	175	73			42	25	115	30			
Shallow Concentrated Flow: Slope (ft/ft) =	0.03	0.06	0.29			0.22	0.30	0.07	0.07			
Shallow Concentrated Flow: Velocity (ft/s) =	1.10	1.66	3.75			3.28	3.81	1.77	1.77			
Shallow Concentrated Flow: T_t (hr) =	0.06	0.03	0.01			0.00	0.00	0.02	0.00			
Channel Flow Section 1: Length (ft) =					1520				425	830	715	578
Channel Flow Section 1: Slope (ft/ft) =					0.07				0.02	0.02	0.02	0.02
Channel Flow Section 1: Cross Section, a (ft^2) =					1.96				0.94	1.04	1.04	0.67
Channel Flow Section 1: Wetted Perim, p_w (ft) =	Modeled in HEC-HMS				5.53	Modeled in HEC-HMS			3.54	5.28	5.28	4.23
Channel Flow Section 1: Hydr Radius, r =					0.35				0.27	0.20	0.20	0.16
Channel Flow Section 1: Manning's Channel (n) =					0.03				0.04	0.04	0.04	0.04
Channel Flow Section 1: Velocity (ft/s) =					5.77				2.49	2.04	2.04	1.76
Channel Flow Section 1: T_t (hr) =					0.07				0.05	0.11	0.10	0.09
Channel Flow Section 2: Length (ft) =									665			
Channel Flow Section 2: Slope (ft/ft) =									0.02			
Channel Flow Section 2: Cross Section, a (ft^2) =									1.15			
Channel Flow Section 2: Wetted Perim, p_w (ft) =	Modeled in HEC-HMS								5.55	Modeled in HEC-HMS		
Channel Flow Section 2: Hydr Radius, r =									0.21			
Channel Flow Section 2: Manning's Channel (n) =									0.04			
Channel Flow Section 2: Velocity (ft/s) =									2.10			
Channel Flow Section 2: T_t (hr) =									0.09			
Time of Concentration, T_c (hr)	0.13	0.12	0.08	0.10	0.13	0.08	0.08	0.17	0.22	0.19	0.18	0.17
Lag Time (min) [min. 6 min per TR-55]	6	6	6	6	6	6	6	6	8	7	6	6

Post Development Conditions	DA Basin-2															DA Basin-3
	D.B2	D.B2-1	D.B2-2	D.B2-C.E1	D.B2-C.E2	D.B2-C.E3	D.B2-S2.1	D.B2-S2.2	D.B2-S3.1	D.B2-S3.2	D.B2-S3.3	D.B2-S3.4	D.B2-S4.1	D.B2-S4.2	D.B2-S4.3	D.B3
Total Drainage Area (ac)	16.46	14.19	1.05	3.76	3.53	1.17	1.18	2.15	1.02	3.63	2.16	2.89	1.74	1.85	2.86	12.13
Coefficient Calcs: Woods (Good), HSG A, CN = 30	1.97	2.69														0.03
Coefficient Calcs: Open Space (Good), HSG A, CN = 39	0.22	0.12														
Coefficient Calcs: Woods (Good), HSG B, CN = 55	3.66	3.39	0.00													0.07
Coefficient Calcs: Open Space (Good), HSG B, CN = 61	7.52	7.21	1.02	2.32	2.02	0.31	1.18	2.15	1.02	3.63	2.16	2.89	1.74	1.85	2.84	7.91
Coefficient Calcs: Gravel, HSG B, CN = 85	1.20	0.06	0.03	0.73	0.70	0.42	0.01	0.00		0.00						1.78
Composite CN	57	53	62	67	67	75	61	61	61	61	61	61	61	61	61	65
Impervious Area:	1.91	0.72		0.71	0.81	0.44									0.02	2.35
* Percent Impervious (%):	12%	5%	0%	19%	23%	38%	0%	0%	0%	0%	0%	0%	0%	0%	1%	19%
Sheet Flow: Length (ft) [max. 100 ft] =	100	100	100	100	100	62	100	92	100	90	90	90	93	87	87	100
Sheet Flow: Slope (ft/ft) =	0.13	0.03	0.32	0.33	0.33	0.25	0.33	0.33	0.07	0.33	0.33	0.33	0.33	0.33	0.33	0.27
Sheet Flow: Manning's (n) =	0.60	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Sheet Flow: T_t (hr) =	0.23	0.20	0.08	0.08	0.08	0.06	0.08	0.07	0.15	0.07	0.07	0.07	0.07	0.07	0.07	0.08
Shallow Concentrated Flow: Land Cover Type	Pasture/Open Space	Forested	Pasture/Open Space	Pasture/Open Space	Pasture/Open Space				Pasture/Open Space							Pasture/Open Space
Shallow Concentrated Flow: Length (ft) [max. 1000 ft] =	535	535	112	25	25				28							340
Shallow Concentrated Flow: Slope (ft/ft) =	0.10	0.08	0.25	0.30	0.30				0.30							0.10
Shallow Concentrated Flow: Velocity (ft/s) =	2.23	0.69	3.48	3.81	3.81				3.81							2.17
Shallow Concentrated Flow: T_t (hr) =	0.067	0.22	0.01	0.00	0.00				0.00							0.04
Channel Flow Section 1: Length (ft) =							268	491		643	753	872	692	722	743	
Channel Flow Section 1: Slope (ft/ft) =							0.02	0.02		0.02	0.02	0.02	0.02	0.02	0.02	
Channel Flow Section 1: Cross Section, a (ft^2) =							0.55	0.75		1.09	0.84	0.94	0.71	0.71	0.94	
Channel Flow Section 1: Wetted Perim, p_w (ft) =	Modeled in HEC-HMS						3.83	4.49	Modeled in HEC-HMS	5.42	4.76	5.02	4.36	4.36	5.02	Modeled in HEC-HMS
Channel Flow Section 1: Hydr Radius, r =							0.14	0.17		0.20	0.18	0.19	0.16	0.16	0.19	
Channel Flow Section 1: Manning's Channel (n) =							0.04	0.04		0.04	0.04	0.04	0.04	0.04	0.04	
Channel Flow Section 1: Velocity (ft/s) =							1.64	1.83		2.07	1.90	1.97	1.79	1.79	1.97	
Channel Flow Section 1: T_t (hr) =							0.05	0.07		0.09	0.11	0.12	0.11	0.11	0.10	
Channel Flow Section 2: Length (ft) =																
Channel Flow Section 2: Slope (ft/ft) =																
Channel Flow Section 2: Cross Section, a (ft^2) =																
Channel Flow Section 2: Wetted Perim, p_w (ft) =	Modeled in HEC-HMS															Modeled in HEC-HMS
Channel Flow Section 2: Hydr Radius, r =																
Channel Flow Section 2: Manning's Channel (n) =																
Channel Flow Section 2: Velocity (ft/s) =																
Channel Flow Section 2: T_t (hr) =																
Time of Concentration, T_c (hr)	0.30	0.42	0.09	0.08	0.08	0.06	0.12	0.15	0.15	0.16	0.18	0.19	0.18	0.18	0.17	0.13
Lag Time (min) [min. 6 min per TR-55]	11	15	6	6	6	6	6	6	6	6	7	7	6	7	6	6

* Percent impervious shown above is an input parameter for HEC-HMS modeling and only applies to open water and pavement.

Stormwater Analysis Attachment 5

HEC-HMS Model Results

Proposed Conditions - 1-Year, 24-Hour Event			
Hydrologic Element	Drainage Area (mi2)	Peak Discharge (ft3/s)	Volume (ac-ft)
B.B1	0.07147	0.54	3.67
B.B2	0.09322	0.49	3.26
B.B3	0.01896	0.18	0.76
C.E1	0.00588	2.95	0.78
C.E2	0.01661	6.41	2.18
C.E3	0.00182	1.75	0.25
C.PE1	0.02217	1.40	0.25
C.PW1	0.0074	0.35	0.08
C.RR1	0.05395	8.34	4.39
C.RR2	0.01189	2.71	1.55
C.RR3	0.06585	10.96	5.94
C.W1	0.00807	3.30	1.06
C.W2	0.00035	0.23	0.05
C.W3	0.00827	4.40	1.09
C.W4	0.00363	1.96	0.48
C.W5	0.00424	2.34	0.56
D.B1	0.01964	12.39	0.96
D.B1-C.W1	0.00807	3.50	1.06
D.B1-C.W2	0.00035	0.24	0.05
D.B1-C.W3	0.00792	4.27	1.04
D.B1-C.W4	0.00363	2.12	0.48
D.B1-C.W5	0.00424	2.56	0.56
D.B1-S1.1	0.00212	0.24	0.27
D.B1-S1.2	0.00582	0.62	0.75
D.B1-S1.3	0.00513	0.56	0.66
D.B1-S1.4	0.00484	0.54	0.63
D.B1-S1.5	0.0023	0.26	0.30
D.B1-1	0.0074	0.38	0.08
D.B2	0.02573	4.36	0.58
D.B2-C.E1	0.00588	3.20	0.78
D.B2-C.E2	0.00552	3.4	0.73
D.B2-C.E3	0.00182	1.86	0.25
D.B2-S2.1	0.00185	0.22	0.24
D.B2-S2.2	0.00336	0.38	0.43
D.B2-S3.1	0.0016	0.18	0.21
D.B2-S3.2	0.00568	0.64	0.73
D.B2-S3.3	0.00338	0.38	0.44
D.B2-S3.4	0.00451	0.49	0.58
D.B2-S4.1	0.00272	0.3	0.35
D.B2-S4.2	0.00288	0.32	0.37
D.B2-S4.3	0.00447	0.53	0.58
D.B2-1	0.02217	1.41	0.25
D.B2-2	0.00165	0.17	0.02
D.B3	0.01896	9.25	0.81
J.B1-I1	0.00807	3.3	1.06
J.B1-I2	0.01547	3.51	1.14
J.B1-I3	0.04396	9.42	4.84
J.B1-I4	0.00787	4.29	1.04
J.B1-I5	0.00424	2.34	0.56
J.B2-CV2E	0.03178	8.08	4.14
J.B2-I6	0.01189	2.71	1.55
J.MH1	0.04396	9.42	4.84
J.MH3	0.00787	4.29	1.04
S.1.1	0.00212	0.24	0.27
S.1.2	0.00794	0.85	1.03
S.1.3	0.01307	1.4	1.69
S.1.4	0.01791	1.93	2.31
S.1.5	0.02021	2.18	2.61
S.2.1	0.00185	0.21	0.24
S.2.2	0.00521	0.59	0.67
S.3.1	0.0016	0.18	0.21
S.3.2	0.00728	0.82	0.94
S.3.3	0.01066	1.19	1.38
S.3.4	0.01517	1.67	1.96
S.4.1	0.00272	0.3	0.35
S.4.2	0.00561	0.62	0.72
S.4.3	0.01007	1.15	1.3

Proposed Conditions - 2-Year, 24-Hour Event			
Hydrologic Element	Drainage Area (mi2)	Peak Discharge (ft3/s)	Volume (ac-ft)
B.B1	0.07147	0.83	4.38
B.B2	0.09322	0.55	3.72
B.B3	0.01896	0.22	1.02
C.E1	0.00588	4.04	0.94
C.E2	0.01661	9.25	2.65
C.E3	0.00182	2.20	0.30
C.PE1	0.02217	1.98	0.42
C.PW1	0.0074	0.85	0.14
C.RR1	0.05395	13.23	5.44
C.RR2	0.01189	4.37	1.88
C.RR3	0.06585	17.53	7.32
C.W1	0.00807	4.77	1.28
C.W2	0.00035	0.31	0.06
C.W3	0.00827	6.45	1.32
C.W4	0.00363	2.73	0.58
C.W5	0.00424	3.23	0.68
D.B1	0.01964	17.06	1.34
D.B1-C.W1	0.00807	5.19	1.29
D.B1-C.W2	0.00035	0.32	0.06
D.B1-C.W3	0.00792	6.25	1.27
D.B1-C.W4	0.00363	2.91	0.58
D.B1-C.W5	0.00424	3.48	0.68
D.B1-S1.1	0.00212	0.52	0.33
D.B1-S1.2	0.00582	1.36	0.91
D.B1-S1.3	0.00513	1.21	0.81
D.B1-S1.4	0.00484	1.15	0.76
D.B1-S1.5	0.0023	0.56	0.36
D.B1-1	0.0074	0.89	0.14
D.B2	0.02573	6.45	0.86
D.B2-C.E1	0.00588	4.47	0.94
D.B2-C.E2	0.00552	4.62	0.89
D.B2-C.E3	0.00182	2.32	0.3
D.B2-S2.1	0.00185	0.46	0.29
D.B2-S2.2	0.00336	0.82	0.53
D.B2-S3.1	0.0016	0.39	0.25
D.B2-S3.2	0.00568	1.39	0.89
D.B2-S3.3	0.00338	0.79	0.53
D.B2-S3.4	0.00451	1.06	0.71
D.B2-S4.1	0.00272	0.64	0.43
D.B2-S4.2	0.00288	0.68	0.45
D.B2-S4.3	0.00447	1.12	0.7
D.B2-1	0.02217	2.03	0.42
D.B2-2	0.00165	0.41	0.04
D.B3	0.01896	13.09	1.12
J.B1-I1	0.00807	4.77	1.28
J.B1-I2	0.01547	5.2	1.42
J.B1-I3	0.04396	15.49	5.92
J.B1-I4	0.00787	5.96	1.27
J.B1-I5	0.00424	3.23	0.68
J.B2-CV2E	0.03178	12.81	5.03
J.B2-I6	0.01189	4.6	1.88
J.MH1	0.04396	15.49	5.92
J.MH3	0.00787	5.96	1.27
S.1.1	0.00212	0.51	0.33
S.1.2	0.00794	1.85	1.25
S.1.3	0.01307	3.05	2.05
S.1.4	0.01791	4.18	2.81
S.1.5	0.02021	4.71	3.17
S.2.1	0.00185	0.46	0.29
S.2.2	0.00521	1.27	0.82
S.3.1	0.0016	0.38	0.25
S.3.2	0.00728	1.74	1.14
S.3.3	0.01066	2.5	1.67
S.3.4	0.01517	3.56	2.38
S.4.1	0.00272	0.64	0.43
S.4.2	0.00561	1.31	0.88
S.4.3	0.01007	2.4	1.58

Proposed Conditions - 10-Year, 24-Hour Event			
Hydrologic Element	Drainage Area (mi2)	Peak Discharge (ft3/s)	Volume (ac-ft)
B.B1	0.07147	4.63	9.43
B.B2	0.09322	4.66	8.95
B.B3	0.01896	0.32	1.74
C.E1	0.00588	7.82	1.44
C.E2	0.01661	18.90	4.05
C.E3	0.00182	3.53	0.45
C.PE1	0.02217	7.93	1.18
C.PW1	0.0074	4.07	0.42
C.RR1	0.05395	31.59	8.87
C.RR2	0.01189	11.40	2.88
C.RR3	0.06585	42.02	11.75
C.W1	0.00807	9.71	1.97
C.W2	0.00035	0.56	0.09
C.W3	0.00827	12.63	2.03
C.W4	0.00363	5.15	0.89
C.W5	0.00424	6.05	1.04
D.B1	0.01964	31.19	2.60
D.B1-C.W1	0.00807	10.58	1.97
D.B1-C.W2	0.00035	0.57	0.09
D.B1-C.W3	0.00792	12.20	1.94
D.B1-C.W4	0.00363	5.38	0.89
D.B1-C.W5	0.00424	6.36	1.04
D.B1-S1.1	0.00212	1.75	0.51
D.B1-S1.2	0.00582	4.32	1.40
D.B1-S1.3	0.00513	4.06	1.23
D.B1-S1.4	0.00484	3.96	1.16
D.B1-S1.5	0.0023	1.90	0.55
D.B1-1	0.0074	4.34	0.42
D.B2	0.02573	17.32	1.98
D.B2-C.E1	0.00588	8.44	1.44
D.B2-C.E2	0.00552	8.37	1.36
D.B2-C.E3	0.00182	3.67	0.45
D.B2-S2.1	0.00185	1.55	0.44
D.B2-S2.2	0.00336	2.79	0.81
D.B2-S3.1	0.0016	1.32	0.38
D.B2-S3.2	0.00568	4.7	1.36
D.B2-S3.3	0.00338	2.73	0.81
D.B2-S3.4	0.00451	3.55	1.08
D.B2-S4.1	0.00272	2.2	0.65
D.B2-S4.2	0.00288	2.33	0.69
D.B2-S4.3	0.00447	3.71	1.07
D.B2-1	0.02217	8.01	1.18
D.B2-2	0.00165	1.37	0.12
D.B3	0.01896	25.41	2.21
J.B1-I1	0.00807	9.71	1.97
J.B1-I2	0.01547	13.54	2.38
J.B1-I3	0.04396	40.37	9.27
J.B1-I4	0.00787	11.2	1.93
J.B1-I5	0.00424	6.05	1.04
J.B2-CV2E	0.03178	31.04	7.69
J.B2-I6	0.01189	11.71	2.88
J.MH1	0.04396	40.37	9.27
J.MH3	0.00787	11.2	1.93
S.1.1	0.00212	1.74	0.51
S.1.2	0.00794	6.02	1.91
S.1.3	0.01307	10.02	3.14
S.1.4	0.01791	13.91	4.3
S.1.5	0.02021	15.77	4.86
S.2.1	0.00185	1.54	0.44
S.2.2	0.00521	4.31	1.25
S.3.1	0.0016	1.3	0.38
S.3.2	0.00728	5.97	1.75
S.3.3	0.01066	8.65	2.56
S.3.4	0.01517	12.14	3.64
S.4.1	0.00272	2.19	0.65
S.4.2	0.00561	4.5	1.35
S.4.3	0.01007	8.19	2.42

Proposed Conditions - 25-Year, 24-Hour Event			
Hydrologic Element	Drainage Area (mi2)	Peak Discharge (ft3/s)	Volume (ac-ft)
B.B1	0.07147	8.54	13.11
B.B2	0.09322	8.39	13.06
B.B3	0.01896	0.37	2.17
C.E1	0.00588	10.17	1.78
C.E2	0.01661	25.43	5.01
C.E3	0.00182	4.25	0.56
C.PE1	0.02217	13.08	1.86
C.PW1	0.0074	6.86	0.66
C.RR1	0.05395	45.93	11.39
C.RR2	0.01189	16.01	3.56
C.RR3	0.06585	60.94	14.95
C.W1	0.00807	12.95	2.43
C.W2	0.00035	0.70	0.11
C.W3	0.00827	16.19	2.51
C.W4	0.00363	6.60	1.10
C.W5	0.00424	7.74	1.29
D.B1	0.01964	39.30	3.55
D.B1-C.W1	0.00807	13.85	2.44
D.B1-C.W2	0.00035	0.71	0.11
D.B1-C.W3	0.00792	15.63	2.40
D.B1-C.W4	0.00363	6.83	1.10
D.B1-C.W5	0.00424	8.05	1.29
D.B1-S1.1	0.00212	2.58	0.63
D.B1-S1.2	0.00582	6.50	1.73
D.B1-S1.3	0.00513	6.04	1.53
D.B1-S1.4	0.00484	5.84	1.44
D.B1-S1.5	0.0023	2.79	0.68
D.B1-1	0.0074	6.95	0.66
D.B2	0.02573	25.14	2.91
D.B2-C.E1	0.00588	10.80	1.78
D.B2-C.E2	0.00552	10.57	1.68
D.B2-C.E3	0.00182	4.39	0.56
D.B2-S2.1	0.00185	2.27	0.55
D.B2-S2.2	0.00336	4.1	1
D.B2-S3.1	0.0016	1.95	0.48
D.B2-S3.2	0.00568	6.92	1.69
D.B2-S3.3	0.00338	4.04	1
D.B2-S3.4	0.00451	5.28	1.34
D.B2-S4.1	0.00272	3.26	0.81
D.B2-S4.2	0.00288	3.45	0.86
D.B2-S4.3	0.00447	5.45	1.33
D.B2-1	0.02217	13.44	1.86
D.B2-2	0.00165	2.02	0.18
D.B3	0.01896	32.85	3.05
J.B1-I1	0.00807	12.95	2.43
J.B1-I2	0.01547	19.11	3.1
J.B1-I3	0.04396	57.65	11.63
J.B1-I4	0.00787	14.34	2.39
J.B1-I5	0.00424	7.74	1.29
J.B2-CV2E	0.03178	43.44	9.53
J.B2-I6	0.01189	16.35	3.56
J.MH1	0.04396	57.65	11.63
J.MH3	0.00787	14.34	2.39
S.1.1	0.00212	2.57	0.63
S.1.2	0.00794	9.01	2.36
S.1.3	0.01307	14.98	3.89
S.1.4	0.01791	20.74	5.33
S.1.5	0.02021	23.5	6.02
S.2.1	0.00185	2.26	0.55
S.2.2	0.00521	6.34	1.55
S.3.1	0.0016	1.92	0.48
S.3.2	0.00728	8.8	2.17
S.3.3	0.01066	12.8	3.17
S.3.4	0.01517	18.01	4.52
S.4.1	0.00272	3.25	0.81
S.4.2	0.00561	6.68	1.67
S.4.3	0.01007	12.1	3

Proposed Conditions - 100-Year, 24-Hour Event			
Hydrologic Element	Drainage Area (mi2)	Peak Discharge (ft3/s)	Volume (ac-ft)
B.B1	0.07147	49.90	19.95
B.B2	0.09322	50.13	20.99
B.B3	0.01896	0.69	2.86
C.E1	0.00588	14.21	2.39
C.E2	0.01661	36.80	6.74
C.E3	0.00182	5.46	0.75
C.PE1	0.02217	23.58	3.32
C.PW1	0.0074	11.49	1.17
C.RR1	0.05395	73.68	16.14
C.RR2	0.01189	24.14	4.79
C.RR3	0.06585	97.15	20.93
C.W1	0.00807	18.57	3.28
C.W2	0.00035	0.95	0.14
C.W3	0.00827	22.19	3.38
C.W4	0.00363	9.10	1.48
C.W5	0.00424	10.64	1.73
D.B1	0.01964	53.07	5.36
D.B1-C.W1	0.00807	19.51	3.28
D.B1-C.W2	0.00035	0.95	0.14
D.B1-C.W3	0.00792	21.38	3.23
D.B1-C.W4	0.00363	9.35	1.48
D.B1-C.W5	0.00424	10.98	1.73
D.B1-S1.1	0.00212	4.05	0.85
D.B1-S1.2	0.00582	10.38	2.33
D.B1-S1.3	0.00513	9.56	2.06
D.B1-S1.4	0.00484	9.19	1.94
D.B1-S1.5	0.0023	4.39	0.92
D.B1-1	0.0074	11.69	1.17
D.B2	0.02573	39.45	4.81
D.B2-C.E1	0.00588	14.88	2.40
D.B2-C.E2	0.00552	14.38	2.26
D.B2-C.E3	0.00182	5.61	0.75
D.B2-S2.1	0.00185	3.55	0.74
D.B2-S2.2	0.00336	6.43	1.35
D.B2-S3.1	0.0016	3.06	0.64
D.B2-S3.2	0.00568	10.85	2.28
D.B2-S3.3	0.00338	6.37	1.35
D.B2-S3.4	0.00451	8.36	1.81
D.B2-S4.1	0.00272	5.14	1.09
D.B2-S4.2	0.00288	5.44	1.16
D.B2-S4.3	0.00447	8.54	1.79
D.B2-1	0.02217	23.87	3.32
D.B2-2	0.00165	3.15	0.31
D.B3	0.01896	45.79	4.69
J.B1-I1	0.00807	18.57	3.28
J.B1-I2	0.01547	28.56	4.45
J.B1-I3	0.04396	87.94	15.93
J.B1-I4	0.00787	19.75	3.21
J.B1-I5	0.00424	10.64	1.73
J.B2-CV2E	0.03178	65.24	12.82
J.B2-I6	0.01189	24.51	4.79
J.MH1	0.04396	87.94	15.93
J.MH3	0.00787	19.75	3.21
S.1.1	0.00212	4.03	0.85
S.1.2	0.00794	14.34	3.18
S.1.3	0.01307	23.81	5.24
S.1.4	0.01791	32.91	7.18
S.1.5	0.02021	37.26	8.1
S.2.1	0.00185	3.54	0.74
S.2.2	0.00521	9.95	2.09
S.3.1	0.0016	3.03	0.64
S.3.2	0.00728	13.84	2.92
S.3.3	0.01066	20.15	4.27
S.3.4	0.01517	28.44	6.08
S.4.1	0.00272	5.13	1.09
S.4.2	0.00561	10.54	2.25
S.4.3	0.01007	19.05	4.04

HEC-HMS Pond Model Results:

Pond ID	1-yr					2-yr					10-yr					25-yr					100-yr				
	Inflow	Inflow Volume	Water Elev.	Discharge	Discharge Volume	Inflow	Inflow Volume	Water Elev.	Discharge	Discharge Volume	Inflow	Inflow Volume	Water Elev.	Discharge	Discharge Volume	Inflow	Inflow Volume	Water Elev.	Discharge	Discharge Volume	Inflow	Inflow Volume	Water Elev.	Discharge	Discharge Volume
	ft^3/s	*ac-ft*	*ft*	*ft^3/s*	*ac-ft*	*ft3/s*	*ac-ft*	*ft*	*ft3/s*	*ac-ft*	*ft3/s*	*ac-ft*	*ft*	*ft3/s*	*ac-ft*	*ft3/s*	*ac-ft*	*ft*	*ft3/s*	*ac-ft*	*ft3/s*	*ac-ft*	*ft*	*ft3/s*	*ac-ft*
Basin 1	**25.89**	**6.84**	**325.10**	**0.54**	**3.67**	**38.71**	**8.52**	**326.09**	**0.83**	**4.38**	**82.76**	**13.80**	**326.86**	**4.63**	**9.43**	**111.28**	**17.57**	**327.28**	**8.54**	**13.11**	**160.75**	**24.50**	**328.23**	**49.90**	**19.95**
Basin 2	**15.59**	**6.54**	**300.16**	**0.49**	**3.26**	**24.60**	**8.23**	**301.35**	**0.55**	**3.72**	**60.44**	**13.84**	**302.36**	**4.66**	**8.95**	**87.06**	**18.04**	**302.78**	**8.39**	**13.07**	**136.65**	**26.05**	**303.73**	**50.13**	**20.99**
Basin 3	**9.27**	**0.81**	**282.57**	**0.18**	**0.76**	**13.14**	**1.12**	**282.82**	**0.22**	**1.02**	**25.41**	**2.21**	**283.74**	**0.32**	**1.74**	**32.84**	**3.05**	**284.41**	**0.37**	**2.17**	**45.79**	**4.69**	**285.64**	**0.69**	**2.86**

Pond ID	25-yr				100-yr			
	Inflow	Inflow Volume	Water Elev.	Discharge	Inflow	Inflow Volume	Water Elev.	Discharge
	ft^3/s	*ac-ft*	*ft*	*ft^3/s*	*ft3/s*	*ac-ft*	*ft*	*ft3/s*
CSWP	**129.78**	**15.76**	**290.60**	**3.34**	**205.36**	**22.20**	**293.97**	**3.34**

Note:

1 Contact Water Basin will have pumped discharge of 1500 gallons per minute (3.34 cfs)

2 Maximum contributing drainage area of 28 acres of open CCR with CN of 91

3 Direct drainage area to Contact Water Basin is 12 acres with CN of 85

Stormwater Analysis Attachment 6

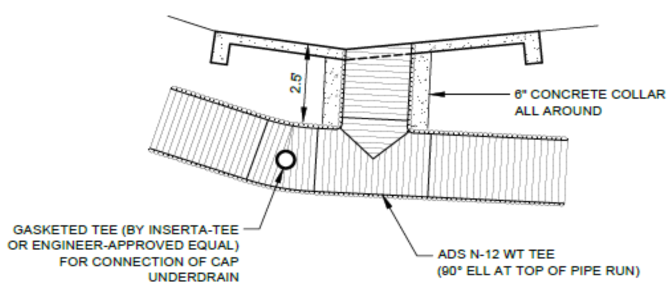
Slope Drains

Non-Contact Slope Drain Drop Inlet - INPUTS

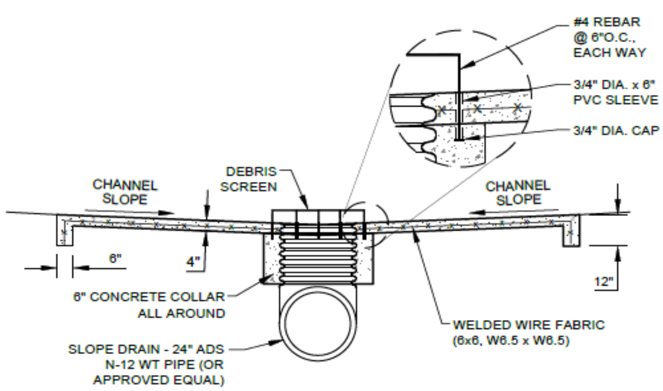
Invert (ft):	0	24" ADS N-12 Pipe Opening w/ Debris Screen
Diameter (in)	24	
Co	0.67	
Cw	3	
Orifice Area (ft^2)	3.14	
Weir Perimeter (ft)	6.28	
% Area Clogged	5	

Note: Max Depth of Drainage Benches are 2 FT

Water Elevation	Riser			
	Drop Inlet	Flow (Orifice)	Flow (Weir)	Controlling Flow
(ft)	*(ft)*	*(cfs)*	*(cfs)*	
0.00	0.00	0.00	0.00	(cfs)
0.10	0.10	5.07	0.57	0.57
0.20	0.20	7.18	1.60	1.60
0.30	0.30	8.79	2.94	2.94
0.40	0.40	10.15	4.53	4.53
0.50	0.50	11.35	6.33	6.33
0.60	0.60	12.43	8.32	8.32
0.70	0.70	13.43	10.49	10.49
0.80	0.80	14.35	12.81	12.81
0.90	0.90	15.22	15.29	15.22
1.00	1.00	16.05	17.91	16.05
1.10	1.10	16.83	20.66	16.83
1.20	1.20	17.58	23.54	17.58
1.30	1.30	18.30	26.54	18.30
1.40	1.40	18.99	29.66	18.99
1.50	1.50	19.65	32.90	19.65
1.60	1.60	20.30	36.24	20.30
1.70	1.70	20.92	39.69	20.92
1.80	1.80	21.53	43.24	21.53
1.90	1.90	22.12	46.90	22.12
2.00	2.00	22.69	50.65	22.69

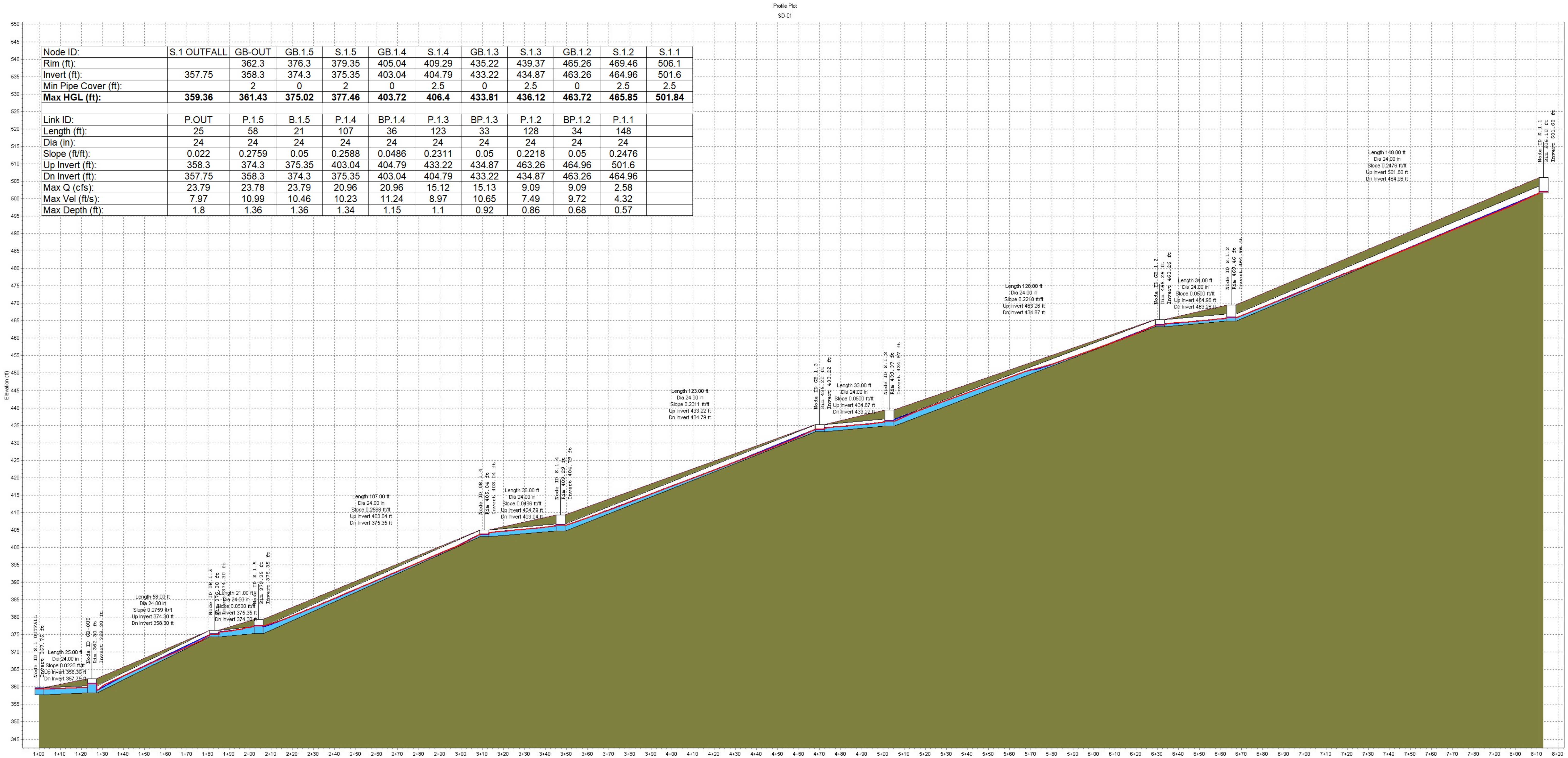


SECTION A-A'



SECTION B-B'

FFCP FacilitySlope Drain Profile:
(25-yr, 24-hr storm event)

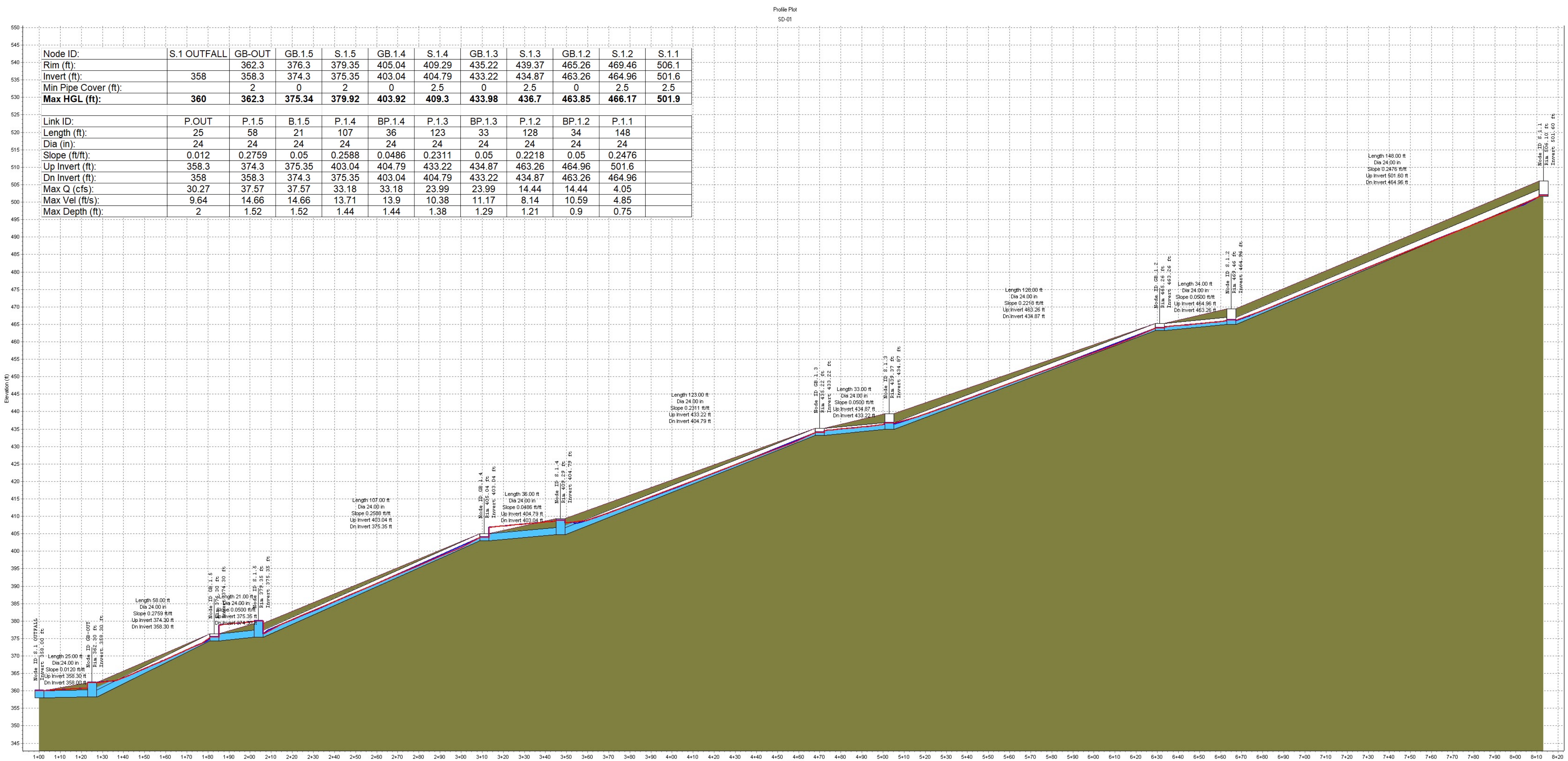


Node ID:	S.1 OUTFALL	GB-OUT	GB.1.5	S.1.5	GB.1.4	S.1.4	GB.1.3	S.1.3	GB.1.2	S.1.2	S.1.1
Rim (ft):		362.3	376.3	379.35	405.04	409.29	435.22	439.37	465.26	469.46	506.1
Invert (ft):	357.75	358.3	374.3	375.35	403.04	404.79	433.22	434.87	463.26	464.96	501.6
Min Pipe Cover (ft):		2	0	2	0	2.5	0	2.5	0	2.5	2.5
Max HGL (ft):	**359.36**	**361.43**	**375.02**	**377.46**	**403.72**	**406.4**	**433.81**	**436.12**	**463.72**	**465.85**	**501.84**

Link ID:	P.OUT	P.1.5	B.1.5	P.1.4	BP.1.4	P.1.3	BP.1.3	P.1.2	BP.1.2	P.1.1	
Length (ft):	25	58	21	107	36	123	33	128	34	148	
Dia (in):	24	24	24	24	24	24	24	24	24	24	
Slope (ft/ft):	0.022	0.2759	0.05	0.2588	0.0486	0.2311	0.05	0.2218	0.05	0.2476	
Up Invert (ft):	358.3	374.3	375.35	403.04	404.79	433.22	434.87	463.26	464.96	501.6	
Dn Invert (ft):	357.75	358.3	374.3	375.35	403.04	404.79	433.22	434.87	463.26	464.96	
Max Q (cfs):	23.79	23.78	23.79	20.96	20.96	15.12	15.13	9.09	9.09	2.58	
Max Vel (ft/s):	7.97	10.99	10.46	10.23	11.24	8.97	10.65	7.49	9.72	4.32	
Max Depth (ft):	1.8	1.36	1.36	1.34	1.15	1.1	0.92	0.86	0.68	0.57	

Autodesk Storm and Sanitary Analysis

FFCP FacilitySlope Drain Profile:
(100-yr, 24-hr storm event)



Node ID:	S.1 OUTFALL	GB-OUT	GB.1.5	S.1.5	GB.1.4	S.1.4	GB.1.3	S.1.3	GB.1.2	S.1.2	S.1.1
Rim (ft):		362.3	376.3	379.35	405.04	409.29	435.22	439.37	465.26	469.46	506.1
Invert (ft):	358	358.3	374.3	375.35	403.04	404.79	433.22	434.87	463.26	464.96	501.6
Min Pipe Cover (ft):		2	0	2	0	2.5	0	2.5	0	2.5	2.5
Max HGL (ft):	**360**	**362.3**	**375.34**	**379.92**	**403.92**	**409.3**	**433.98**	**436.7**	**463.85**	**466.17**	**501.9**

Link ID:	P.OUT	P.1.5	B.1.5	P.1.4	BP.1.4	P.1.3	BP.1.3	P.1.2	BP.1.2	P.1.1
Length (ft):	25	58	21	107	36	123	33	128	34	148
Dia (in):	24	24	24	24	24	24	24	24	24	24
Slope (ft/ft):	0.012	0.2759	0.05	0.2588	0.0486	0.2311	0.05	0.2218	0.05	0.2476
Up Invert (ft):	358.3	374.3	375.35	403.04	404.79	433.22	434.87	463.26	464.96	501.6
Dn Invert (ft):	358	358.3	374.3	375.35	403.04	404.79	433.22	434.87	463.26	464.96
Max Q (cfs):	30.27	37.57	37.57	33.18	33.18	23.99	23.99	14.44	14.44	4.05
Max Vel (ft/s):	9.64	14.66	14.66	13.71	13.9	10.38	11.17	8.14	10.59	4.85
Max Depth (ft):	2	1.52	1.52	1.44	1.44	1.38	1.29	1.21	0.9	0.75

Autodesk Storm and Sanitary Analysis

Stormwater Analysis Attachment 7

Culvert Calculations

FFCP FACILITY CULVERT SCHEDULE																
Culvert Name/No.	Culvert Details							Channel Details		Max Capacity	Design Flows				Notes
	Diameter (in) **[A]**	No. of Barrels	Type **[B]**	Slope (%) **[C]**	Length (ft) **[x]**	Inv. In El. **[I]**	Inv. Out El. **[O]**	Reference Top El.	Reference HEC HMS Node	Q_{MAX}	Q_2	Q_{10}	Q_{25}	Q_{100}	
C1A	36	2	Class IV RCP	1.7%	80	360.2	358.8	364.2	C.W3	100.7	6.5	12.6	16.2	22.2	With Headwall and Endwall
C2A	18	1	Class III RCP	1.7%	60	304.0	303.0	308.0	D.B2-2	15.4	0.4	1.4	2.0	3.2	With Headwall
C2B	36	1	Class III RCP	3.3%	54	304.8	303.0	308.8	D.B2	53.1	6.5	17.3	25.1	39.5	With Headwall
C2C	36	2	Class III RCP	6.1%	56	305.4	302.0	309.4	C.RR3	169.2	17.7	42.0	61.0	97.2	With Headwall
C2D	36	2	Class III RCP	8.3%	96	332.0	324.0	336.0	C.RR3	103.2	17.7	42.0	61.0	97.2	With Headwall and Endwall
C2E	36	2	Class III RCP	5.1%	68	365.5	362.0	369.5	C.RR1	102.0	13.4	31.6	46.1	73.7	With Headwall and Endwall
C2F	24	1	Class III RCP	1.6%	208	354.3	351.0	362.3	C.RR2	40.0	4.4	11.4	16.0	24.1	Drop Inlet

HY-8 Culvert Analysis Report

Culvert Data: C1A

Site Data - C1A

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 360.20 ft

Outlet Station: 80.00 ft

Outlet Elevation: 358.80 ft

Number of Barrels: 2

Culvert Data Summary - C1A

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

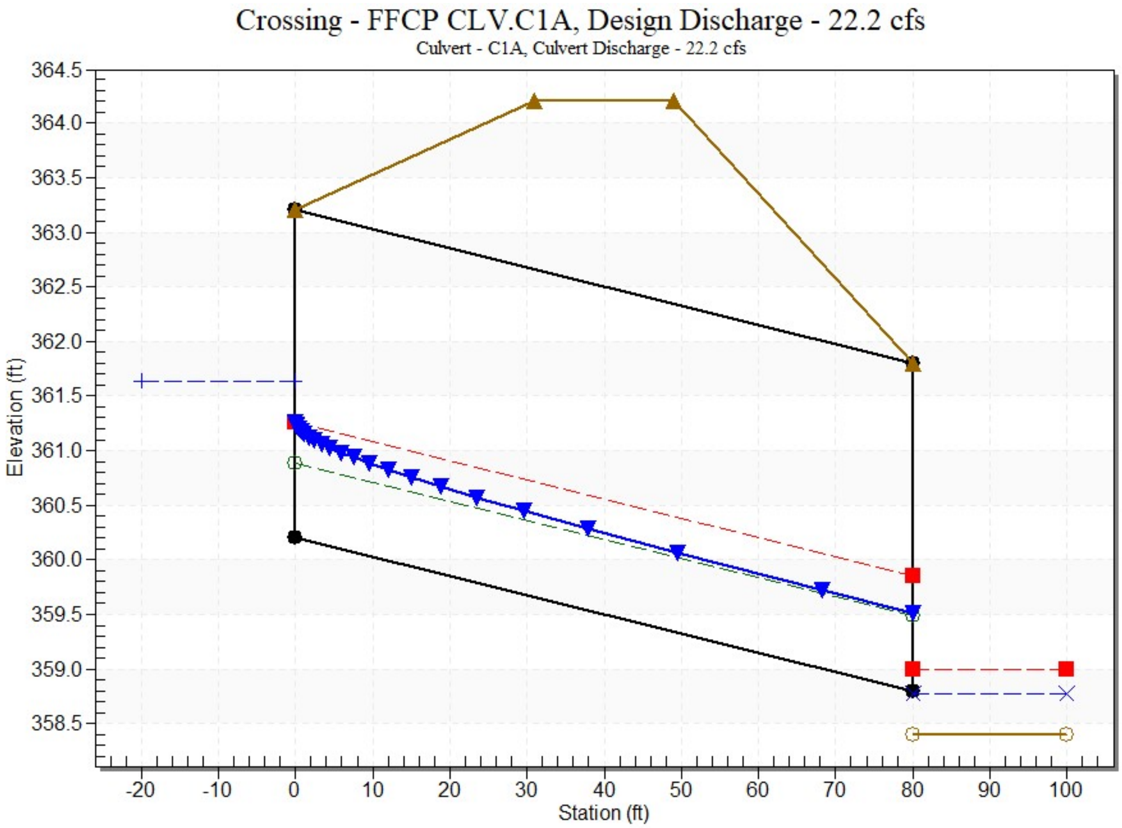
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C1A



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: FFCP CLV.C1A

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C1A Discharge (cfs)	Roadway Discharge (cfs)	Iterations
360.96	Q-2YR	6.50	6.50	0.00	1
361.27	Q-10YR	12.60	12.60	0.00	1
361.42	Q-25YR	16.20	16.20	0.00	1
361.64	Q-100YR	22.20	22.20	0.00	1
364.20	Overtopping	100.66	100.66	0.00	Overtopping

Culvert Data: C2A

Site Data - C2A

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 304.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 303.00 ft

Number of Barrels: 1

Culvert Data Summary - C2A

Barrel Shape: Circular

Barrel Diameter: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

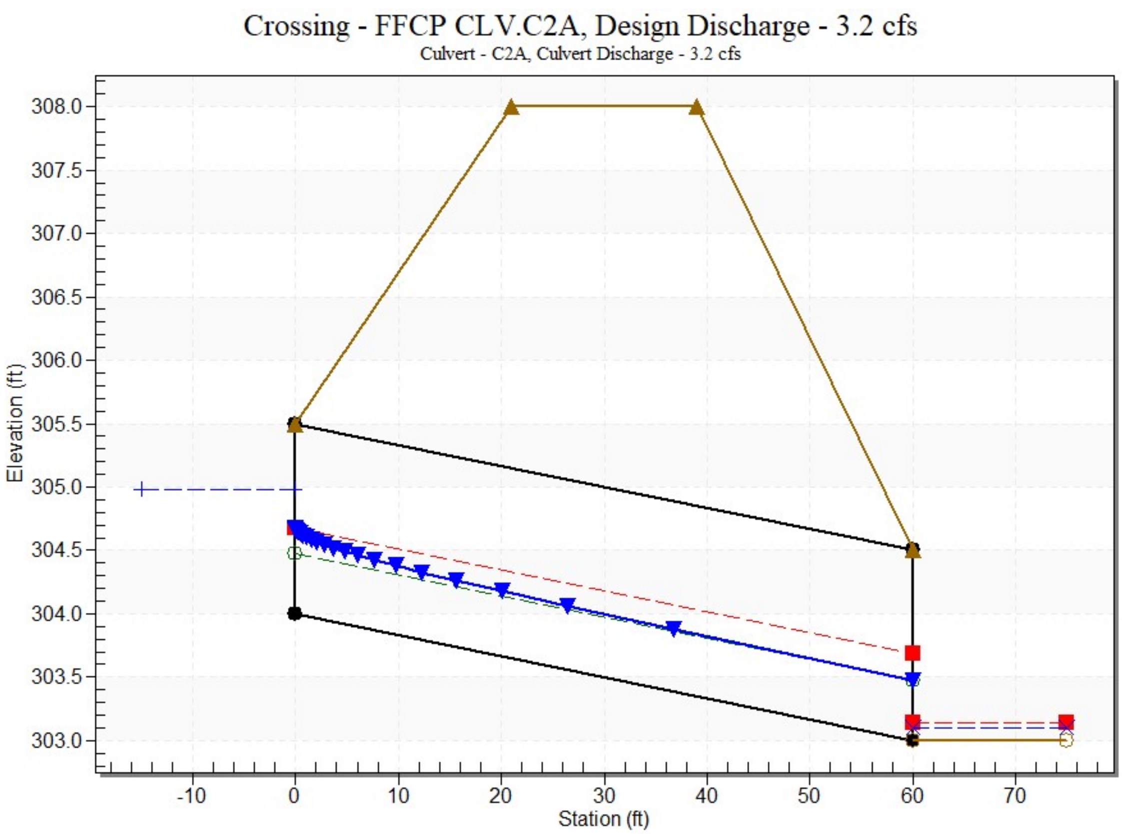
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C2A



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 2 - Summary of Culvert Flows at Crossing: FFCP CLV.C2A

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C2A Discharge (cfs)	Roadway Discharge (cfs)	Iterations
304.32	Q-2YR	0.41	0.41	0.00	1
304.60	Q-10YR	1.40	1.40	0.00	1
304.73	Q-25YR	2.00	2.00	0.00	1
304.98	Q-100YR	3.20	3.20	0.00	1
308.00	Overtopping	15.38	15.38	0.00	Overtopping

Culvert Data: C2B

Site Data - C2B

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 304.80 ft

Outlet Station: 54.00 ft

Outlet Elevation: 303.00 ft

Number of Barrels: 1

Culvert Data Summary - C2B

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

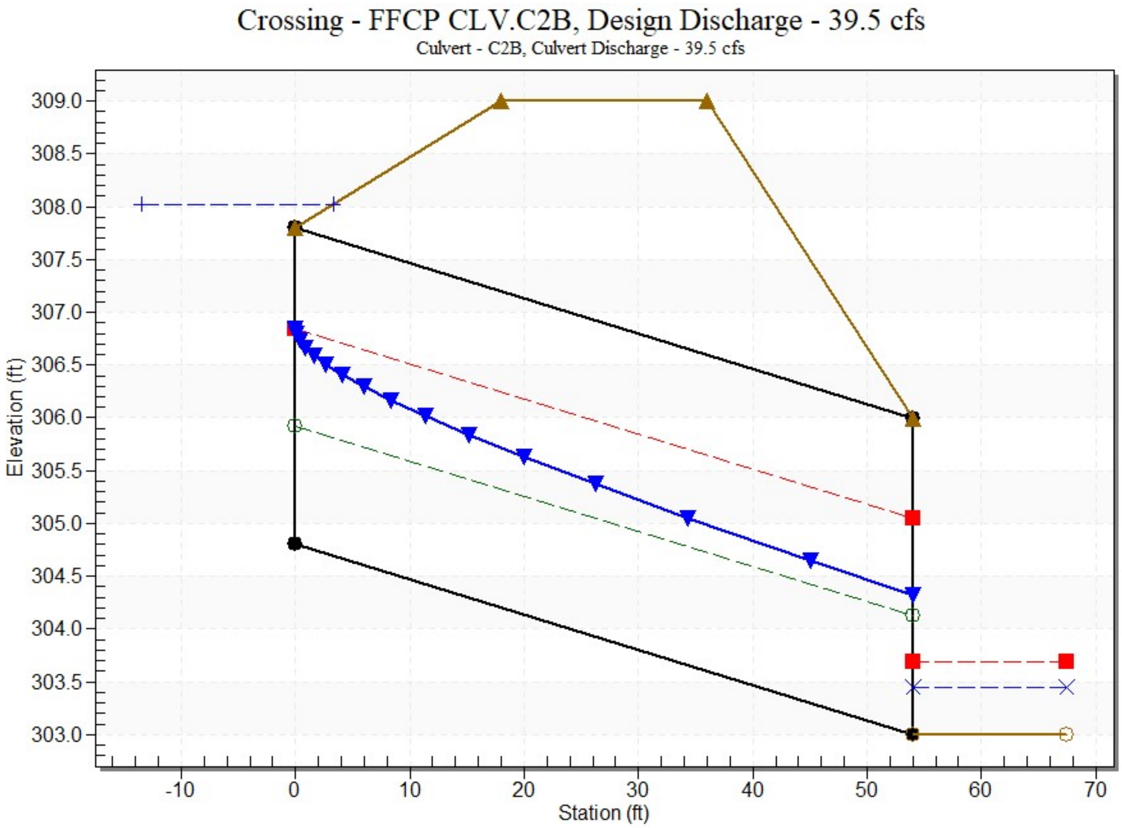
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C2B



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 3 - Summary of Culvert Flows at Crossing: FFCP CLV.C2B

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C2B Discharge (cfs)	Roadway Discharge (cfs)	Iterations
305.87	Q-2YR	6.50	6.50	0.00	1
306.67	Q-10YR	17.30	17.30	0.00	1
307.17	Q-25YR	25.10	25.10	0.00	1
308.02	Q-100YR	39.50	39.50	0.00	1
309.00	Overtopping	53.13	53.13	0.00	Overtopping

Culvert Data: C2C

Site Data - C2C

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 305.40 ft

Outlet Station: 56.00 ft

Outlet Elevation: 302.00 ft

Number of Barrels: 2

Culvert Data Summary - C2C

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

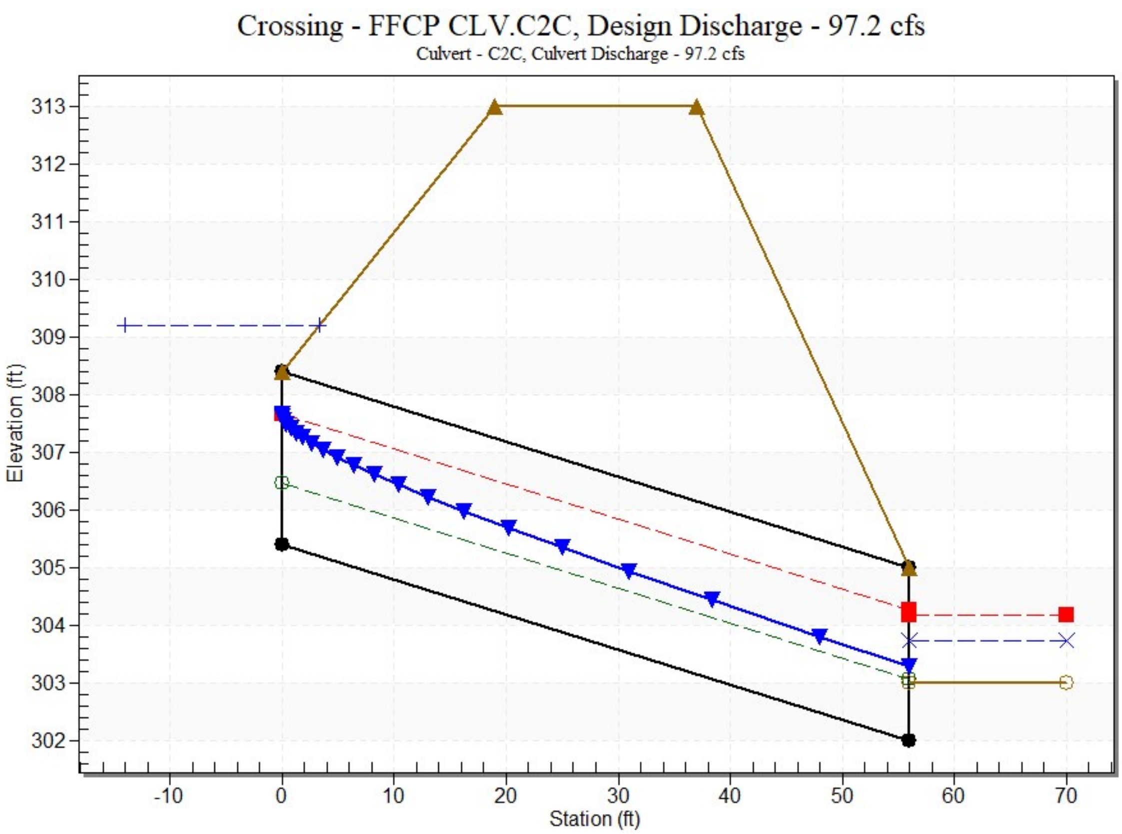
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C2C



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 4 - Summary of Culvert Flows at Crossing: FFCP CLV.C2C

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C2C Discharge (cfs)	Roadway Discharge (cfs)	Iterations
306.63	Q-2YR	17.70	17.70	0.00	1
307.48	Q-10YR	42.00	42.00	0.00	1
308.04	Q-25YR	61.00	61.00	0.00	1
309.20	Q-100YR	97.20	97.20	0.00	1
313.00	Overtopping	169.22	169.22	0.00	Overtopping

Culvert Data: C2D

Site Data - C2D

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 332.00 ft

Outlet Station: 96.00 ft

Outlet Elevation: 324.00 ft

Number of Barrels: 2

Culvert Data Summary - C2D

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

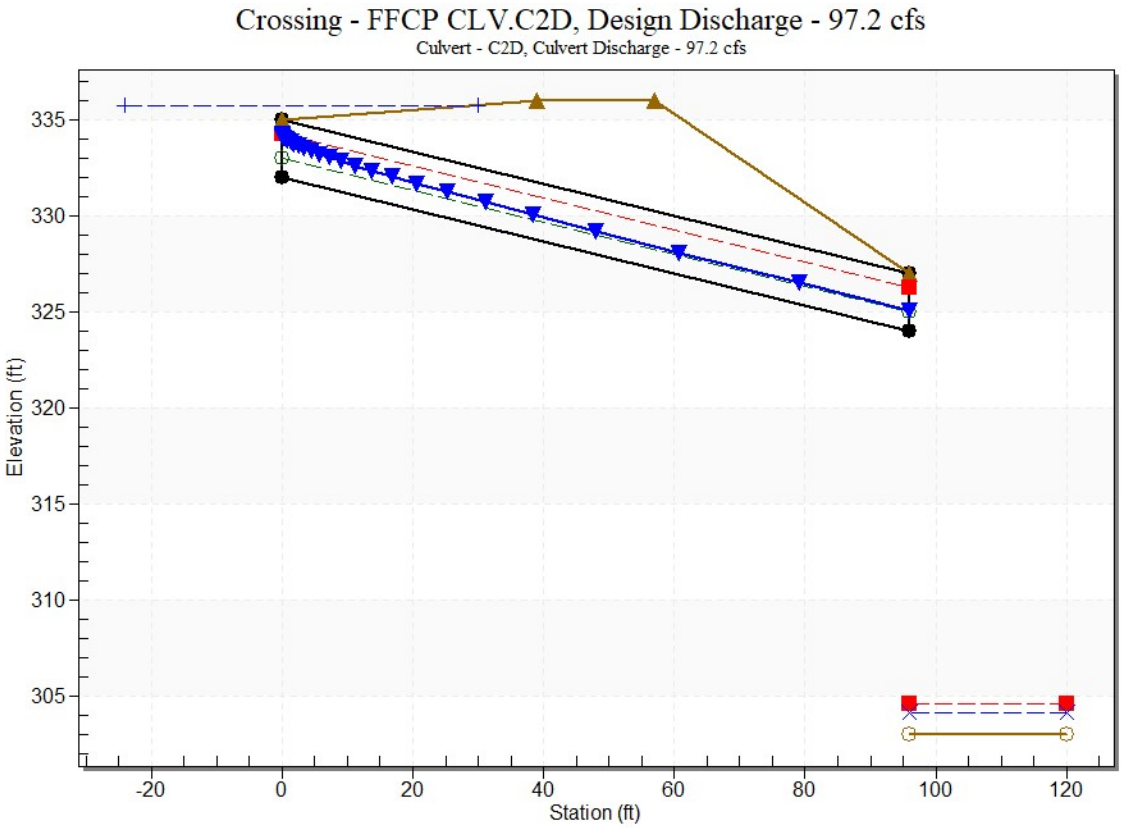
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C2D



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 5 - Summary of Culvert Flows at Crossing: FFCP CLV.C2D

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C2D Discharge (cfs)	Roadway Discharge (cfs)	Iterations
333.21	Q-2YR	17.70	17.70	0.00	1
334.04	Q-10YR	42.00	42.00	0.00	1
334.61	Q-25YR	61.00	61.00	0.00	1
335.77	Q-100YR	97.20	97.20	0.00	1
336.00	Overtopping	103.15	103.15	0.00	Overtopping

Culvert Data: C2E

Site Data - C2E

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 365.50 ft

Outlet Station: 68.00 ft

Outlet Elevation: 362.00 ft

Number of Barrels: 2

Culvert Data Summary - C2E

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

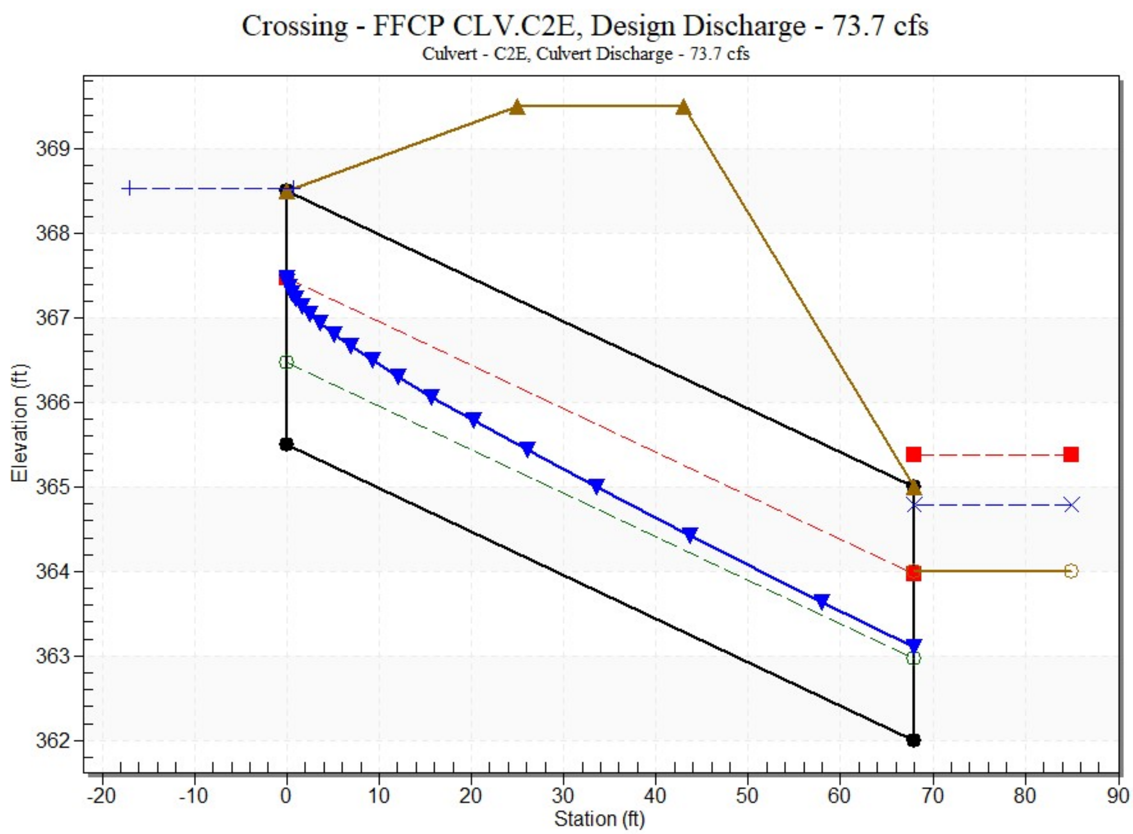
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C2E



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 6 - Summary of Culvert Flows at Crossing: FFCP CLV.C2E

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C2E Discharge (cfs)	Roadway Discharge (cfs)	Iterations
366.57	Q-2YR	13.40	13.40	0.00	1
367.24	Q-10YR	31.60	31.60	0.00	1
367.72	Q-25YR	46.10	46.10	0.00	1
368.53	Q-100YR	73.70	73.70	0.00	1
369.50	Overtopping	101.96	101.96	0.00	Overtopping

Culvert Data: C2F

Site Data - C2F

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 354.30 ft

Outlet Station: 208.00 ft

Outlet Elevation: 351.00 ft

Number of Barrels: 1

Culvert Data Summary - C2F

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

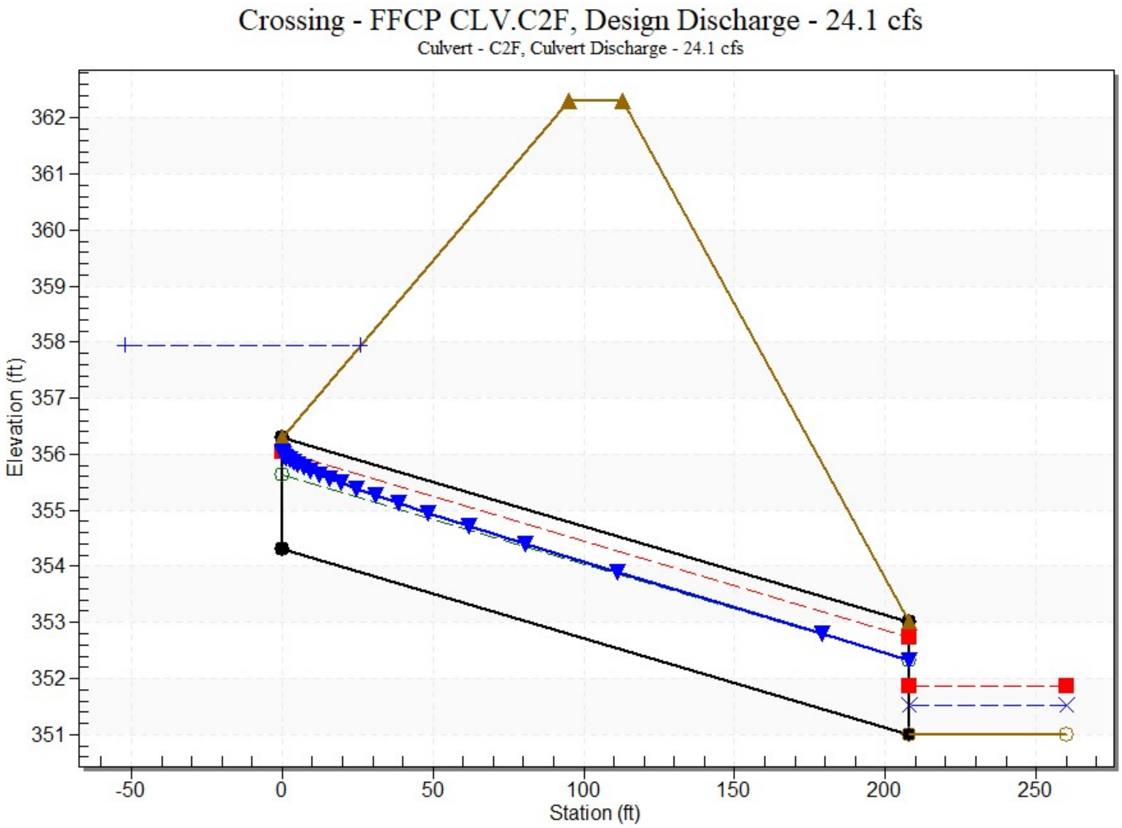
Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Water Surface Profile Plot for Culvert: C2F



Crossing Discharge Data

Discharge Selection Method: User Defined

Table 7 - Summary of Culvert Flows at Crossing: FFCP CLV.C2F

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	C2F Discharge (cfs)	Roadway Discharge (cfs)	Iterations
355.31	Q-2YR	4.40	4.40	0.00	1
356.14	Q-10YR	11.40	11.40	0.00	1
356.67	Q-25YR	16.00	16.00	0.00	1
357.94	Q-100YR	24.10	24.10	0.00	1
362.30	Overtopping	40.03	40.03	0.00	Overtopping

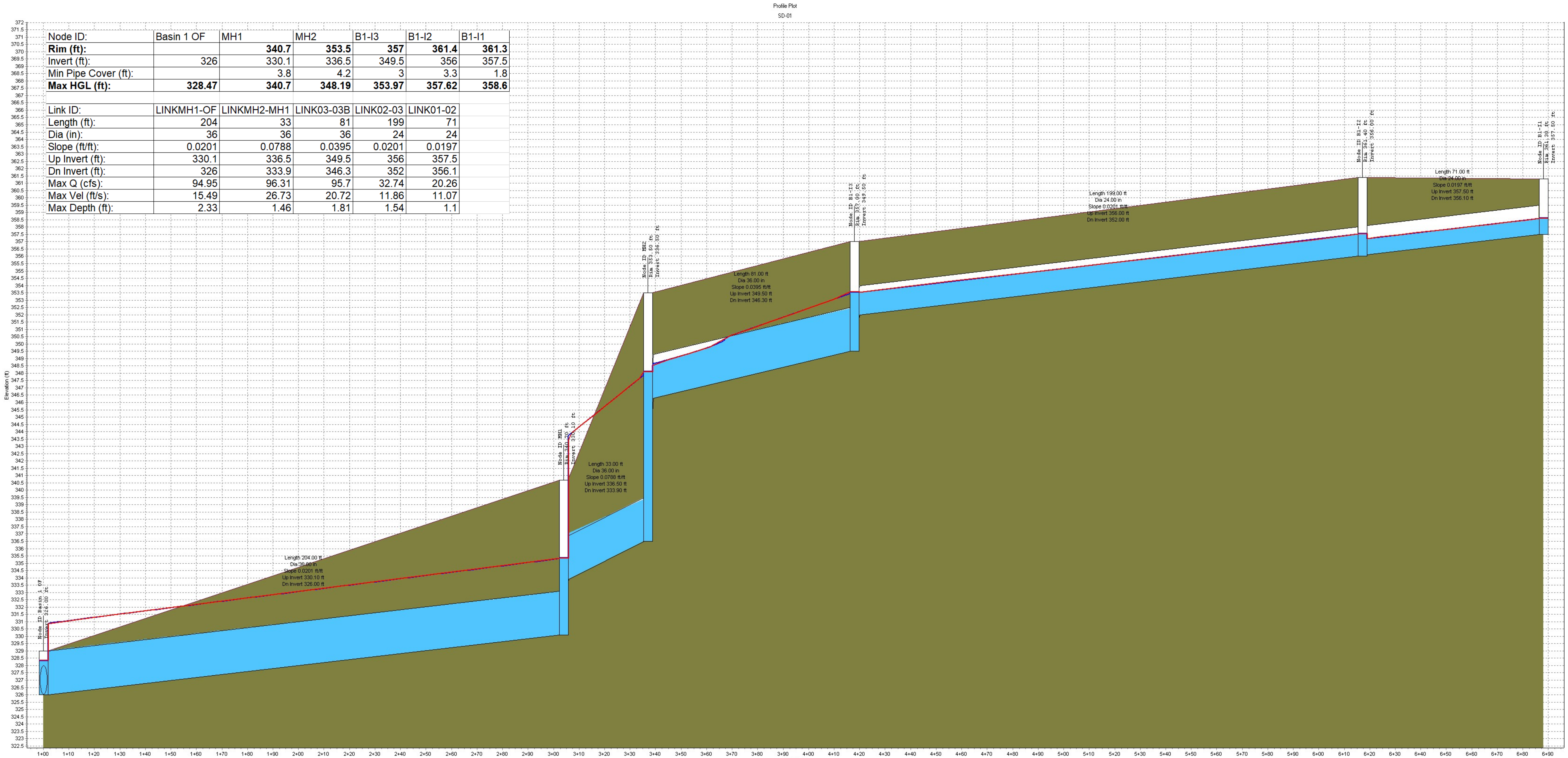
Stormwater Analysis Attachment 8

Storm Sewer System Profiles

FFCP Facility Storm Drain Profile A:
(100-yr, 24-hr storm event)

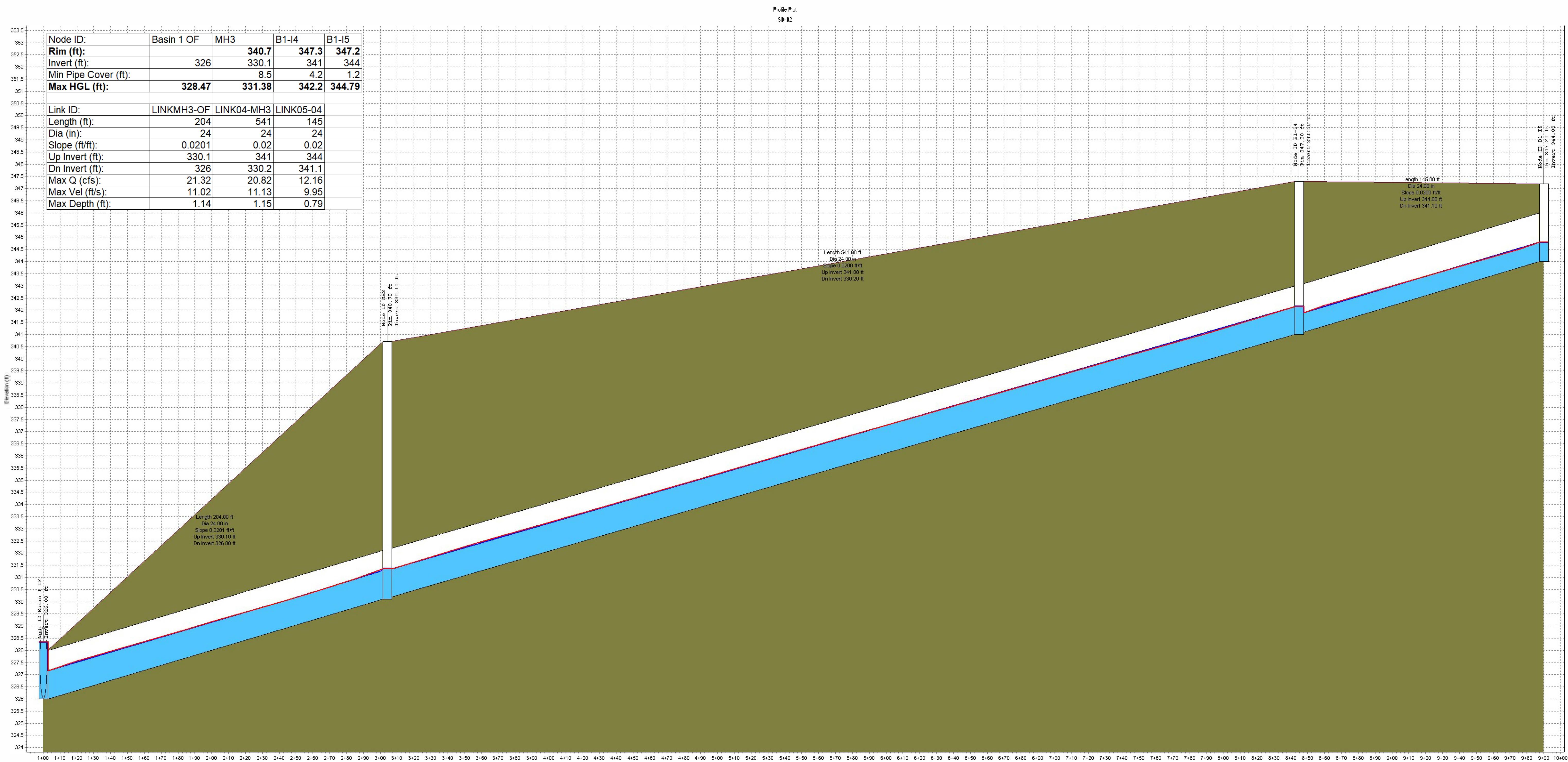
Node ID:	Basin 1 OF	MH1	MH2	B1-I3	B1-I2	B1-I1
Rim (ft):		**340.7**	**353.5**	**357**	**361.4**	**361.3**
Invert (ft):	326	330.1	336.5	349.5	356	357.5
Min Pipe Cover (ft):		3.8	4.2	3	3.3	1.8
Max HGL (ft):	**328.47**	**340.7**	**348.19**	**353.97**	**357.62**	**358.6**

Link ID:	LINKMH1-OF	LINKMH2-MH1	LINK03-03B	LINK02-03	LINK01-02
Length (ft):	204	33	81	199	71
Dia (in):	36	36	36	24	24
Slope (ft/ft):	0.0201	0.0788	0.0395	0.0201	0.0197
Up Invert (ft):	330.1	336.5	349.5	356	357.5
Dn Invert (ft):	326	333.9	346.3	352	356.1
Max Q (cfs):	94.95	96.31	95.7	32.74	20.26
Max Vel (ft/s):	15.49	26.73	20.72	11.86	11.07
Max Depth (ft):	2.33	1.46	1.81	1.54	1.1



Autodesk Storm and Sanitary Analysis

FFCP Facility Storm Drain Profile B:
(100-yr, 24-hr storm event)



Node ID:	Basin 1 OF	MH3	B1-I4	B1-I5
Rim (ft):		**340.7**	**347.3**	**347.2**
Invert (ft):	326	330.1	341	344
Min Pipe Cover (ft):		8.5	4.2	1.2
Max HGL (ft):	**328.47**	**331.38**	**342.2**	**344.79**

Link ID:	LINKMH3-OF	LINK04-MH3	LINK05-04
Length (ft):	204	541	145
Dia (in):	24	24	24
Slope (ft/ft):	0.0201	0.02	0.02
Up Invert (ft):	330.1	341	344
Dn Invert (ft):	326	330.2	341.1
Max Q (cfs):	21.32	20.82	12.16
Max Vel (ft/s):	11.02	11.13	9.95
Max Depth (ft):	1.14	1.15	0.79

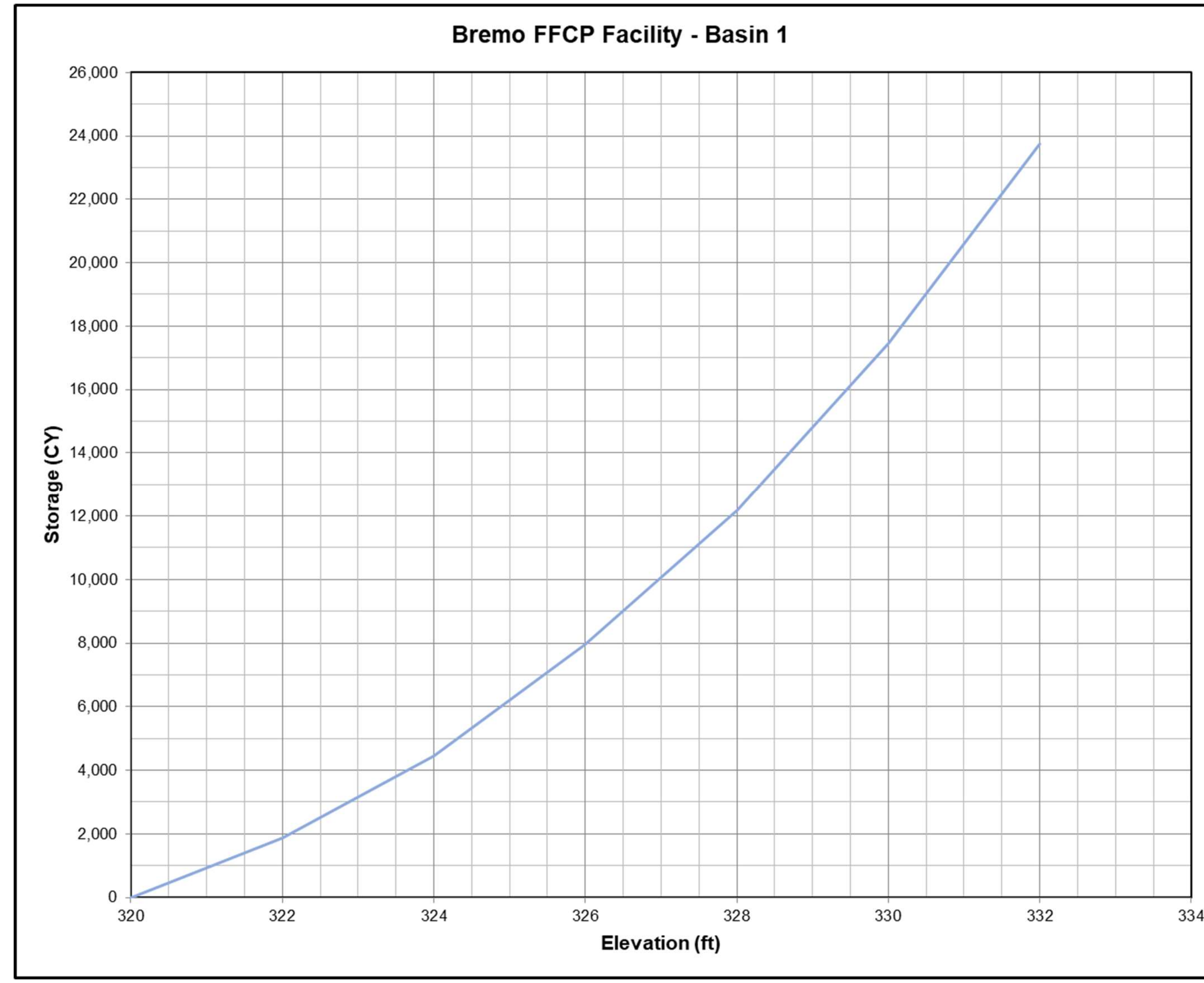
Stormwater Analysis Attachment 9

Pond Stage-Storage and Rating Curve

Bremo FFCP Facility - Basin 1

Stage-Storage Data

Elevation	Area		Incremental Volume		Cumulative Volume		
(ft)	(sqft)	(acres)	(cuft)	(CY)	(cuft)	(CY)	(ac-ft)
332.00	88,231.0	*2.026*	*169,692*	*6,285*	*640,937*	*23,738*	*14.71*
330.00	81,505.0	*1.871*	*142,698*	*5,285*	*471,245*	*17,454*	*10.82*
328.00	61,654.0	*1.415*	*113,561*	*4,206*	*328,547*	*12,168*	*7.54*
326.00	52,043.0	*1.195*	*94,854*	*3,513*	*214,986*	*7,962*	*4.94*
324.00	42,956.0	*0.986*	*69,819*	*2,586*	*120,132*	*4,449*	*2.76*
322.00	27,440.0	*0.630*	*50,313*	*1,863*	*50,313*	*1,863*	*1.16*
320.00	22,940.0	*0.527*					



FFCP Facility Basin 1 Discharge Rating Table - INPUTS

3" CIRCULAR ORIFICE		RECTANGULAR 18" X 18" NOTCH		60" Riser		Barrel (CALCULATED IN UD CULVERT SPREADSHEET)		Trapezoidal Spillway	
Invert (ft):	320	Invert (ft):	326	Invert (ft):	327.5	Invert (ft):	320	Invert (ft):	330
Diameter (in)	3	Length (ft):	1.5	Diameter (in)	60	Outlet (ft)	315	B. Width (ft):	15
Diameter (ft)	0.250	Height (ft):	1.5	Diameter (ft)	5	Diameter (in):	36	Top Width (ft):	23
Co	0.61	Co	0.61	Co	0.61	Length (ft)	125	Side Slope (ft/ft):	4
Orifice Area (ft^2)	0.0491	Cw	3.33	Cw	3.33				
Cw	3.33	Orifice Area (ft^2)	2.25	Orifice/Weir Area (ft^2)	19.63				
				Weir Perimeter (ft)	15.71				

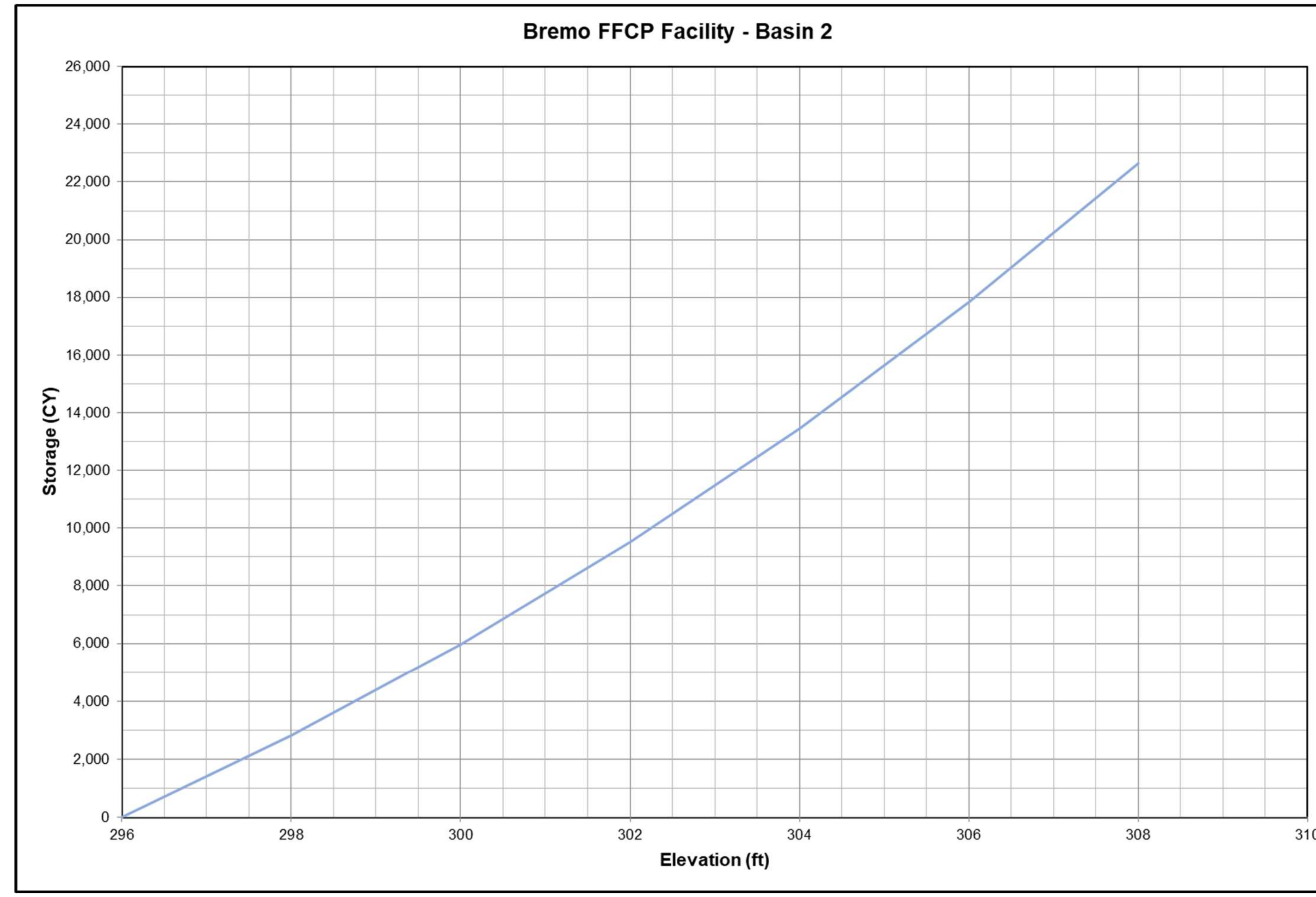
NOTE: OUTFLOW CALCULATIONS DOES NOT INCLUDE EMERGENCY SPILLWAY FLOW (Modeled as Separate Aux. Spillway in HEC-HMS)

Water Elevation	Discharge 1				Discharge 2				Riser				Barrel		E. Spillway		Outflow
	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow	Head	Flow	
(ft)	*(ft)*	*(cfs)*	*(cfs)*	*(cfs)*	*(ft)*	*(cfs)*	*(cfs)*	*(cfs)*	*(ft)*	*(cfs)*	*(cfs)*	*(cfs)*	*(ft)*	*(cfs)*	*(ft)*	*(cfs)*	*(cfs)*
320.00	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*	*0.00*	0.00	0.00	0.00
320.25	0.25	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.25*	*0.30*	0.00	0.00	0.12
320.50	0.50	0.17	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.50*	*1.30*	0.00	0.00	0.17
320.75	0.75	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.75*	*3.40*	0.00	0.00	0.21
321.00	1.00	0.24	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.00*	*5.80*	0.00	0.00	0.24
321.25	1.25	0.27	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.25*	*8.90*	0.00	0.00	0.27
321.50	1.50	0.29	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.50*	*12.40*	0.00	0.00	0.29
321.75	1.75	0.32	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.75*	*15.70*	0.00	0.00	0.32
322.00	2.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.00*	*19.40*	0.00	0.00	0.34
322.25	2.25	0.36	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.25*	*23.40*	0.00	0.00	0.36
322.50	2.50	0.38	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.50*	*27.60*	0.00	0.00	0.38
322.75	2.75	0.40	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.75*	*31.90*	0.00	0.00	0.40
323.00	3.00	0.42	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.00*	*36.10*	0.00	0.00	0.42
323.25	3.25	0.43	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.25*	*40.20*	0.00	0.00	0.43
323.50	3.50	0.45	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.50*	*44.00*	0.00	0.00	0.45
323.75	3.75	0.47	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.75*	*47.50*	0.00	0.00	0.47
324.00	4.00	0.48	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.00*	*50.80*	0.00	0.00	0.48
324.25	4.25	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.25*	*53.90*	0.00	0.00	0.50
324.50	4.50	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.50*	*56.80*	0.00	0.00	0.51
324.75	4.75	0.52	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.75*	*59.60*	0.00	0.00	0.52
325.00	5.00	0.54	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.00*	*62.20*	0.00	0.00	0.54
325.25	5.25	0.55	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.25*	*64.70*	0.00	0.00	0.55
325.50	5.50	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.50*	*67.10*	0.00	0.00	0.56
325.75	5.75	0.58	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.75*	*69.40*	0.00	0.00	0.58
326.00	6.00	0.59	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*6.00*	*71.60*	0.00	0.00	0.59
326.25	6.25	0.60	0.00	0.60	0.25	5.51	0.62	0.62	0.00	0.00	0.00	0.00	*6.25*	*73.80*	0.00	0.00	1.23
326.50	6.50	0.61	0.00	0.61	0.50	7.79	1.77	1.77	0.00	0.00	0.00	0.00	*6.50*	*75.90*	0.00	0.00	2.38
326.75	6.75	0.62	0.00	0.62	0.75	9.54	3.24	3.24	0.00	0.00	0.00	0.00	*6.75*	*77.90*	0.00	0.00	3.87
327.00	7.00	0.64	0.00	0.64	1.00	11.01	5.00	5.00	0.00	0.00	0.00	0.00	*7.00*	*79.90*	0.00	0.00	5.63
327.25	7.25	0.65	0.00	0.65	1.25	12.31	6.98	6.98	0.00	0.00	0.00	0.00	*7.25*	*81.80*	0.00	0.00	7.63
327.50	7.50	0.66	0.00	0.66	1.50	13.49	9.18	13.49	0.00	0.00	0.00	0.00	*7.50*	*83.70*	0.00	0.00	14.15
327.75	7.75	0.67	0.00	0.67	1.75	14.57	11.56	14.57	0.25	48.06	6.54	6.54	*7.75*	*85.50*	0.00	0.00	21.78
328.00	8.00	0.68	0.00	0.68	2.00	15.58	14.13	15.58	0.50	67.97	18.49	18.49	*8.00*	*87.30*	0.00	0.00	34.75
328.25	8.25	0.69	0.00	0.69	2.25	16.52	16.86	16.52	0.75	83.24	33.97	33.97	*8.25*	*89.10*	0.00	0.00	51.19
328.50	8.50	0.70	0.00	0.70	2.50	17.42	19.74	17.42	1.00	96.12	52.31	52.31	*8.50*	*90.80*	0.00	0.00	70.42
328.75	8.75	0.71	0.00	0.71	2.75	18.27	22.78	18.27	1.25	107.46	73.10	73.10	*8.75*	*92.50*	0.00	0.00	92.08
329.00	9.00	0.72	0.00	0.72	3.00	19.08	25.95	19.08	1.50	117.72	96.10	96.10	*9.00*	*94.20*	0.00	0.00	94.20
329.25	9.25	0.73	0.00	0.73	3.25	19.86	29.27	19.86	1.75	127.15	121.09	121.09	*9.25*	*95.80*	0.00	0.00	95.80
329.50	9.50	0.74	0.00	0.74	3.50	20.61	32.71	20.61	2.00	135.93	147.95	135.93	*9.50*	*97.30*	0.00	0.00	97.30
329.75	9.75	0.75	0.00	0.75	3.75	21.33	36.27	21.33	2.25	144.18	176.54	144.18	*9.75*	*98.80*	0.00	0.00	98.80
330.00	10.00	0.76	0.00	0.76	4.00	22.03	39.96	22.03	2.50	151.98	206.76	151.98	*10.00*	*100.30*	0.00	0.00	100.30
330.25	10.25	0.77	0.00	0.77	4.25	22.71	43.76	22.71	2.75	159.39	238.54	159.39	*10.25*	*101.80*	0.25	6.11	101.80
330.50	10.50	0.78	0.00	0.78	4.50	23.36	47.68	23.36	3.00	166.48	271.80	166.48	*10.50*	*103.20*	0.50	18.19	103.20
330.75	10.75	0.79	0.00	0.79	4.75	24.01	51.71	24.01	3.25	173.28	306.47	173.28	*10.75*	*104.70*	0.75	35.08	104.70
331.00	11.00	0.80	0.00	0.80	5.00	24.63	55.85	24.63	3.50	179.82	342.50	179.82	*11.00*	*106.10*	1.00	56.58	106.10
331.25	11.25	0.81	0.00	0.81	5.25	25.24	60.09	25.24	3.75	186.13	379.85	186.13	*11.25*	*107.50*	1.25	82.66	107.50
331.50	11.50	0.81	0.00	0.81	5.50	25.83	64.43	25.83	4.00	192.24	418.46	192.24	*11.50*	*108.80*	1.50	113.37	108.80
331.75	11.75	0.82	0.00	0.82	5.75	26.41	68.87	26.41	4.25	198.15	458.30	198.15	*11.75*	*110.20*	1.75	148.81	110.20
332.00	12.00	0.83	0.00	0.83	6.00	26.98	73.41	26.98	4.50	203.90	499.32	203.90	*12.00*	*111.50*	2.00	189.08	111.50

Bremo FFCP Facility - Basin 2

Stage-Storage Data

Elevation	Area		Incremental Volume		Cumulative Volume		
(ft)	(sqft)	(acres)	(cuft)	(CY)	(cuft)	(CY)	(ac-ft)
308.00	67,810.3	*1.557*	*129,614*	*4,801*	*611,191*	*22,637*	*14.03*
306.00	61,849.0	*1.420*	*117,915*	*4,367*	*481,577*	*17,836*	*11.06*
304.00	56,112.5	*1.288*	*106,666*	*3,951*	*363,662*	*13,469*	*8.35*
302.00	50,600.8	*1.162*	*95,866*	*3,551*	*256,996*	*9,518*	*5.90*
300.00	45,313.9	*1.040*	*85,516*	*3,167*	*161,130*	*5,968*	*3.70*
298.00	40,251.7	*0.924*	*75,615*	*2,801*	*75,615*	*2,801*	*1.74*
296.00	35,414.4	*0.813*					



FFCP Facility Basin 2 Discharge Rating Table - INPUTS

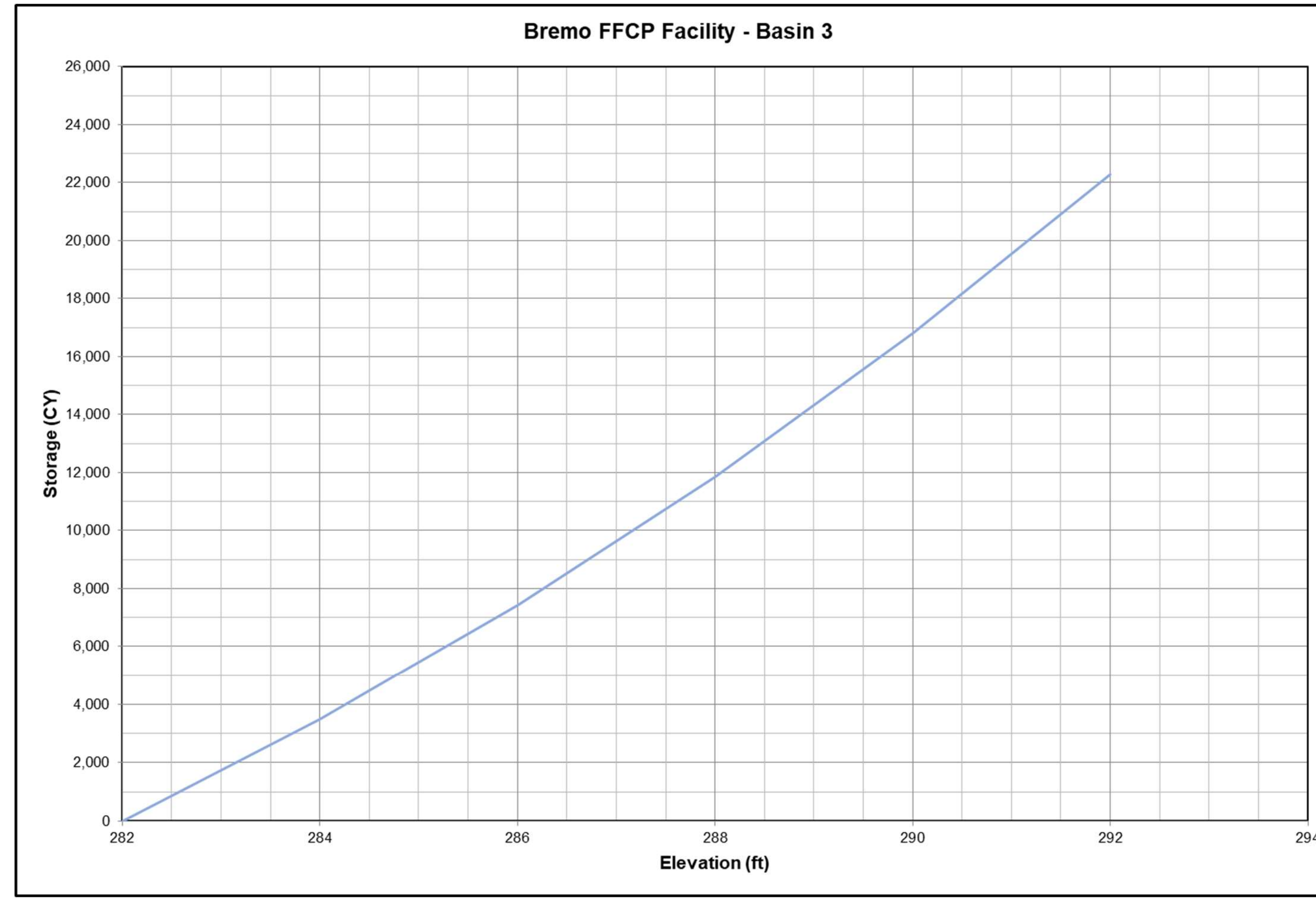
3" CIRCULAR ORIFICE		RECTANGULAR 18" X 18" NOTCH		60" Riser		Barrel		Trapezoidal Spillway		
Invert (ft):	296	Invert (ft):	301.5	Invert (ft):	303	Invert (ft):	296	Invert (ft):	306	NOTE: OUTFLOW CALCULATIONS DOES NOT INCLUDE EMERGENCY SPILLWAY FLOW (Modeled as Separate Aux. Spillway in HEC-HMS)
Diameter (in)	3	Length (ft):	1.5	Diameter (in)	60	Outlet (ft)	290	B. Width (ft):	15	
Diameter (ft)	0.250	Height (ft):	1.5	Diameter (ft)	5	Diameter (in):	36	Top Width (ft):	23	
Co	0.61	Co	0.61	Co	0.61	Length (ft)	125	Side Slope (ft/ft):	4	
Orifice Area (ft^2)	0.0491	Cw	3.33	Cw	3.33	CALCULATED IN UD CULVERT SPREADSHEET				
Cw	3.33	Orifice Area (ft^2)	2.25	Orifice/Weir Area (ft^2)	19.63					
				Weir Perimeter (ft)	15.71					

Water Elevation	Discharge 1				Discharge 2				Riser				Barrel		E. Spillway		Outflow
	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow	Head	Flow	
(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(cfs)
296.00	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*	*0.00*	0.00	0.00	0.00
296.25	0.25	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.25*	*0.40*	0.00	0.00	0.12
296.50	0.50	0.17	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.50*	*1.30*	0.00	0.00	0.17
296.75	0.75	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.75*	*3.40*	0.00	0.00	0.21
297.00	1.00	0.24	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.00*	*5.90*	0.00	0.00	0.24
297.25	1.25	0.27	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.25*	*9.00*	0.00	0.00	0.27
297.50	1.50	0.29	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.50*	*12.60*	0.00	0.00	0.29
297.75	1.75	0.32	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*1.75*	*15.90*	0.00	0.00	0.32
298.00	2.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.00*	*19.60*	0.00	0.00	0.34
298.25	2.25	0.36	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.25*	*23.60*	0.00	0.00	0.36
298.50	2.50	0.38	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.50*	*27.80*	0.00	0.00	0.38
298.75	2.75	0.40	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*2.75*	*32.10*	0.00	0.00	0.40
299.00	3.00	0.42	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.00*	*36.30*	0.00	0.00	0.42
299.25	3.25	0.43	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.25*	*40.40*	0.00	0.00	0.43
299.50	3.50	0.45	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.50*	*44.10*	0.00	0.00	0.45
299.75	3.75	0.47	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*3.75*	*47.70*	0.00	0.00	0.47
300.00	4.00	0.48	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.00*	*51.00*	0.00	0.00	0.48
300.25	4.25	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.25*	*54.10*	0.00	0.00	0.50
300.50	4.50	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.50*	*57.00*	0.00	0.00	0.51
300.75	4.75	0.52	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*4.75*	*59.70*	0.00	0.00	0.52
301.00	5.00	0.54	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.00*	*62.30*	0.00	0.00	0.54
301.25	5.25	0.55	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.25*	*64.80*	0.00	0.00	0.55
301.50	5.50	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*5.50*	*67.20*	0.00	0.00	0.56
301.75	5.75	0.58	0.00	0.58	0.25	5.51	0.62	0.62	0.00	0.00	0.00	0.00	*5.75*	*69.50*	0.00	0.00	1.20
302.00	6.00	0.59	0.00	0.59	0.50	7.79	1.77	1.77	0.00	0.00	0.00	0.00	*6.00*	*71.80*	0.00	0.00	2.35
302.25	6.25	0.60	0.00	0.60	0.75	9.54	3.24	3.24	0.00	0.00	0.00	0.00	*6.25*	*73.90*	0.00	0.00	3.85
302.50	6.50	0.61	0.00	0.61	1.00	11.01	5.00	5.00	0.00	0.00	0.00	0.00	*6.50*	*76.00*	0.00	0.00	5.61
302.75	6.75	0.62	0.00	0.62	1.25	12.31	6.98	6.98	0.00	0.00	0.00	0.00	*6.75*	*78.00*	0.00	0.00	7.61
303.00	7.00	0.64	0.00	0.64	1.50	13.49	9.18	13.49	0.00	0.00	0.00	0.00	*7.00*	*80.00*	0.00	0.00	14.13
303.25	7.25	0.65	0.00	0.65	1.75	14.57	11.56	14.57	0.25	48.06	6.54	6.54	*7.25*	*81.90*	0.00	0.00	21.76
303.50	7.50	0.66	0.00	0.66	2.00	15.58	14.13	15.58	0.50	67.97	18.49	18.49	*7.50*	*83.80*	0.00	0.00	34.73
303.75	7.75	0.67	0.00	0.67	2.25	16.52	16.86	16.52	0.75	83.24	33.97	33.97	*7.75*	*85.60*	0.00	0.00	51.17
304.00	8.00	0.68	0.00	0.68	2.50	17.42	19.74	17.42	1.00	96.12	52.31	52.31	*8.00*	*87.40*	0.00	0.00	70.40
304.25	8.25	0.69	0.00	0.69	2.75	18.27	22.78	18.27	1.25	107.46	73.10	73.10	*8.25*	*89.20*	0.00	0.00	89.20
304.50	8.50	0.70	0.00	0.70	3.00	19.08	25.95	19.08	1.50	117.72	96.10	96.10	*8.50*	*90.90*	0.00	0.00	90.90
304.75	8.75	0.71	0.00	0.71	3.25	19.86	29.27	19.86	1.75	127.15	121.09	121.09	*8.75*	*92.60*	0.00	0.00	92.60
305.00	9.00	0.72	0.00	0.72	3.50	20.61	32.71	20.61	2.00	135.93	147.95	135.93	*9.00*	*94.30*	0.00	0.00	94.30
305.25	9.25	0.73	0.00	0.73	3.75	21.33	36.27	21.33	2.25	144.18	176.54	144.18	*9.25*	*95.90*	0.00	0.00	95.90
305.50	9.50	0.74	0.00	0.74	4.00	22.03	39.96	22.03	2.50	151.98	206.76	151.98	*9.50*	*97.40*	0.00	0.00	97.40
305.75	9.75	0.75	0.00	0.75	4.25	22.71	43.76	22.71	2.75	159.39	238.54	159.39	*9.75*	*99.00*	0.00	0.00	99.00
306.00	10.00	0.76	0.00	0.76	4.50	23.36	47.68	23.36	3.00	166.48	271.80	166.48	*10.00*	*100.40*	0.00	0.00	100.40
306.25	10.25	0.77	0.00	0.77	4.75	24.01	51.71	24.01	3.25	173.28	306.47	173.28	*10.25*	*101.90*	0.25	6.11	101.90
306.50	10.50	0.78	0.00	0.78	5.00	24.63	55.85	24.63	3.50	179.82	342.50	179.82	*10.50*	*103.40*	0.50	18.19	103.40
306.75	10.75	0.79	0.00	0.79	5.25	25.24	60.09	25.24	3.75	186.13	379.85	186.13	*10.75*	*104.80*	0.75	35.08	104.80
307.00	11.00	0.80	0.00	0.80	5.50	25.83	64.43	25.83	4.00	192.24	418.46	192.24	*11.00*	*106.20*	1.00	56.58	106.20
307.25	11.25	0.81	0.00	0.81	5.75	26.41	68.87	26.41	4.25	198.15	458.30	198.15	*11.25*	*107.60*	1.25	82.66	107.60
307.50	11.50	0.81	0.00	0.81	6.00	26.98	73.41	26.98	4.50	203.90	499.32	203.90	*11.50*	*108.90*	1.50	113.37	108.90
307.75	11.75	0.82	0.00	0.82	6.25	27.54	78.05	27.54	4.75	209.48	541.51	209.48	*11.75*	*110.30*	1.75	148.81	110.30
308.00	12.00	0.83	0.00	0.83	6.50	28.08	82.78	28.08	5.00	214.93	584.82	214.93	*12.00*	*111.60*	2.00	189.08	111.60

Bremo FFCP Facility - Basin 3

Stage-Storage Data

Elevation	Area		Incremental Volume		Cumulative Volume		
(ft)	(sqft)	(acres)	(cuft)	(CY)	(cuft)	(CY)	(ac-ft)
292.00	77,833.5	*1.787*	*148,208*	*5,489*	*601,724*	*22,286*	*13.81*
290.00	70,436.5	*1.617*	*133,701*	*4,952*	*453,516*	*16,797*	*10.41*
288.00	63,327.5	*1.454*	*119,769*	*4,436*	*319,815*	*11,845*	*7.34*
286.00	56,506.5	*1.297*	*106,413*	*3,941*	*200,046*	*7,409*	*4.59*
284.00	49,973.5	*1.147*	*93,633*	*3,468*	*93,633*	*3,468*	*2.15*
282.00	43,728.5	*1.004*					



FFCP Facility Basin 3 Discharge Rating Table - INPUTS

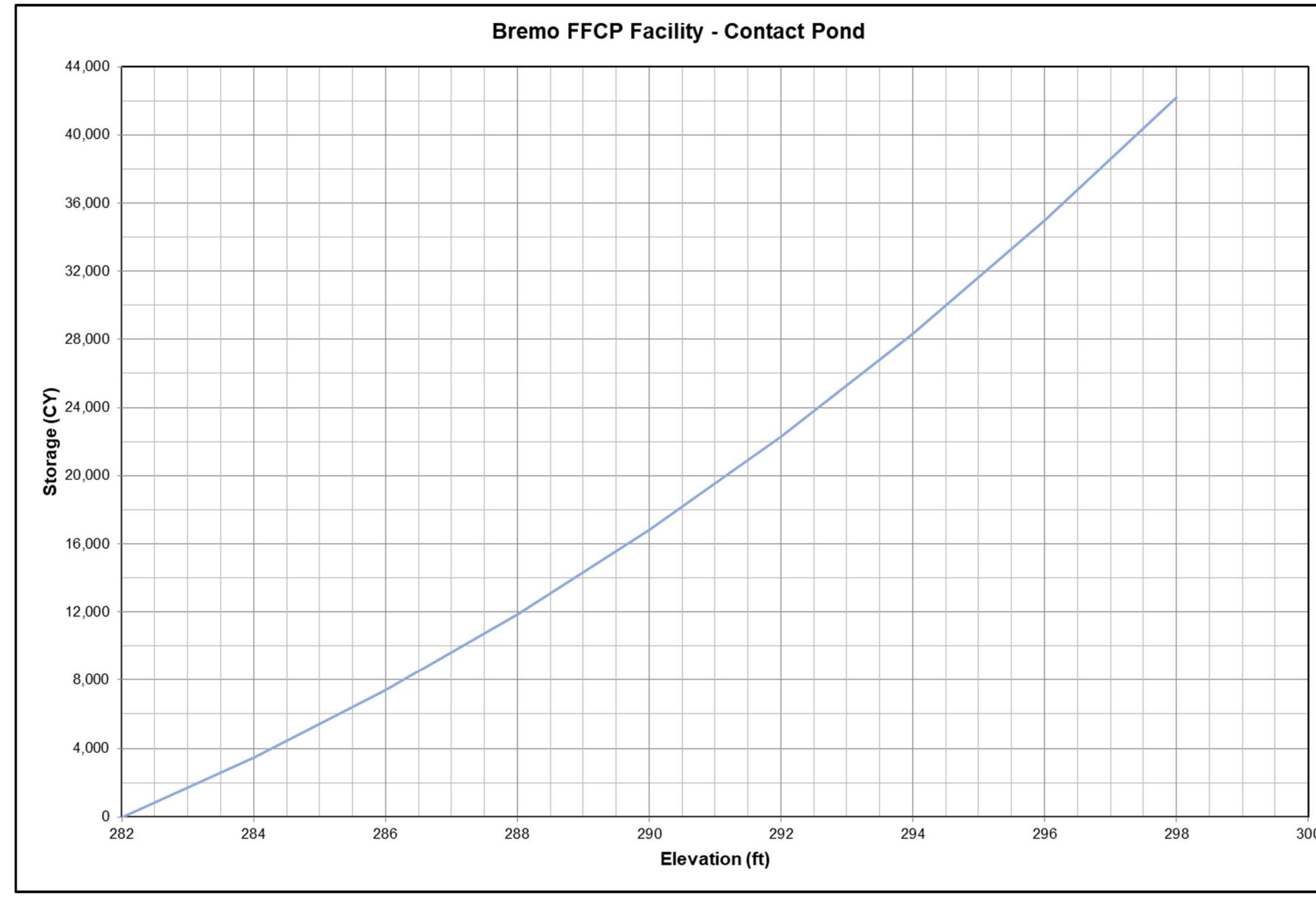
Discharge 1			Discharge 2			Riser			Barrel		E. Spillway		
Invert (ft):	282	3" CIRCULAR ORIFICE	Invert (ft):	285.5	RECTANGULAR 12" X 18" NOTCH	Invert (ft):	287	48" Riser	Invert (ft):	282	Invert (ft):	290	NOTE: OUTFLOW CALCULATIONS DOES NOT INCLUDE EMERGENCY SPILLWAY FLOW (Modeled as Separate Aux. Spillway in HEC-HMS)
Diameter (in)	3		Length (ft):	1		Diameter (in)	48		Outlet (ft)	278	B. Width (ft):	15	
Diameter (ft)	0.250		Height (ft):	1.5		Diameter (ft)	4		Diameter (in):	24	Top Width (ft):	23	
Co	0.61		Co	0.61		Co	0.61		Length (ft)	120	Side Slope (ft/ft):	4	
Orifice Area (ft^2)	0.0491		Cw	3.33		Cw	3.33		CALCULATED IN UD CULVERT SPREADSHEET		Trapezoidal Spillway		
Cw	3.33		Orifice Area (ft^2)	1.5		Orifice/Weir Area (ft^2)	12.57						
						Weir Perimeter (ft)	12.57						

Water Elevation	Discharge 1				Discharge 2				Riser				Barrel		E. Spillway		Outflow
	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow (Orifice)	Flow (Weir)	Controlling Flow	Head	Flow	Head	Flow	
(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(cfs)
282.00	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	0.00	0.00	0.00	0.00
282.25	0.25	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.30	0.00	0.00	0.12
282.50	0.50	0.17	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.30	0.00	0.00	0.17
282.75	0.75	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	2.70	0.00	0.00	0.21
283.00	1.00	0.24	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	4.60	0.00	0.00	0.24
283.25	1.25	0.27	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	6.30	0.00	0.00	0.27
283.50	1.50	0.29	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	8.40	0.00	0.00	0.29
283.75	1.75	0.32	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	10.70	0.00	0.00	0.32
284.00	2.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	13.00	0.00	0.00	0.34
284.25	2.25	0.36	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	15.20	0.00	0.00	0.36
284.50	2.50	0.38	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	17.20	0.00	0.00	0.38
284.75	2.75	0.40	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.75	19.00	0.00	0.00	0.40
285.00	3.00	0.42	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	20.60	0.00	0.00	0.42
285.25	3.25	0.43	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.25	22.10	0.00	0.00	0.43
285.50	3.50	0.45	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.50	23.40	0.00	0.00	0.45
285.75	3.75	0.47	0.00	0.47	0.25	3.67	0.42	0.42	0.00	0.00	0.00	0.00	3.75	24.70	0.00	0.00	0.88
286.00	4.00	0.48	0.00	0.48	0.50	5.19	1.18	1.18	0.00	0.00	0.00	0.00	4.00	26.00	0.00	0.00	1.66
286.25	4.25	0.50	0.00	0.50	0.75	6.36	2.16	2.16	0.00	0.00	0.00	0.00	4.25	27.10	0.00	0.00	2.66
286.50	4.50	0.51	0.00	0.51	1.00	7.34	3.33	3.33	0.00	0.00	0.00	0.00	4.50	28.20	0.00	0.00	3.84
286.75	4.75	0.52	0.00	0.52	1.25	8.21	4.65	4.65	0.00	0.00	0.00	0.00	4.75	29.30	0.00	0.00	5.18
287.00	5.00	0.54	0.00	0.54	1.50	8.99	6.12	8.99	0.00	0.00	0.00	0.00	5.00	30.30	0.00	0.00	9.53
287.25	5.25	0.55	0.00	0.55	1.75	9.71	7.71	9.71	0.25	30.76	5.23	5.23	5.25	31.30	0.00	0.00	15.49
287.50	5.50	0.56	0.00	0.56	2.00	10.38	9.42	10.38	0.50	43.50	14.79	14.79	5.50	32.30	0.00	0.00	25.74
287.75	5.75	0.58	0.00	0.58	2.25	11.01	11.24	11.01	0.75	53.27	27.18	27.18	5.75	33.20	0.00	0.00	33.20
288.00	6.00	0.59	0.00	0.59	2.50	11.61	13.16	11.61	1.00	61.52	41.85	41.85	6.00	34.20	0.00	0.00	34.20
288.25	6.25	0.60	0.00	0.60	2.75	12.18	15.19	12.18	1.25	68.78	58.48	58.48	6.25	35.10	0.00	0.00	35.10
288.50	6.50	0.61	0.00	0.61	3.00	12.72	17.30	12.72	1.50	75.34	76.88	75.34	6.50	35.90	0.00	0.00	35.90
288.75	6.75	0.62	0.00	0.62	3.25	13.24	19.51	13.24	1.75	81.38	96.87	81.38	6.75	36.70	0.00	0.00	36.70
289.00	7.00	0.64	0.00	0.64	3.50	13.74	21.80	13.74	2.00	87.00	118.36	87.00	7.00	37.50	0.00	0.00	37.50
289.25	7.25	0.65	0.00	0.65	3.75	14.22	24.18	14.22	2.25	92.27	141.23	92.27	7.25	38.30	0.00	0.00	38.30
289.50	7.50	0.66	0.00	0.66	4.00	14.69	26.64	14.69	2.50	97.26	165.41	97.26	7.50	39.00	0.00	0.00	39.00
289.75	7.75	0.67	0.00	0.67	4.25	15.14	29.18	15.14	2.75	102.01	190.83	102.01	7.75	39.80	0.00	0.00	39.80
290.00	8.00	0.68	0.00	0.68	4.50	15.58	31.79	15.58	3.00	106.55	217.44	106.55	8.00	40.50	0.00	0.00	40.50
290.25	8.25	0.69	0.00	0.69	4.75	16.00	34.47	16.00	3.25	110.90	245.18	110.90	8.25	41.20	0.25	6.11	41.20
290.50	8.50	0.70	0.00	0.70	5.00	16.42	37.23	16.42	3.50	115.08	274.00	115.08	8.50	41.90	0.50	18.19	41.90
290.75	8.75	0.71	0.00	0.71	5.25	16.82	40.06	16.82	3.75	119.12	303.88	119.12	8.75	42.60	0.75	35.08	42.60
291.00	9.00	0.72	0.00	0.72	5.50	17.22	42.95	17.22	4.00	123.03	334.77	123.03	9.00	43.30	1.00	56.58	43.30
291.25	9.25	0.73	0.00	0.73	5.75	17.61	45.91	17.61	4.25	126.82	366.64	126.82	9.25	44.00	1.25	82.66	44.00
291.50	9.50	0.74	0.00	0.74	6.00	17.99	48.94	17.99	4.50	130.49	399.46	130.49	9.50	44.60	1.50	113.37	44.60
291.75	9.75	0.75	0.00	0.75	6.25	18.36	52.03	18.36	4.75	134.07	433.21	134.07	9.75	45.30	1.75	148.81	45.30
292.00	10.00	0.76	0.00	0.76	6.50	18.72	55.18	18.72	5.00	137.55	467.85	137.55	10.00	45.90	2.00	189.08	45.90

Bremo FFCP Facility - Contact Pond

Stage-Storage Data

Elevation	Area		Incremental Volume		Cumulative Volume		
(ft)	(sqft)	(acres)	(cuft)	(CY)	(cuft)	(CY)	(ac-ft)
298.00	101,752.8	2.336	195,182	7,229	1,139,145	42,191	26.15
296.00	93,487.6	2.146	178,947	6,628	943,963	34,962	21.67
294.00	85,518.6	1.963	163,292	6,048	765,016	28,334	17.56
292.00	77,833.5	1.787	148,208	5,489	601,724	22,286	13.81
290.00	70,436.5	1.617	133,701	4,952	453,516	16,797	10.41
288.00	63,327.5	1.454	119,769	4,436	319,815	11,845	7.34
286.00	56,506.5	1.297	106,413	3,941	200,046	7,409	4.59
284.00	49,973.5	1.147	93,633	3,468	93,633	3,468	2.15
282.00	43,728.5	1.004					

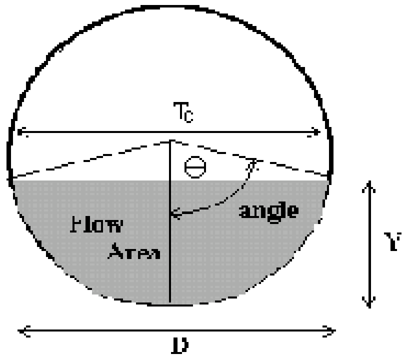


Stormwater Analysis Attachment 10

Contact Stormwater Pipes

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

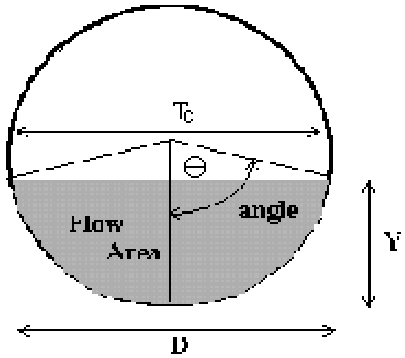
Project: **Bremo FFCP - Part B**
Pipe ID: **Contact Stormwater Piping @ 1.5%**



Design Information (Input)			
Pipe Invert Slope	So =	0.0150	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	36.00	inches
Design discharge	**Q =**	**81.91**	**cfs**
Full-flow Capacity (Calculated)			
Full-flow area	Af =	7.07	sq ft
Full-flow wetted perimeter	Pf =	9.42	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	81.91	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	2.26	radians
Flow area	An =	6.20	sq ft
Top width	Tn =	2.31	ft
Wetted perimeter	Pn =	6.79	ft
Flow depth	Yn =	2.46	ft
Flow velocity	Vn =	13.21	fps
Discharge	Qn =	81.91	cfs
Percent Full Flow	Flow =	100.0%	of full flow
Normal Depth Froude Number	Fr_n =	1.42	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.60	radians
Critical flow area	Ac =	6.85	sq ft
Critical top width	Tc =	1.54	ft
Critical flow depth	Yc =	2.79	ft
Critical flow velocity	Vc =	11.96	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

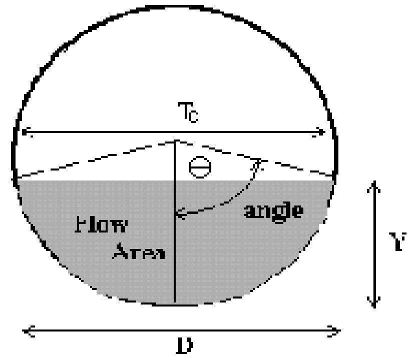
Project: **Bremo FFCP - Part B**
Pipe ID: **Contact Slope Drain @ 5.0%**



Design Information (Input)			
Pipe Invert Slope	So =	0.0500	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	24.00	inches
Design discharge	**Q =**	**50.72**	**cfs**
Full-flow Capacity (Calculated)			
Full-flow area	Af =	3.14	sq ft
Full-flow wetted perimeter	Pf =	6.28	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	50.72	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	2.26	radians
Flow area	An =	2.76	sq ft
Top width	Tn =	1.54	ft
Wetted perimeter	Pn =	4.53	ft
Flow depth	Yn =	1.64	ft
Flow velocity	Vn =	18.40	fps
Discharge	Qn =	50.72	cfs
Percent Full Flow	Flow =	100.0%	of full flow
Normal Depth Froude Number	Fr_n =	2.42	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.95	radians
Critical flow area	Ac =	3.14	sq ft
Critical top width	Tc =	0.39	ft
Critical flow depth	Yc =	1.98	ft
Critical flow velocity	Vc =	16.17	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: **Bremo FFCP - Part B**
Pipe ID: **Contact Slope Drain @ 33.3%**



Design Information (Input)

Pipe Invert Slope	So =	0.3333	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	24.00	inches
Design discharge	**Q =**	**130.96**	**cfs**

Full-flow Capacity (Calculated)

Full-flow area	Af =	3.14	sq ft
Full-flow wetted perimeter	Pf =	6.28	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	130.96	cfs

Calculation of Normal Flow Condition

Half Central Angle (0<Theta<3.14)	Theta =	2.26	radians
Flow area	An =	2.76	sq ft
Top width	Tn =	1.54	ft
Wetted perimeter	Pn =	4.53	ft
Flow depth	Yn =	1.64	ft
Flow velocity	Vn =	47.52	fps
Discharge	Qn =	130.96	cfs
Percent Full Flow	Flow =	100.0%	of full flow
Normal Depth Froude Number	Fr_n =	6.26	supercritical

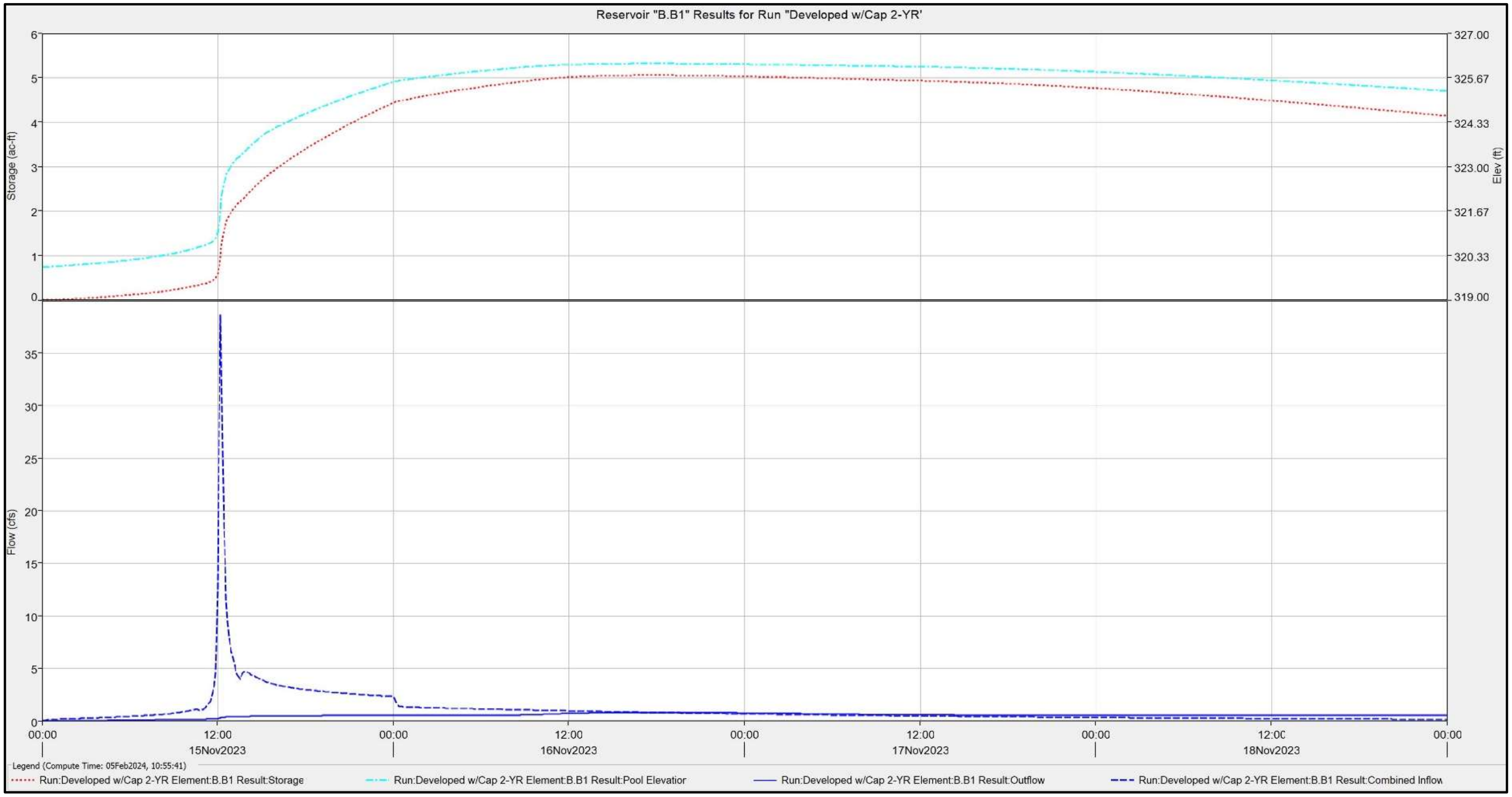
Calculation of Critical Flow Condition

Half Central Angle (0<Theta-c<3.14)	Theta-c =	3.11	radians
Critical flow area	Ac =	3.14	sq ft
Critical top width	Tc =	0.06	ft
Critical flow depth	Yc =	2.00	ft
Critical flow velocity	Vc =	41.69	fps
Critical Depth Froude Number	Fr_c =	1.00	

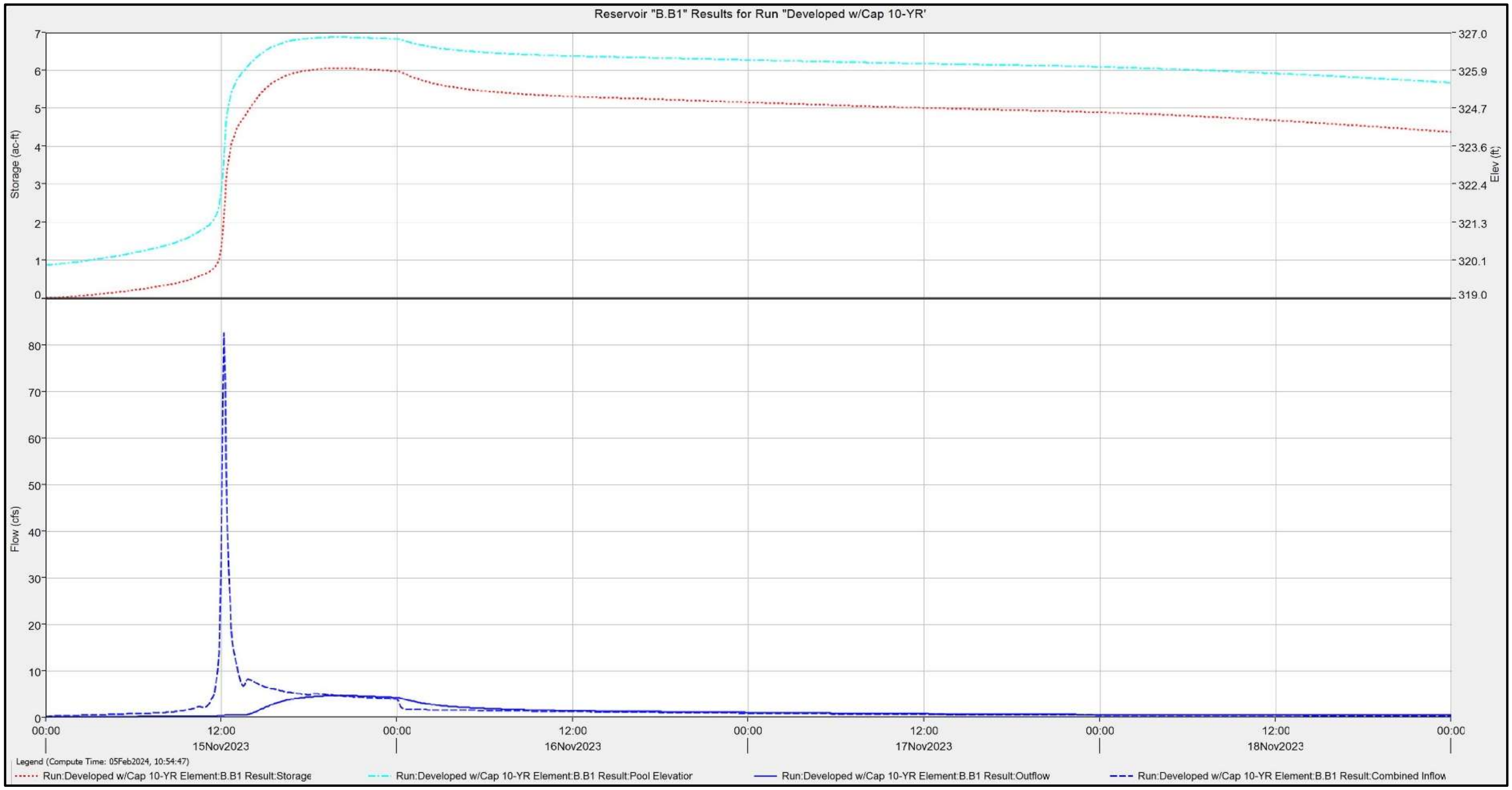
Stormwater Analysis Attachment 11

Basin Hydrographs

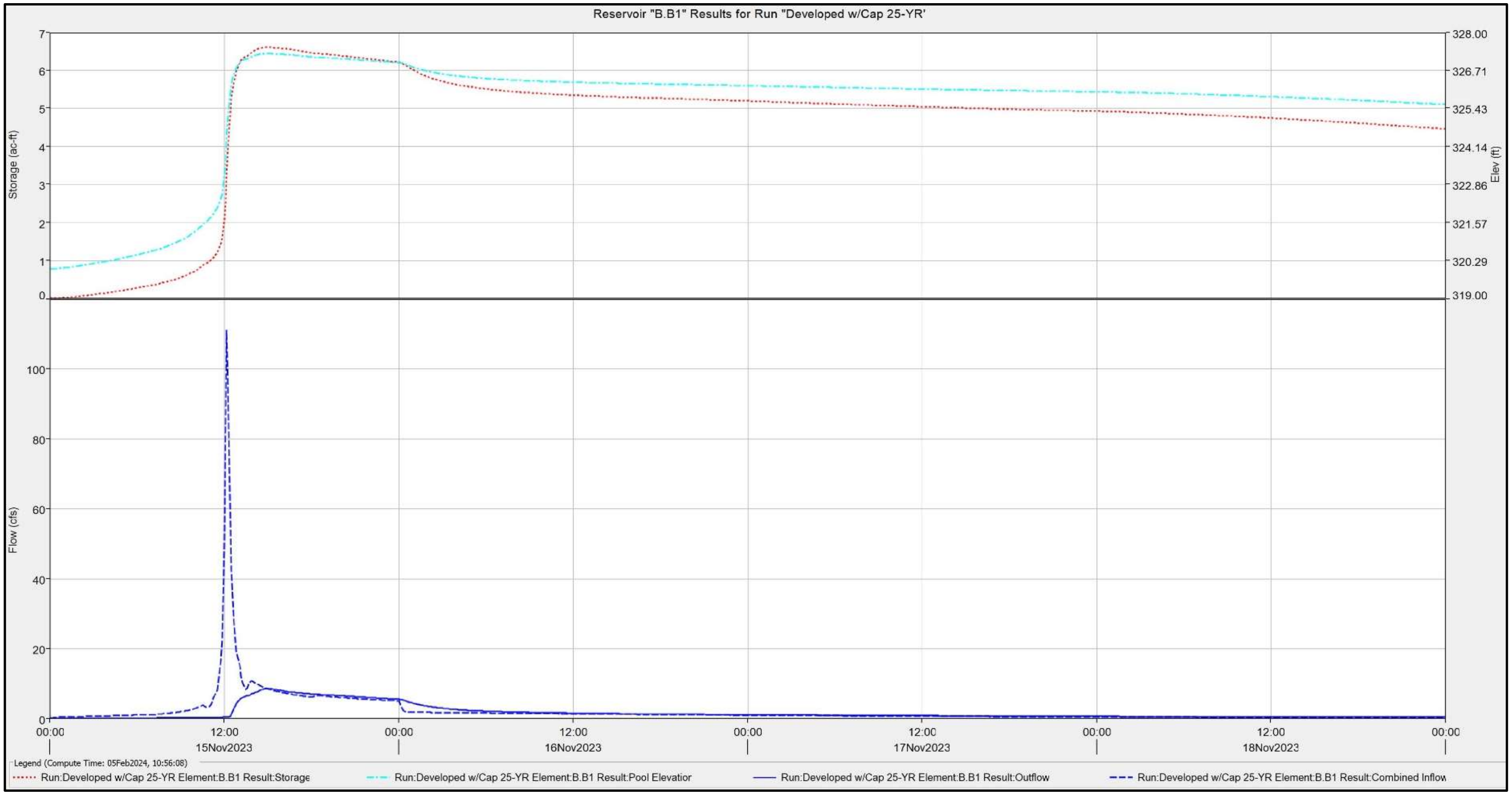
FFCP Facility Basin 1
2-YR Output Hydrograph



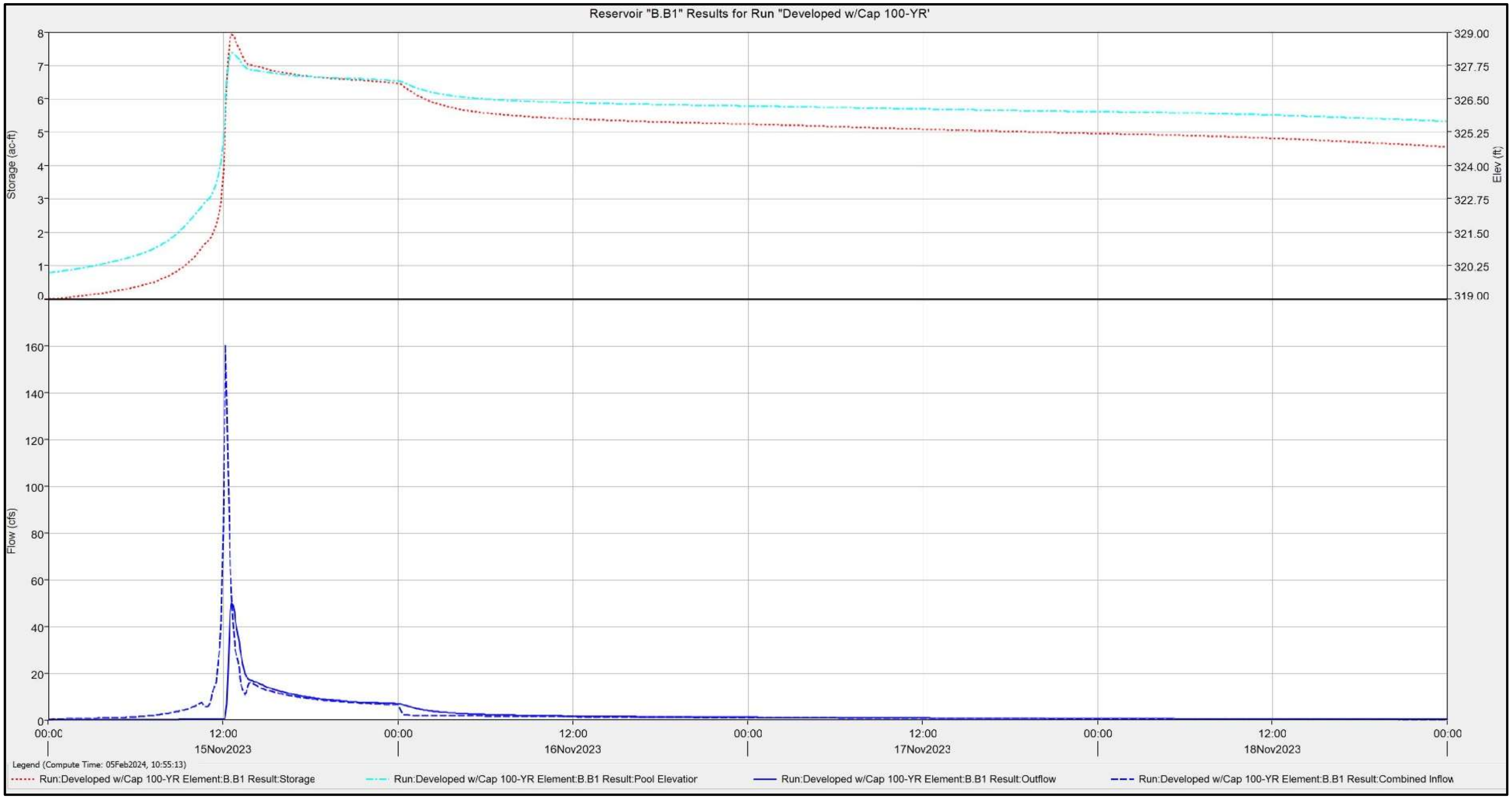
FFCP Facility Basin 1
10-YR Output Hydrograph



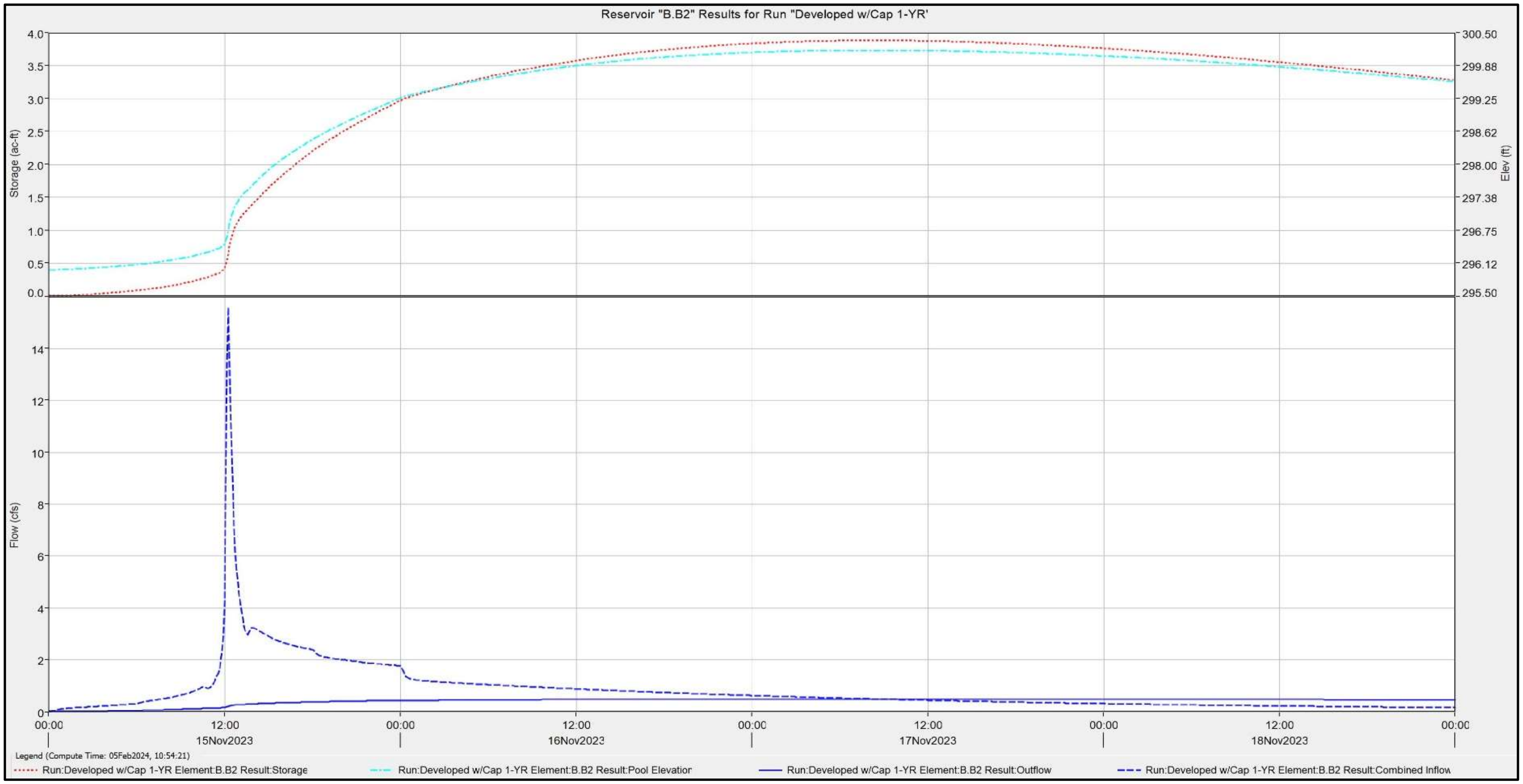
FFCP Facility Basin 1
25-YR Output Hydrograph



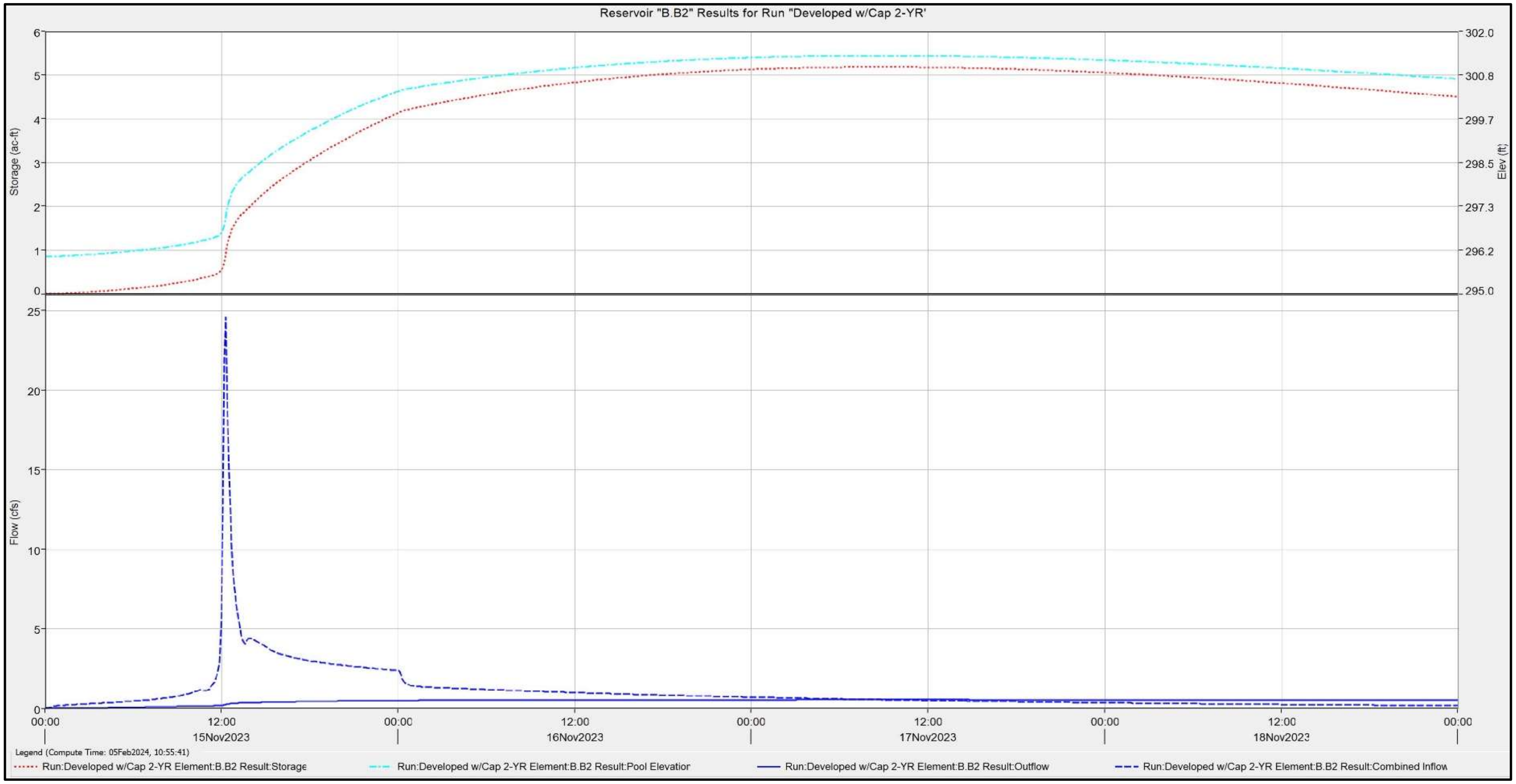
FFCP Facility Basin 1
100-YR Output Hydrograph



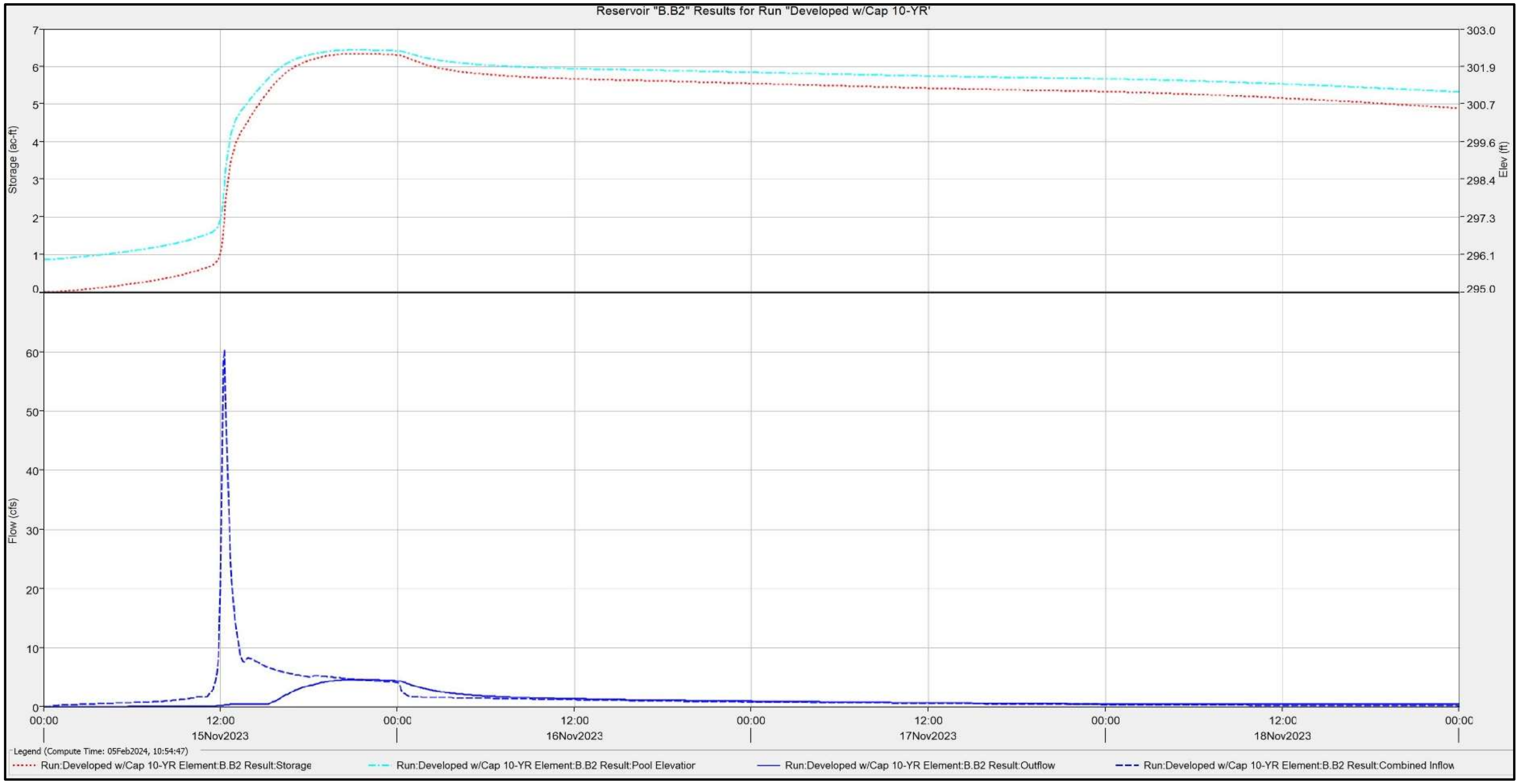
FFCP Facility Basin 2
1-YR Output Hydrograph



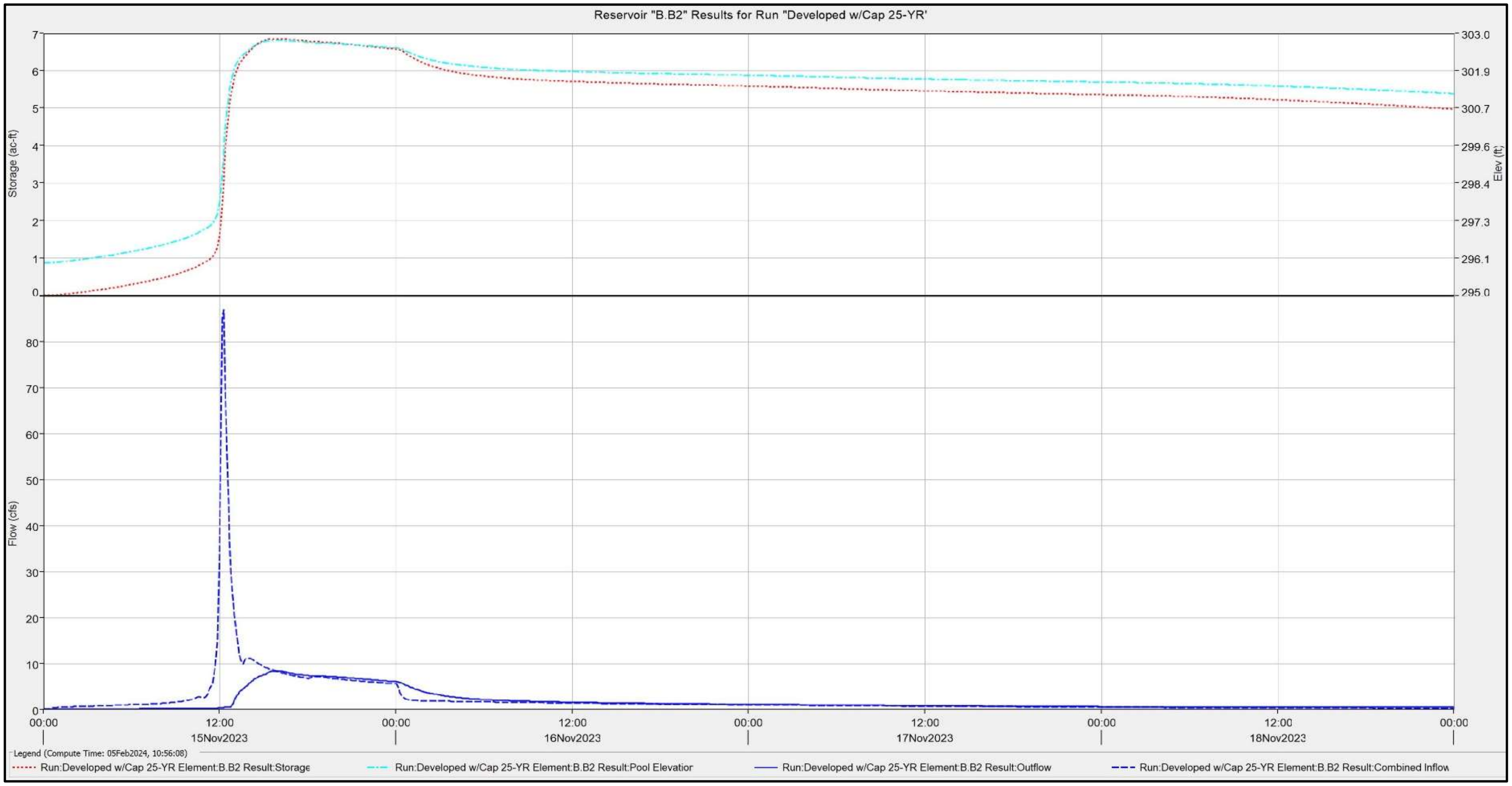
FFCP Facility Basin 2
2-YR Output Hydrograph



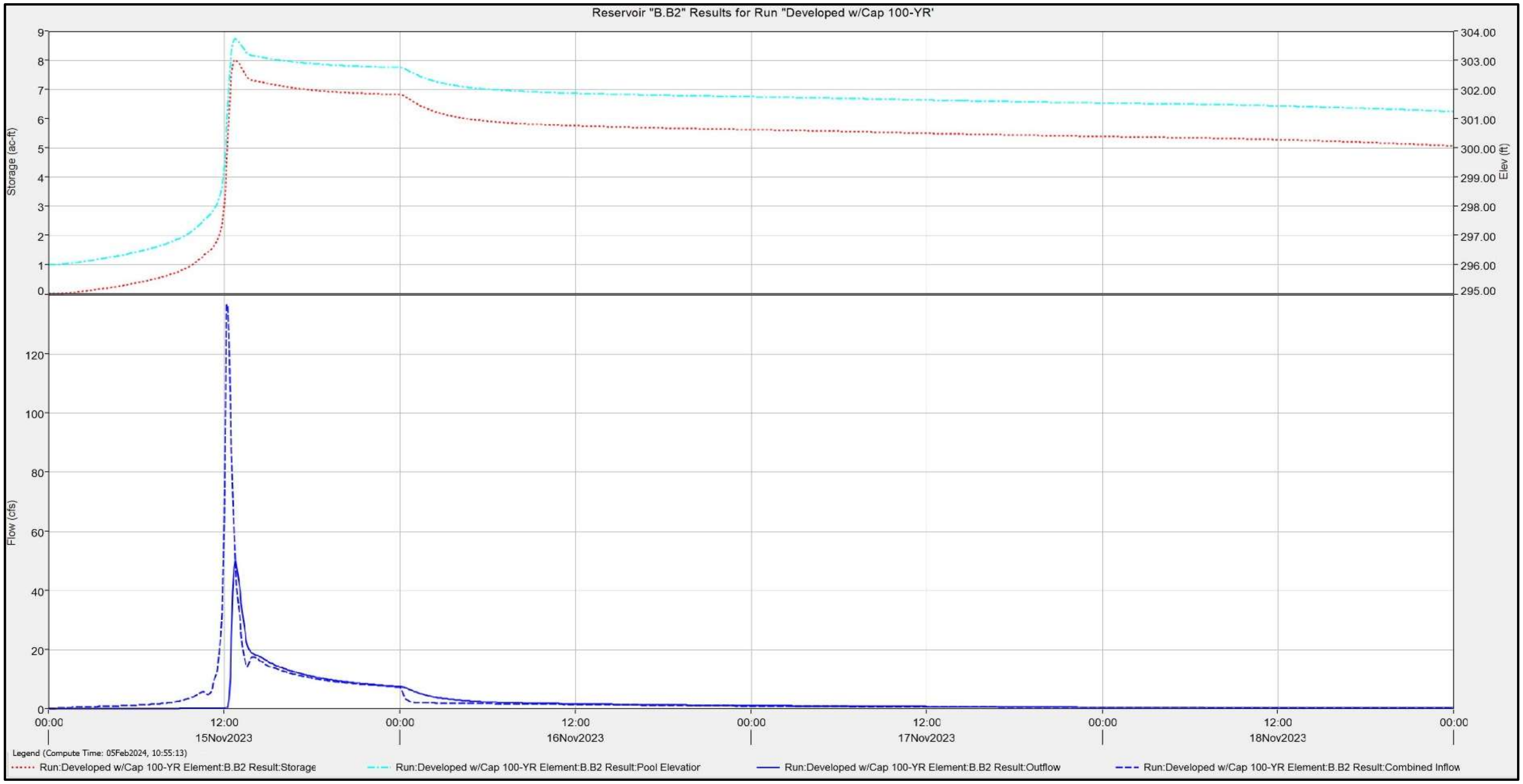
FFCP Facility Basin 2
10-YR Output Hydrograph



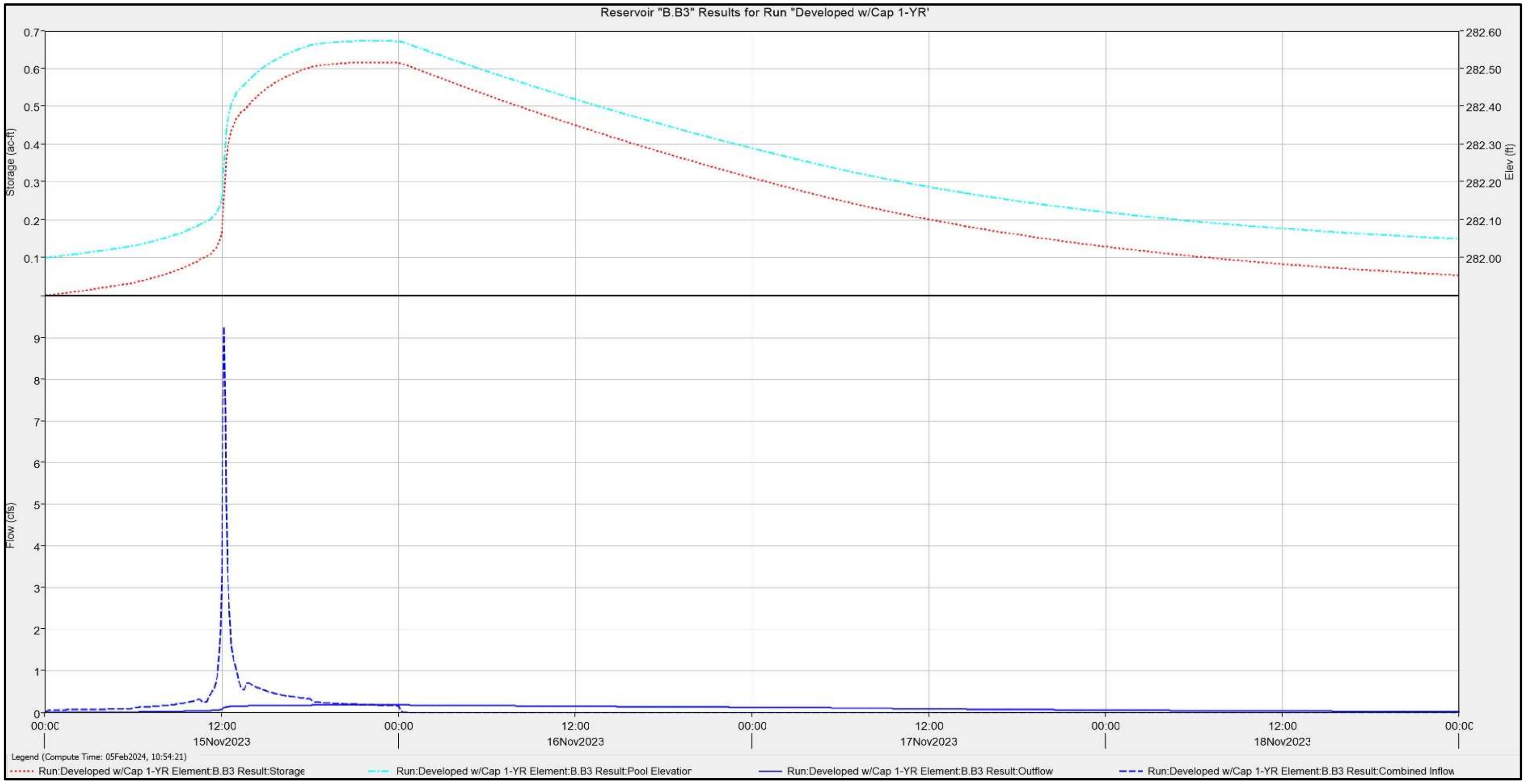
FFCP Facility Basin 2
25-YR Output Hydrograph



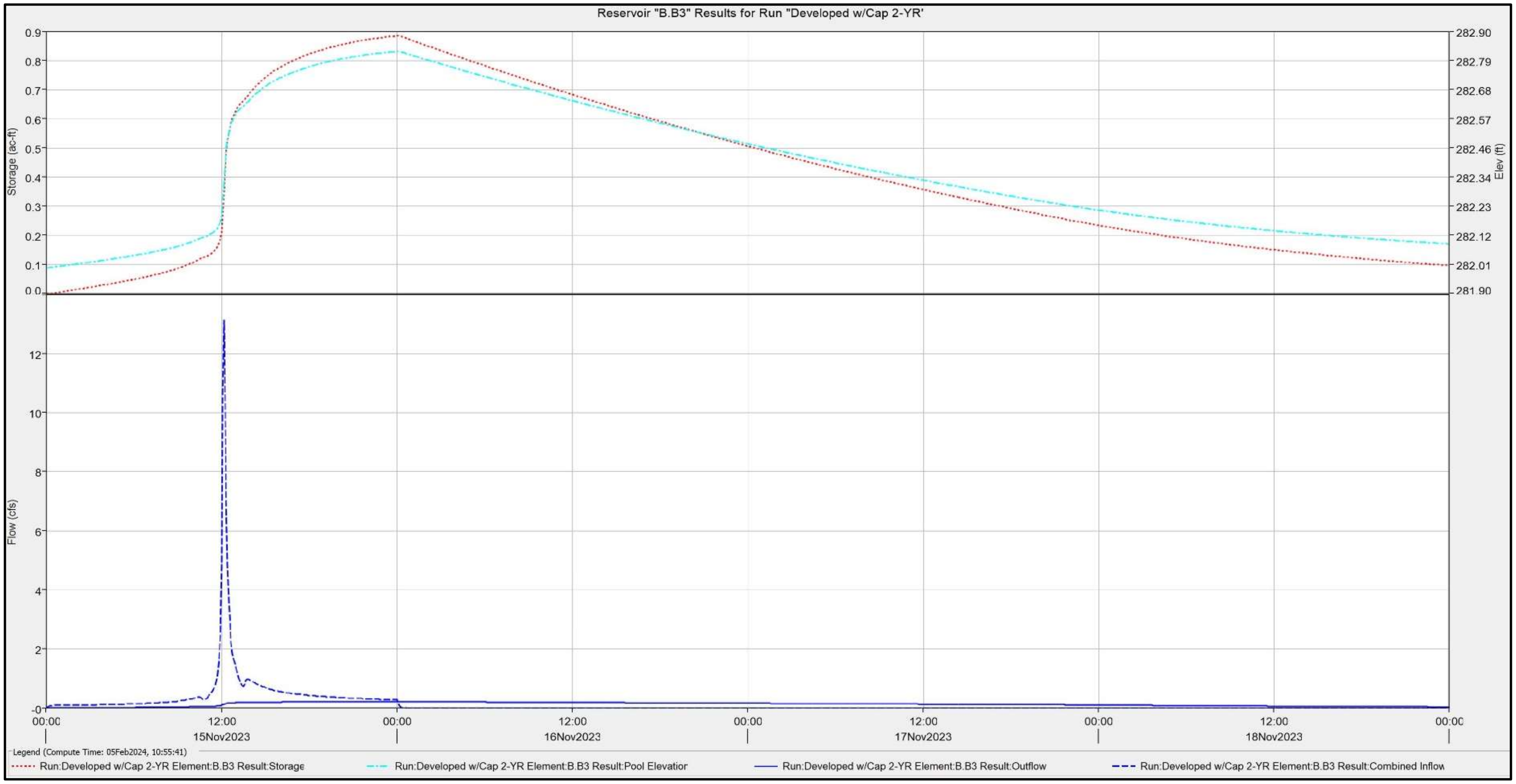
FFCP Facility Basin 2
100-YR Output Hydrograph



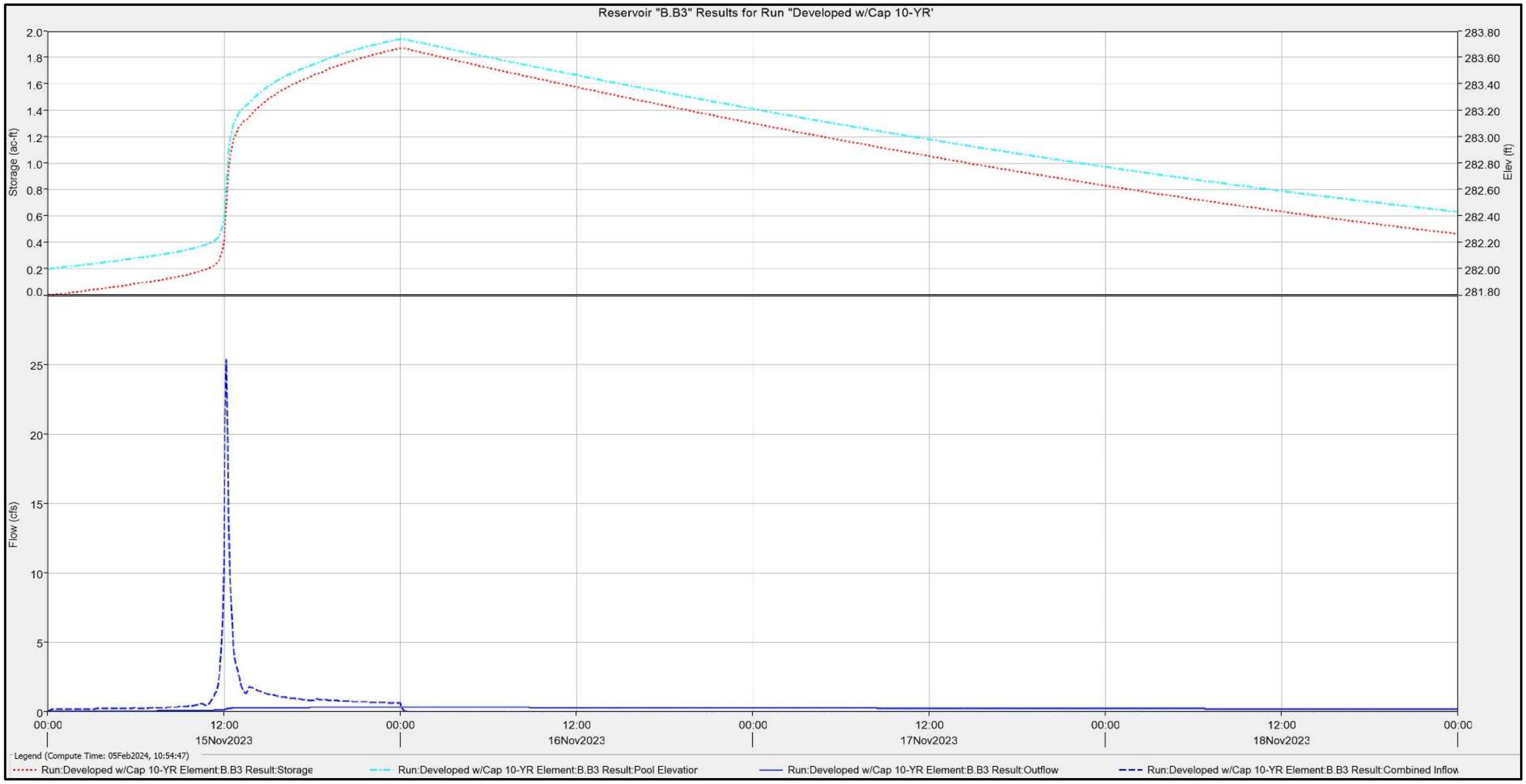
FFCP Facility Basin 3
1-YR Output Hydrograph



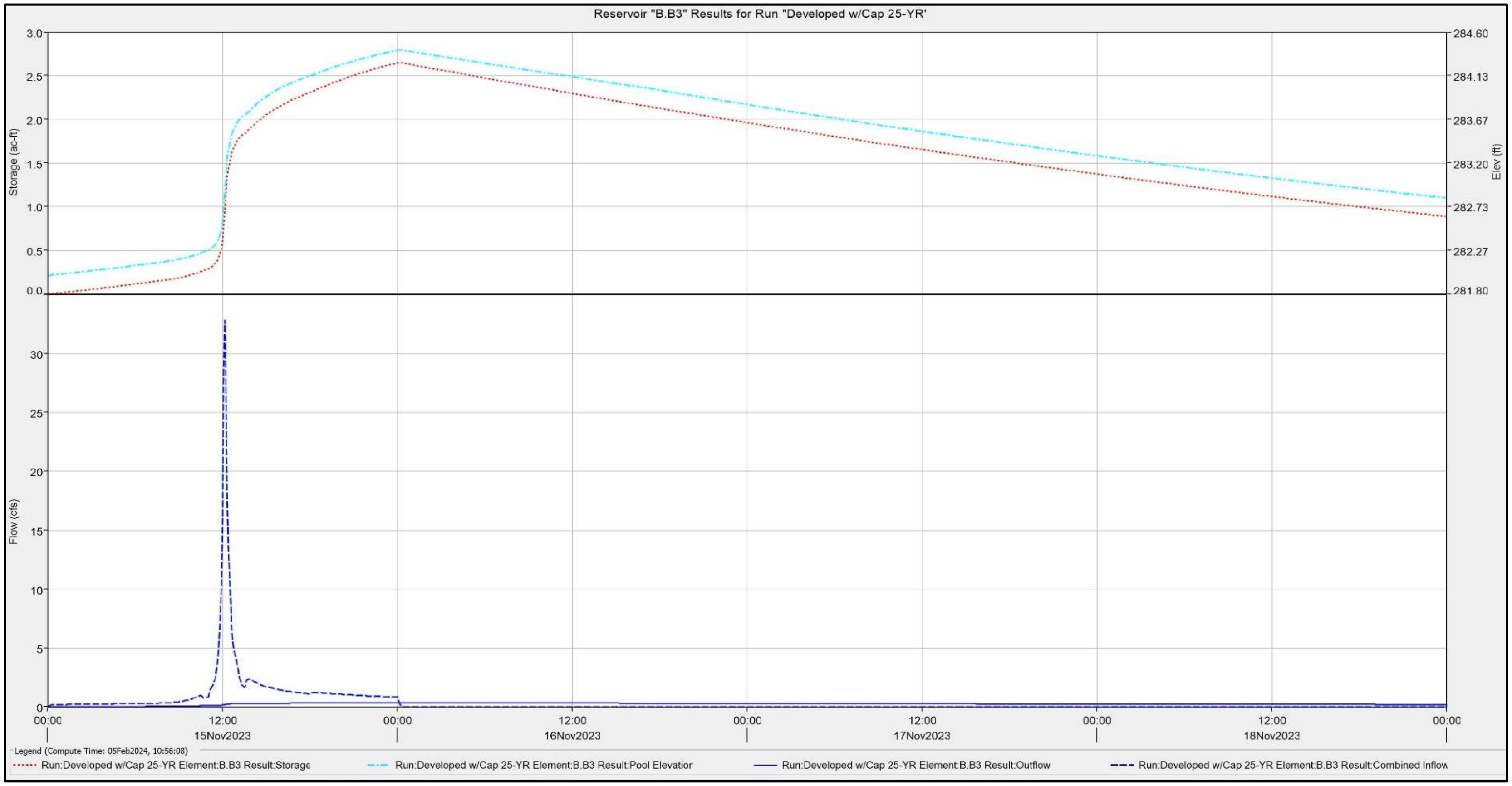
FFCP Facility Basin 3
2-YR Output Hydrograph



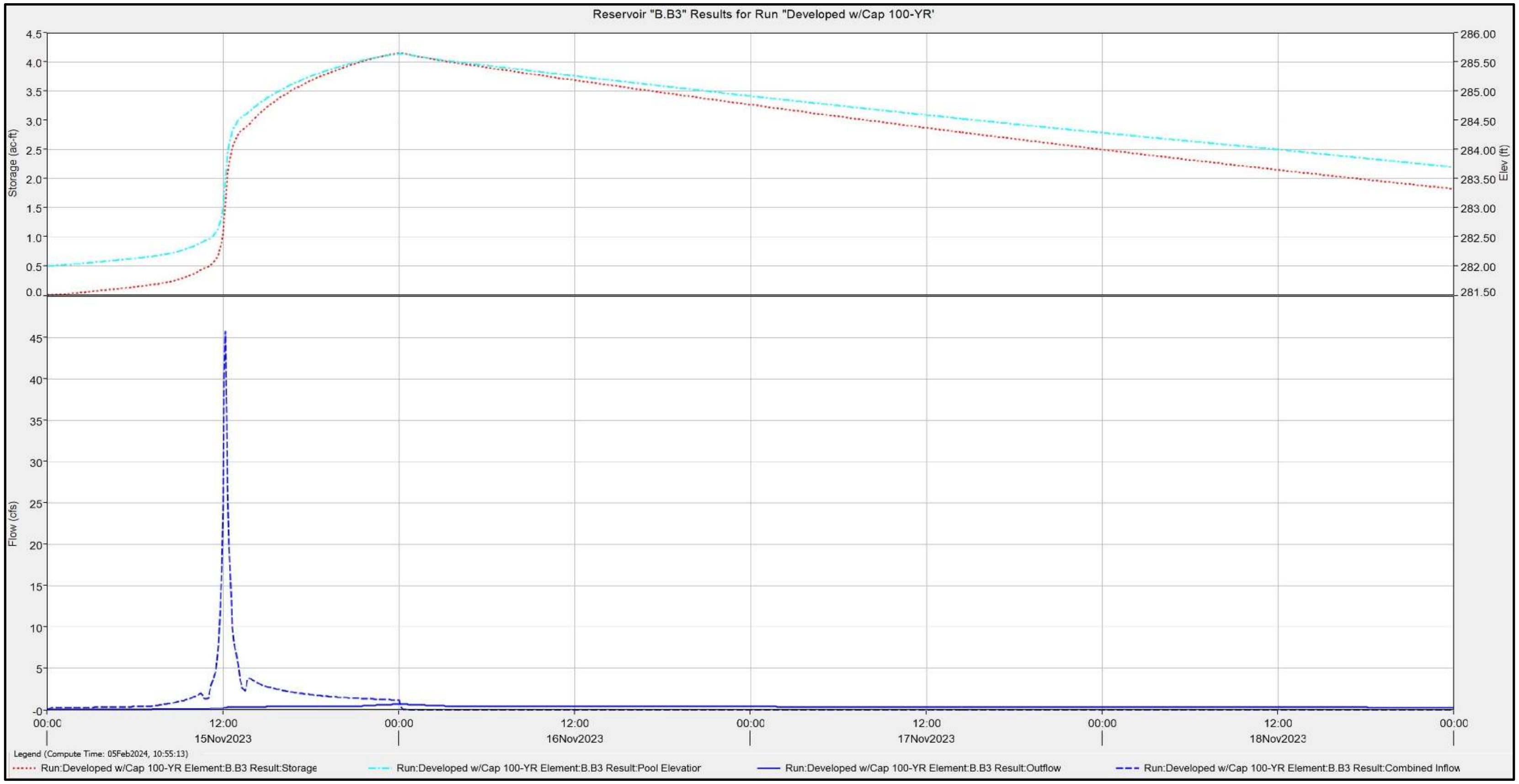
FFCP Facility Basin 3
10-YR Output Hydrograph



FFCP Facility Basin 3
25-YR Output Hydrograph

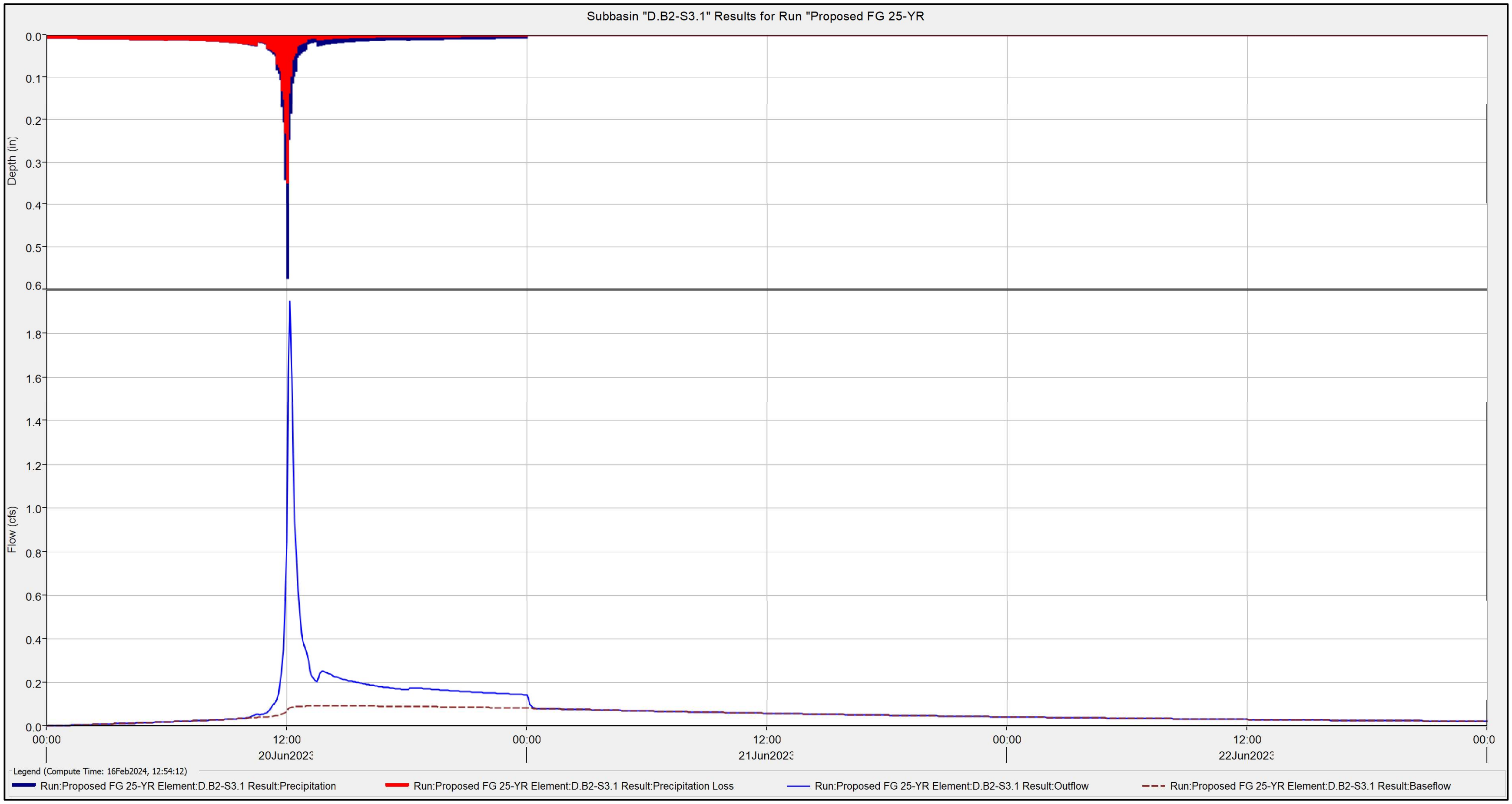


FFCP Facility Basin 3
100-YR Output Hydrograph

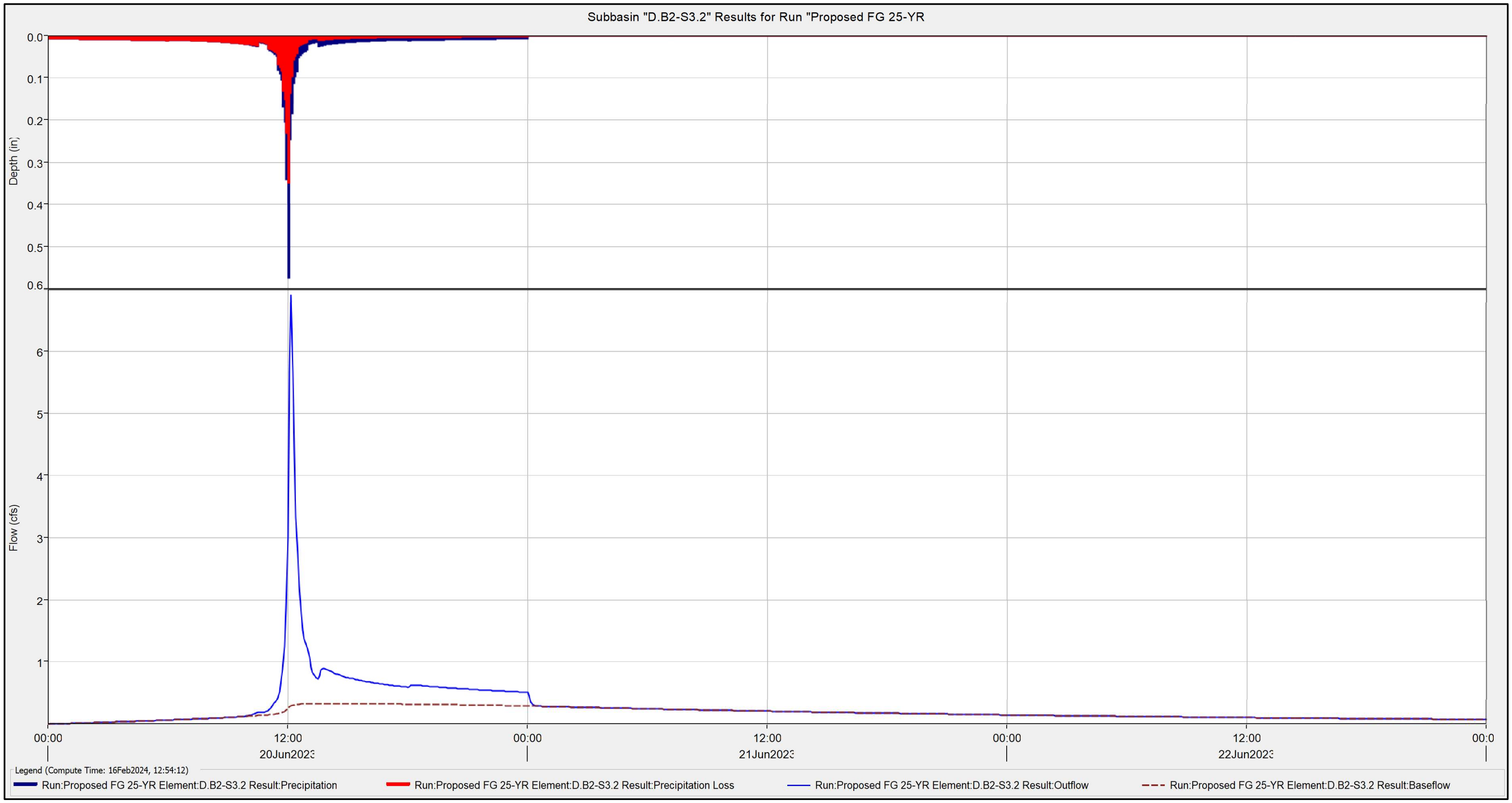


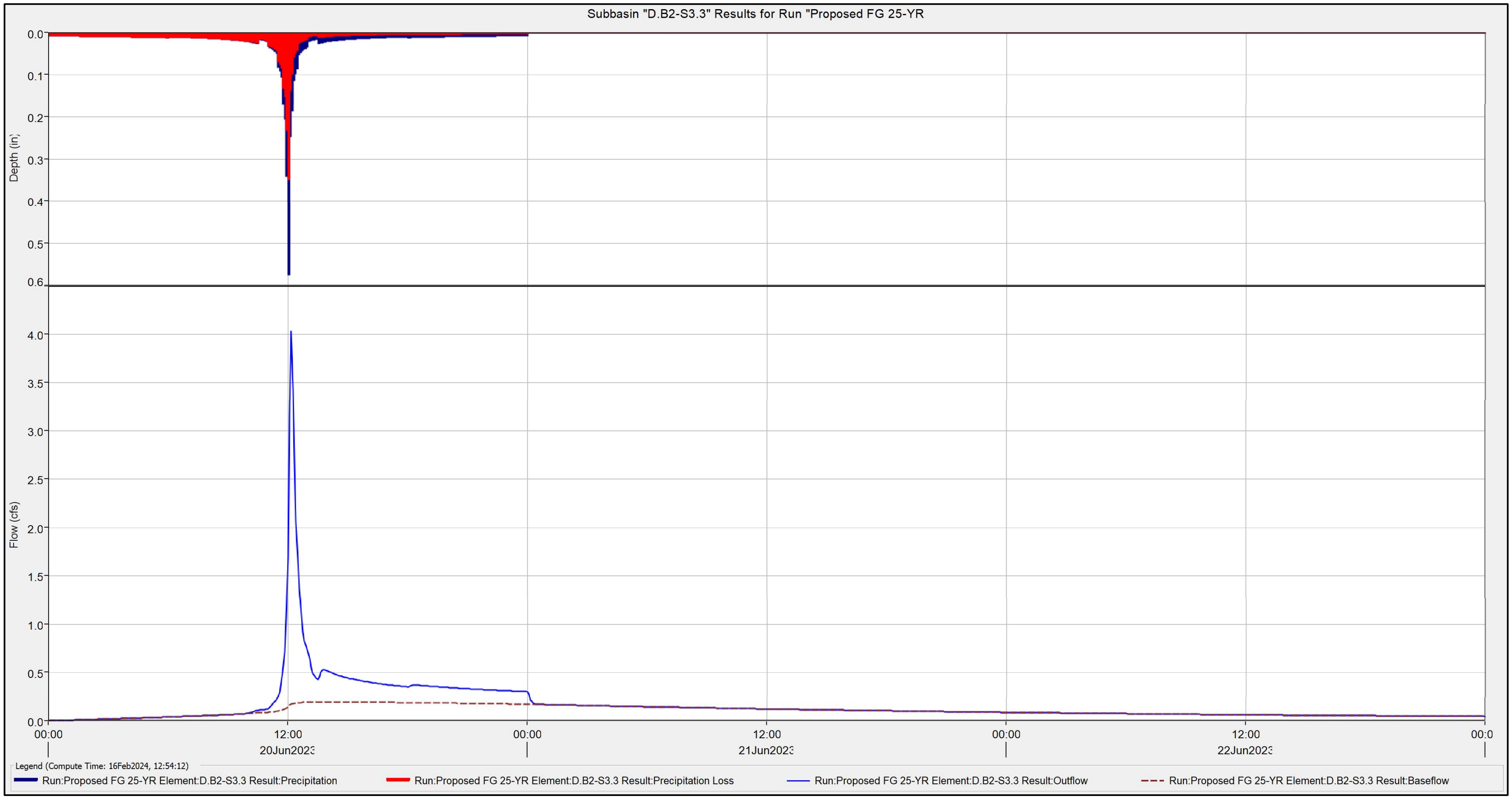
Stormwater Analysis Attachment 12

Final Cover Area Subbasin Hydrographs

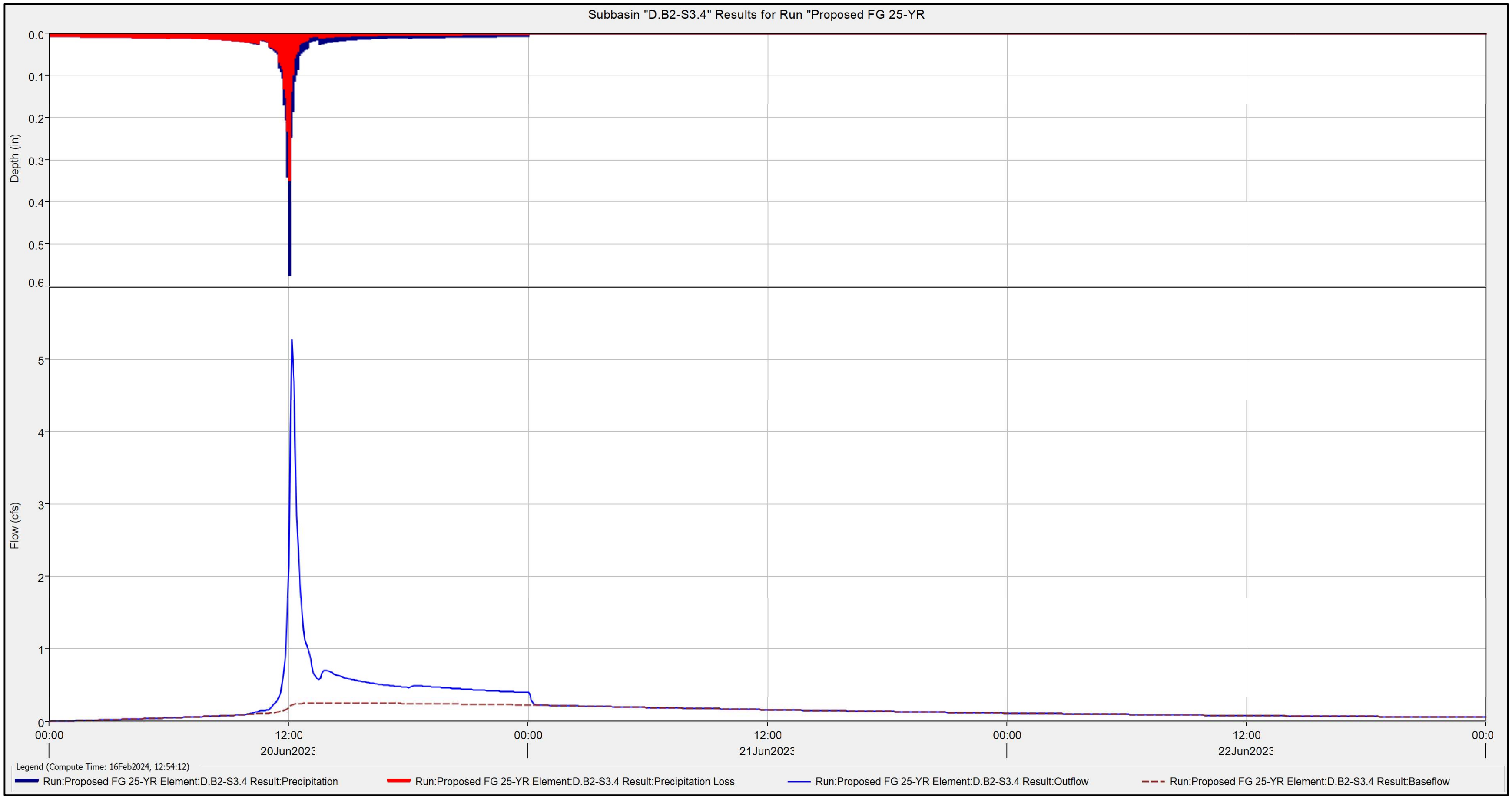


Subbasin "D.B2-S3.1" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S3.1 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S3.1 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S3.1 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S3.1 Result:Baseflow

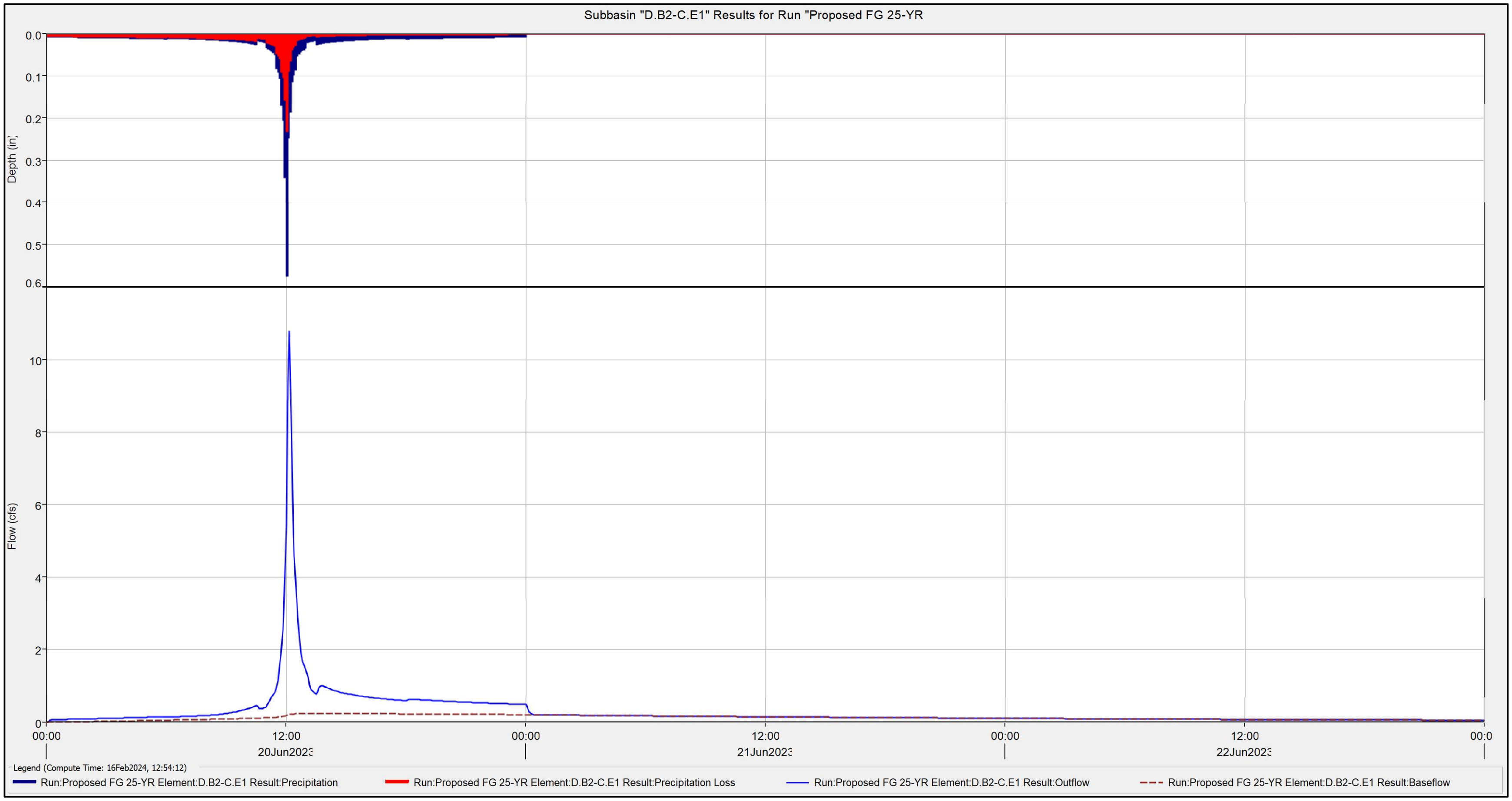

Subbasin "D.B2-S3.2" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
6
5
4
3
2
1
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S3.2 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S3.2 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S3.2 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S3.2 Result:Baseflow

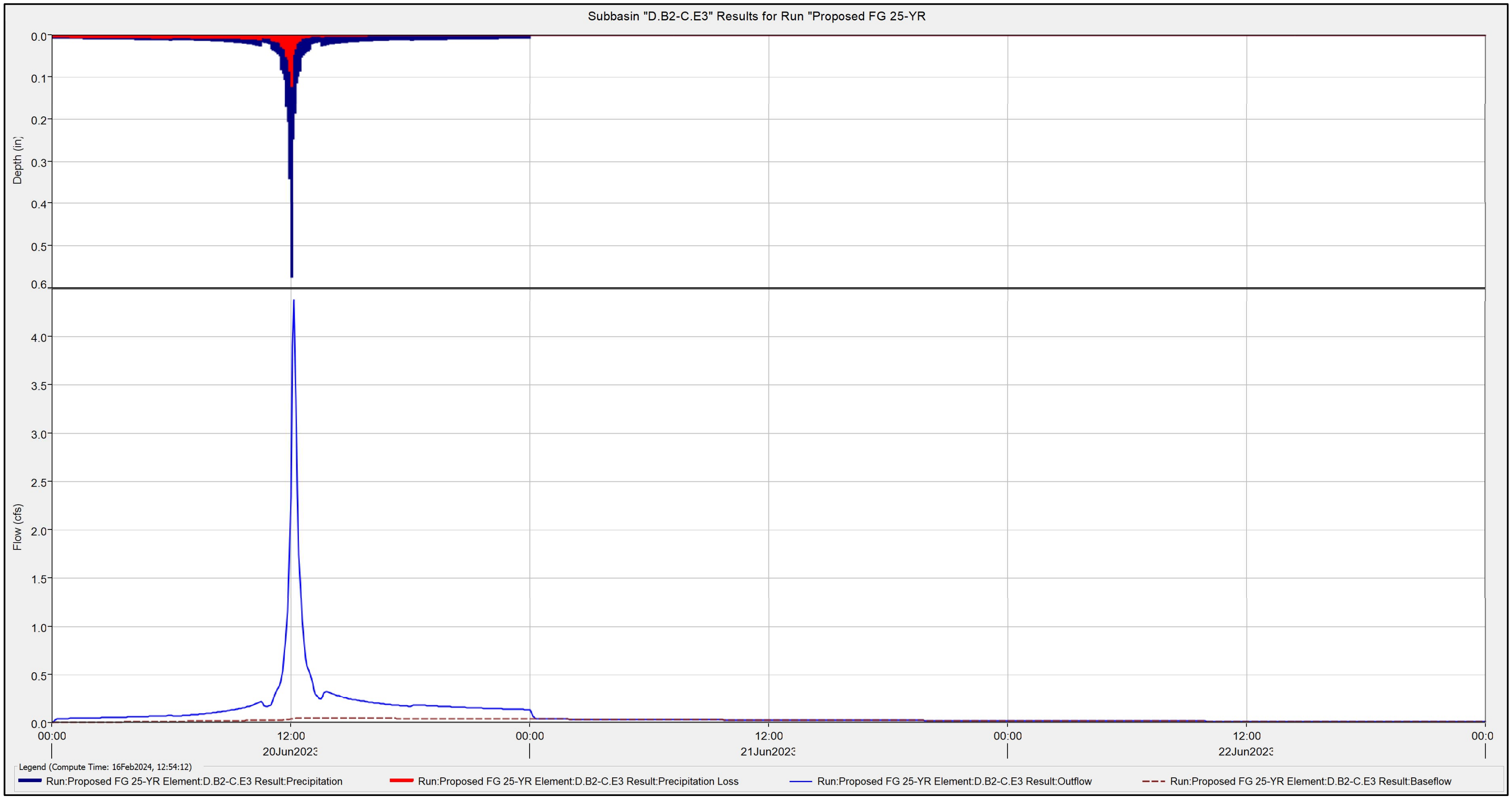


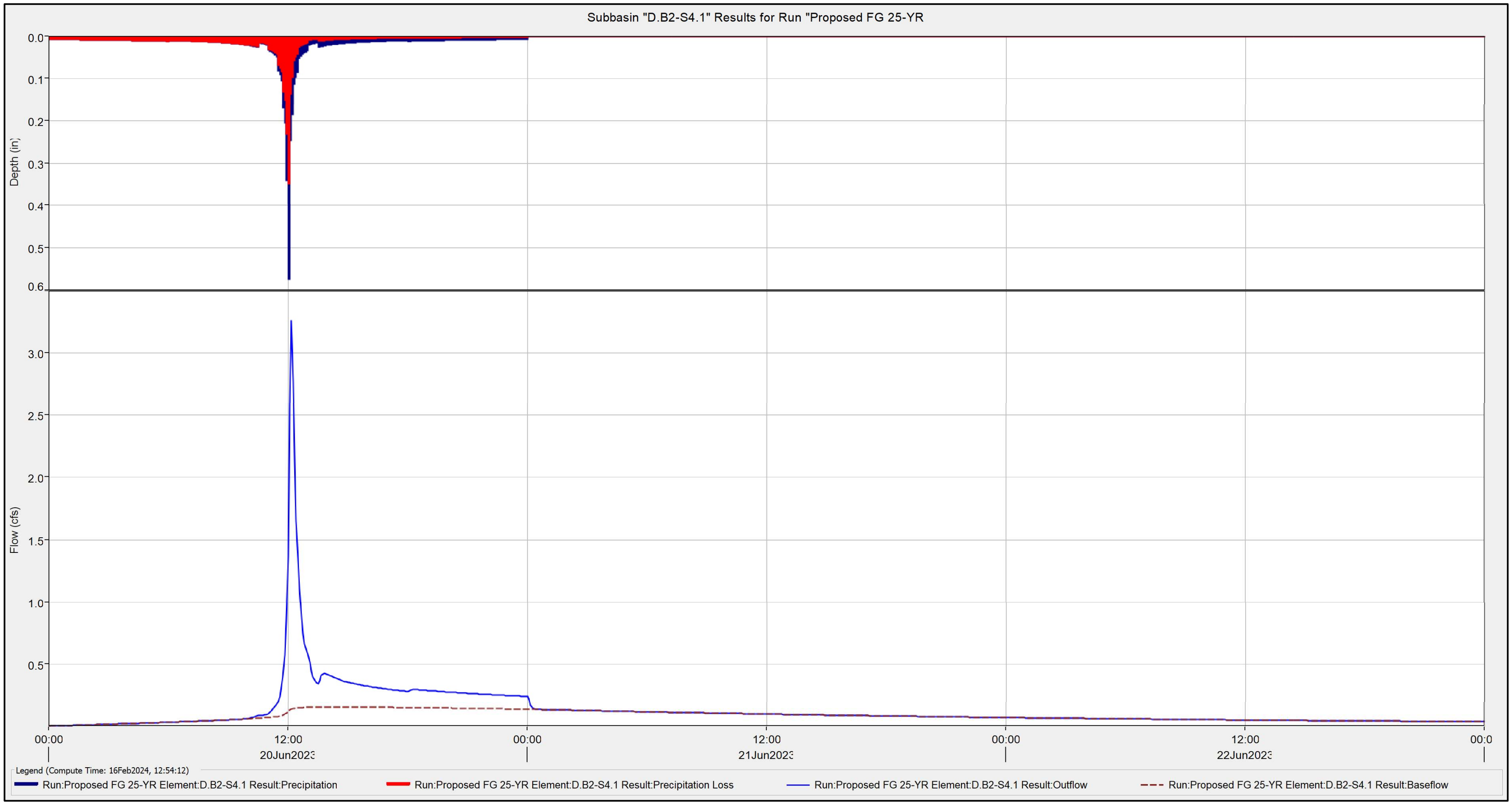
Subbasin "D.B2-S3.3" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S3.3 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S3.3 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S3.3 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S3.3 Result:Baseflow



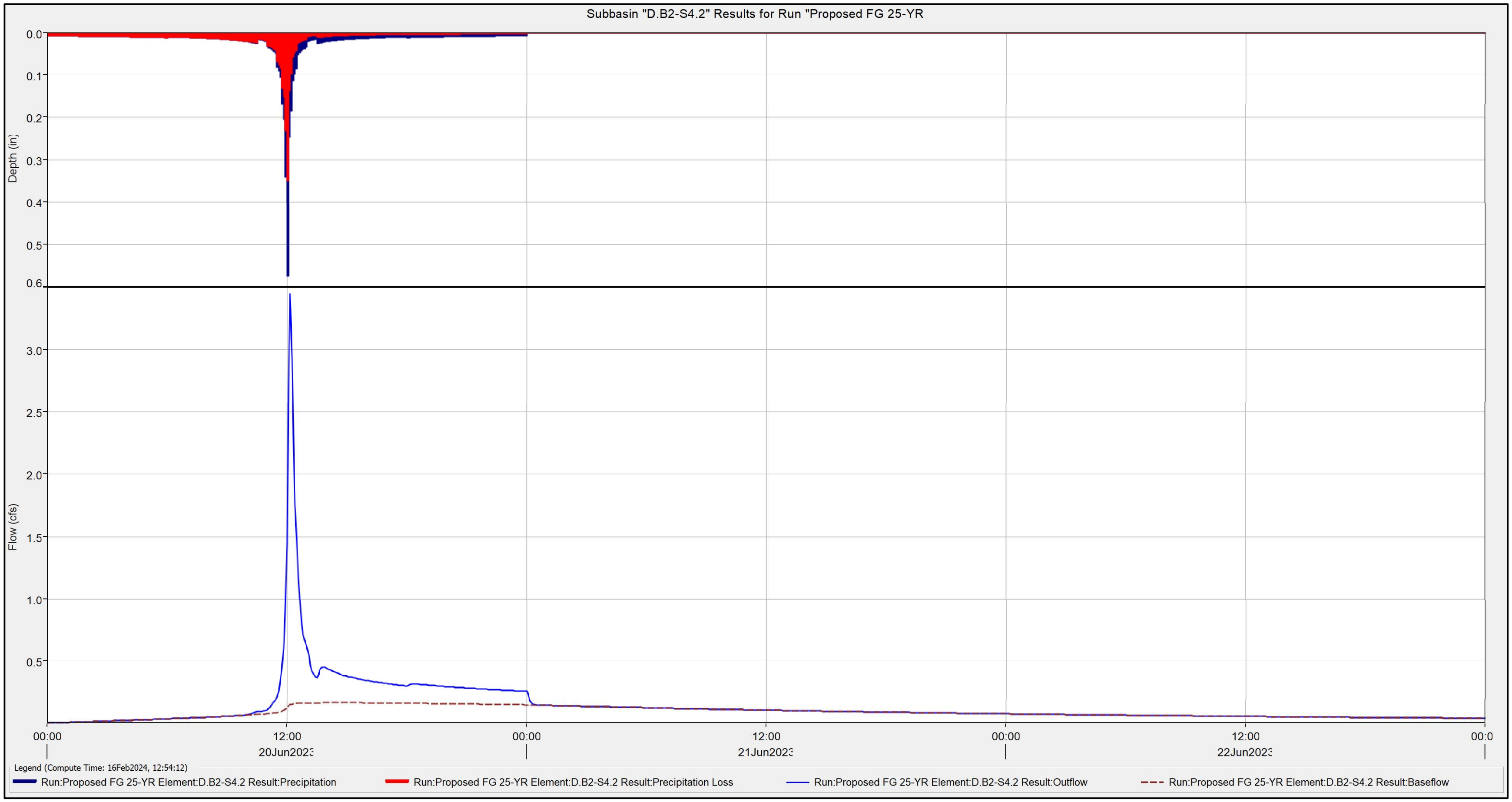
Subbasin "D.B2-S3.4" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
5
4
3
2
1
0
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S3.4 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S3.4 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S3.4 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S3.4 Result:Baseflow


Subbasin "D.B2-C.E1" Results for Run "Proposed FG 25-YR
Depth (in)
Flow (cfs)
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-C.E1 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-C.E1 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-C.E1 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-C.E1 Result:Baseflow

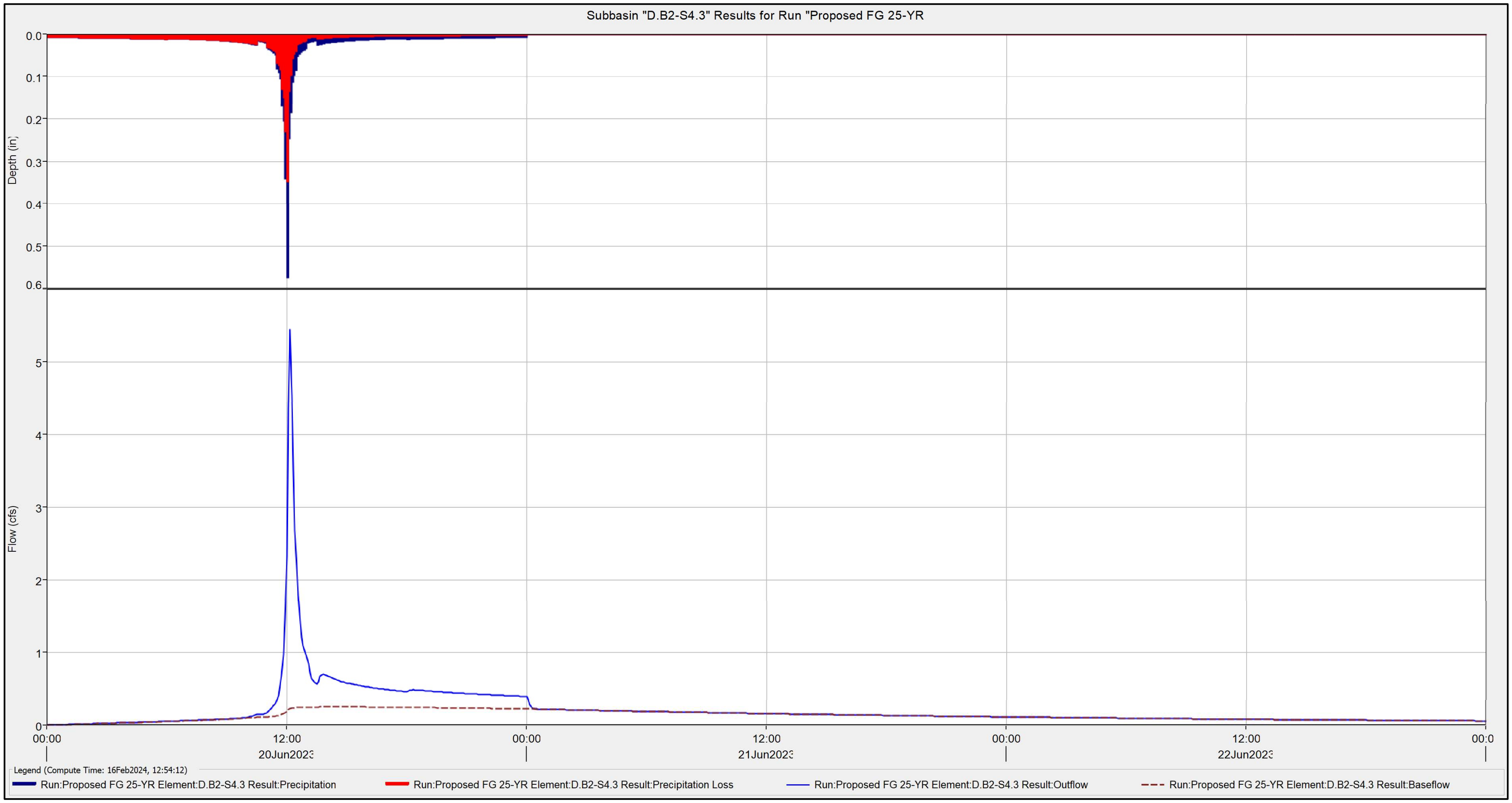

Subbasin "D.B2-C.E3" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-C.E3 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-C.E3 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-C.E3 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-C.E3 Result:Baseflow



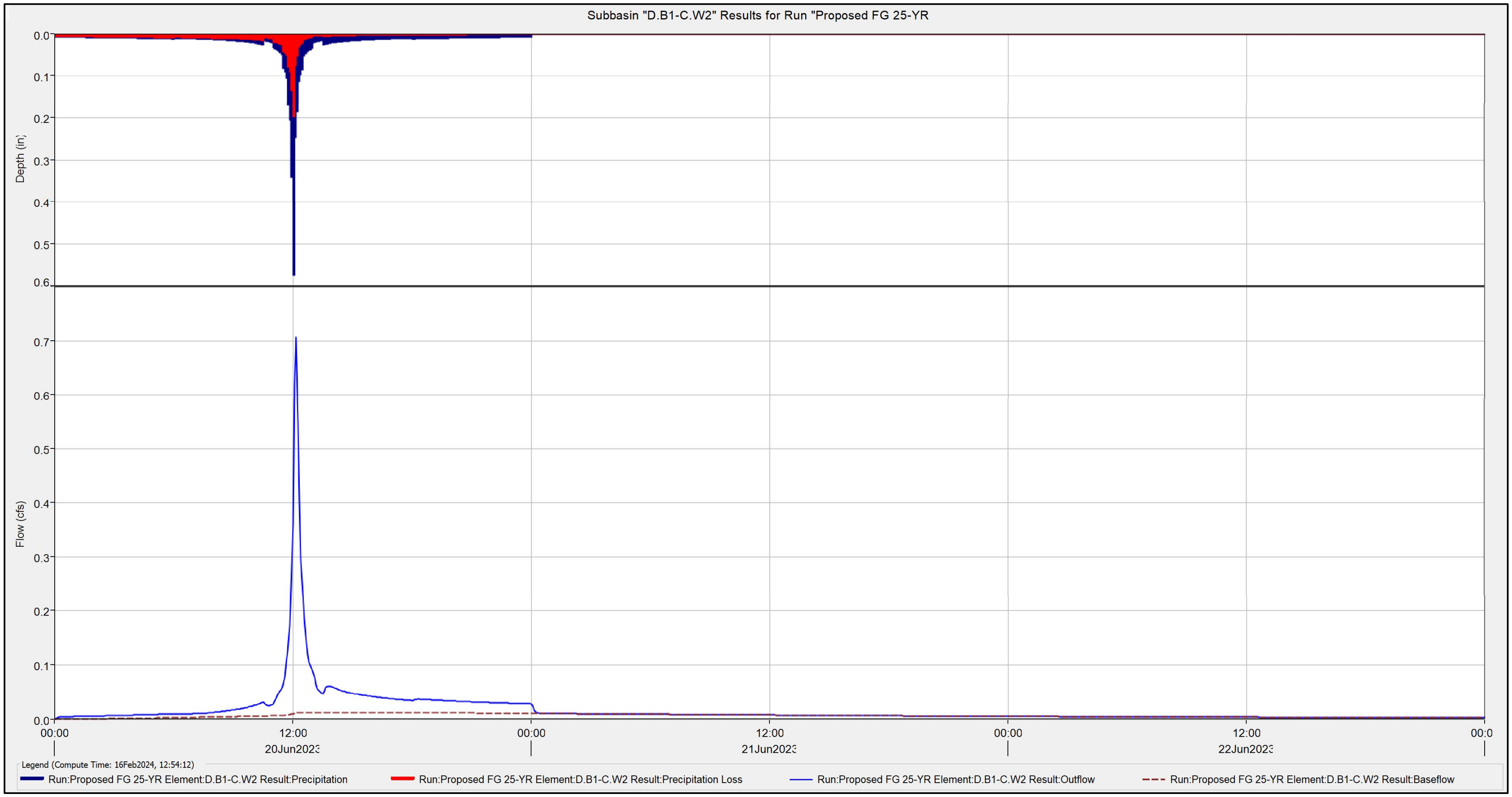
Subbasin "D.B2-S4.1" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
3.0
2.5
2.0
1.5
1.0
0.5
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S4.1 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S4.1 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S4.1 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S4.1 Result:Baseflow

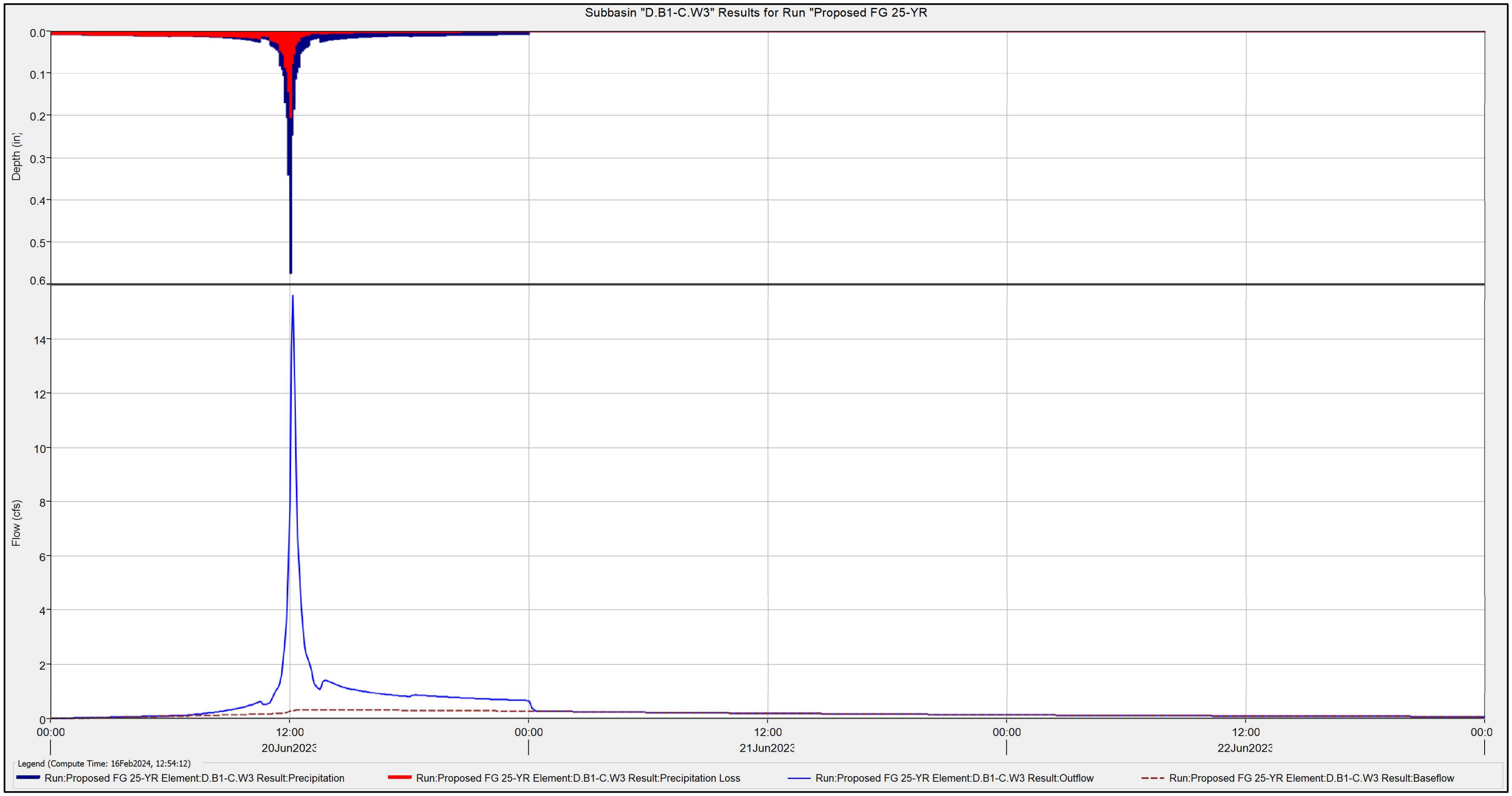


Subbasin "D.B2-S4.2" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
3.0
2.5
2.0
1.5
1.0
0.5
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S4.2 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S4.2 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S4.2 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S4.2 Result:Baseflow

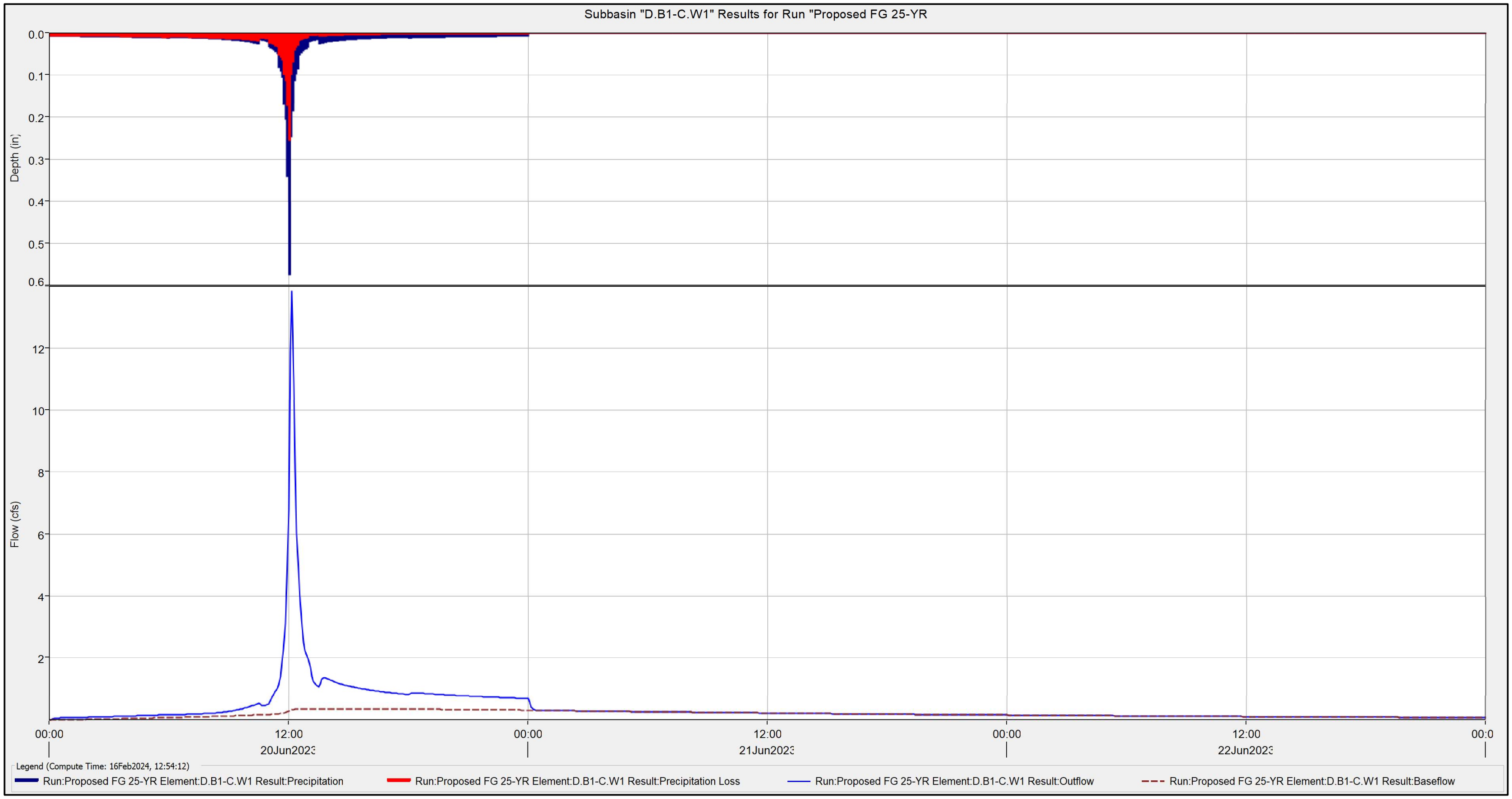


Subbasin "D.B2-S4.3" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
0
1
2
3
4
5
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B2-S4.3 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B2-S4.3 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B2-S4.3 Result:Outflow
Run:Proposed FG 25-YR Element:D.B2-S4.3 Result:Baseflow

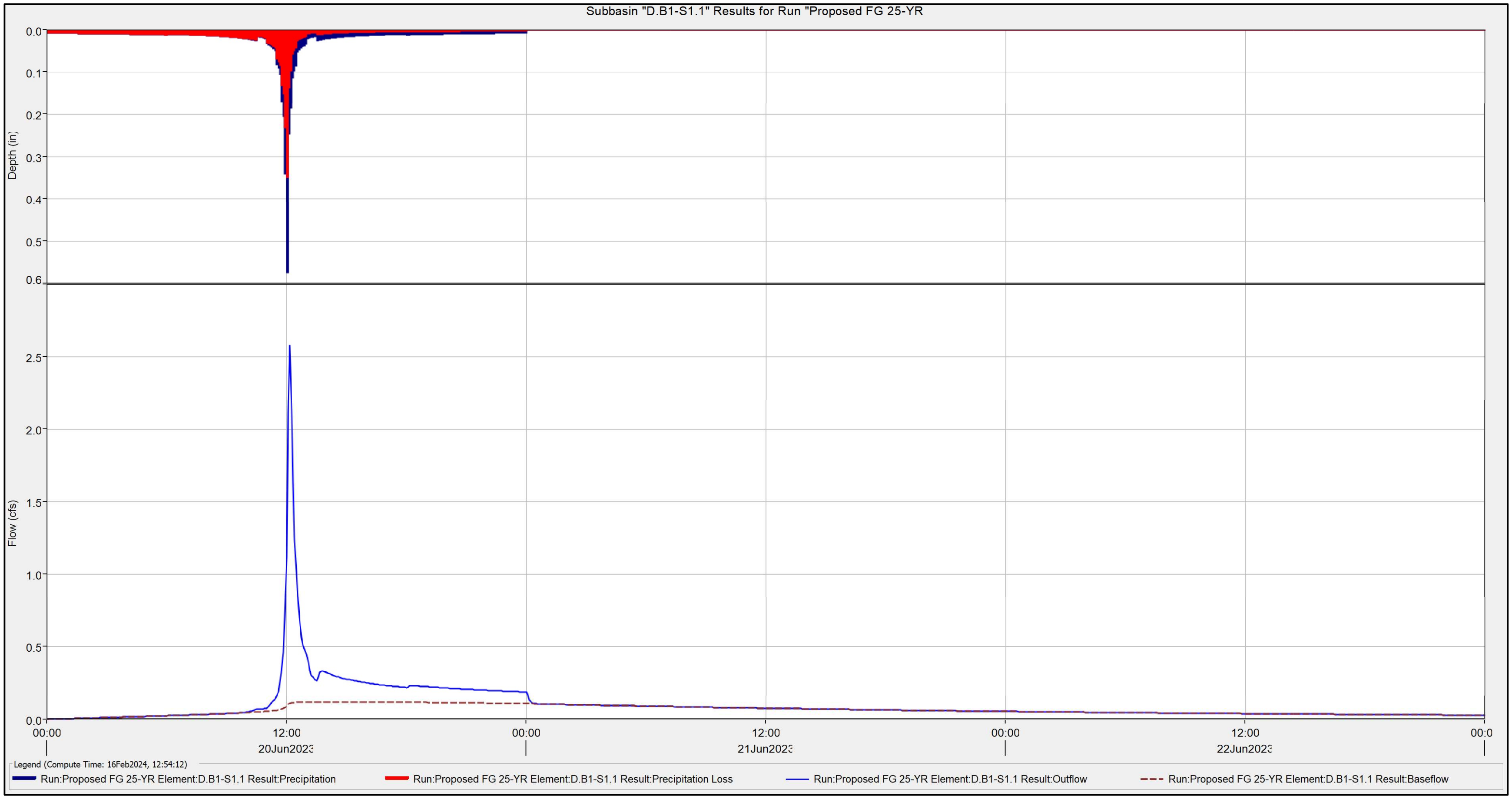

Subbasin "D.B1-C.W2" Results for Run "Proposed FG 25-YR
Depth (in)
Flow (cfs)
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-C.W2 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-C.W2 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-C.W2 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-C.W2 Result:Baseflow

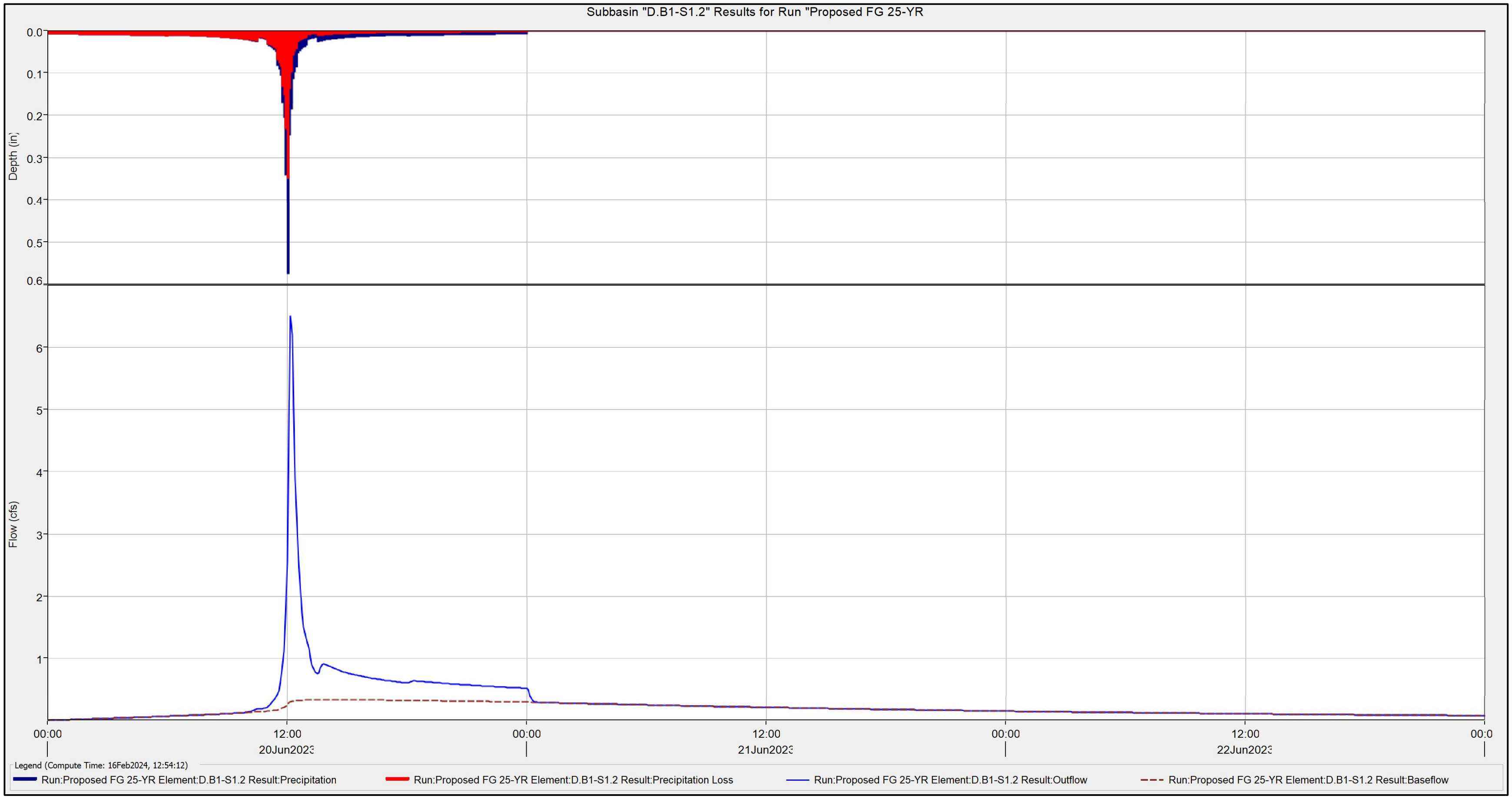


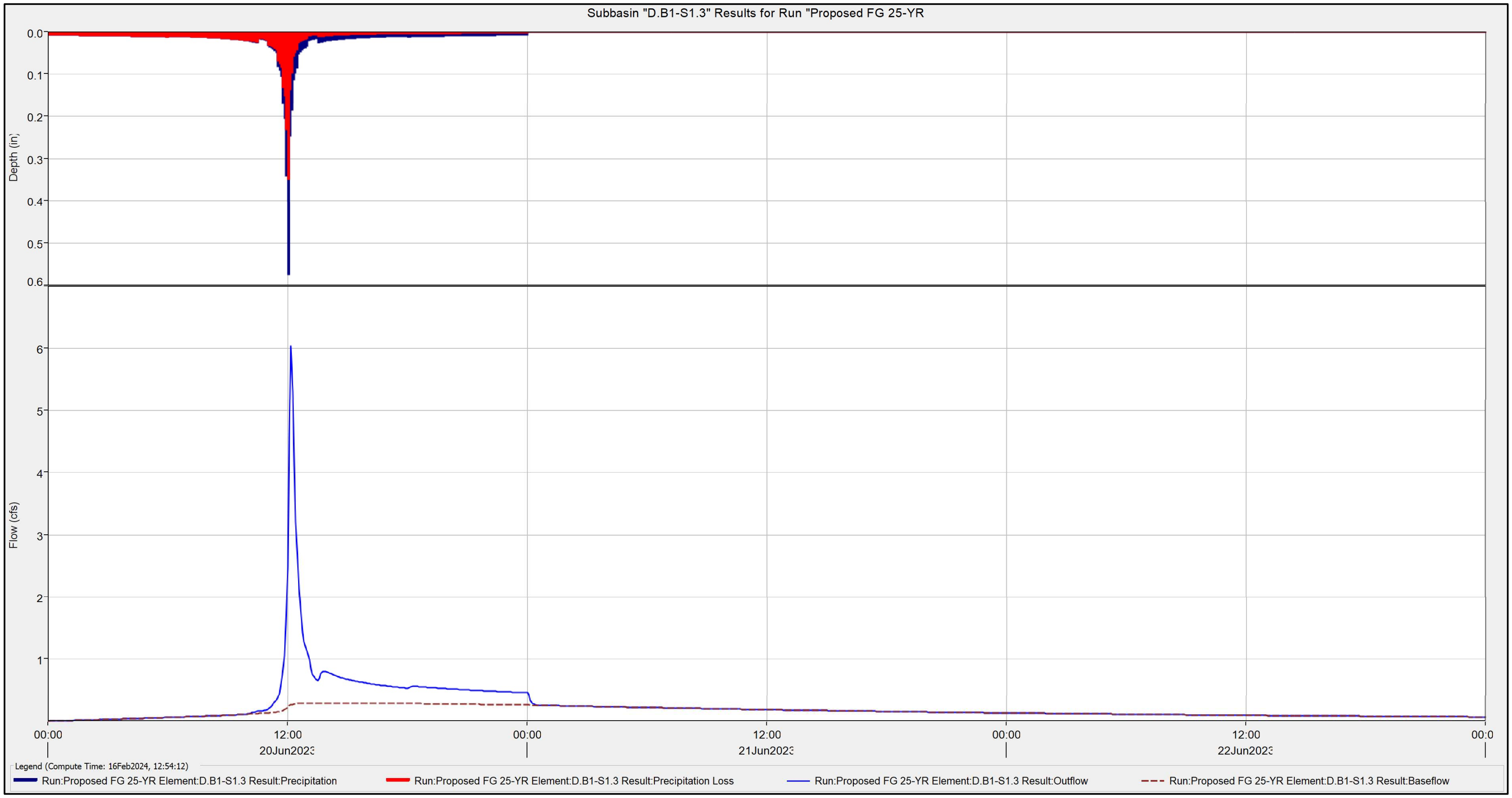
Subbasin "D.B1-C.W3" Results for Run "Proposed FG 25-YR
Depth (in)
Flow (cfs)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
14
12
10
8
6
4
2
0
00:00
12:00
00:00
12:00
00:00
12:00
00:0
20Jun2023
21Jun2023
22Jun2023
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-C.W3 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-C.W3 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-C.W3 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-C.W3 Result:Baseflow



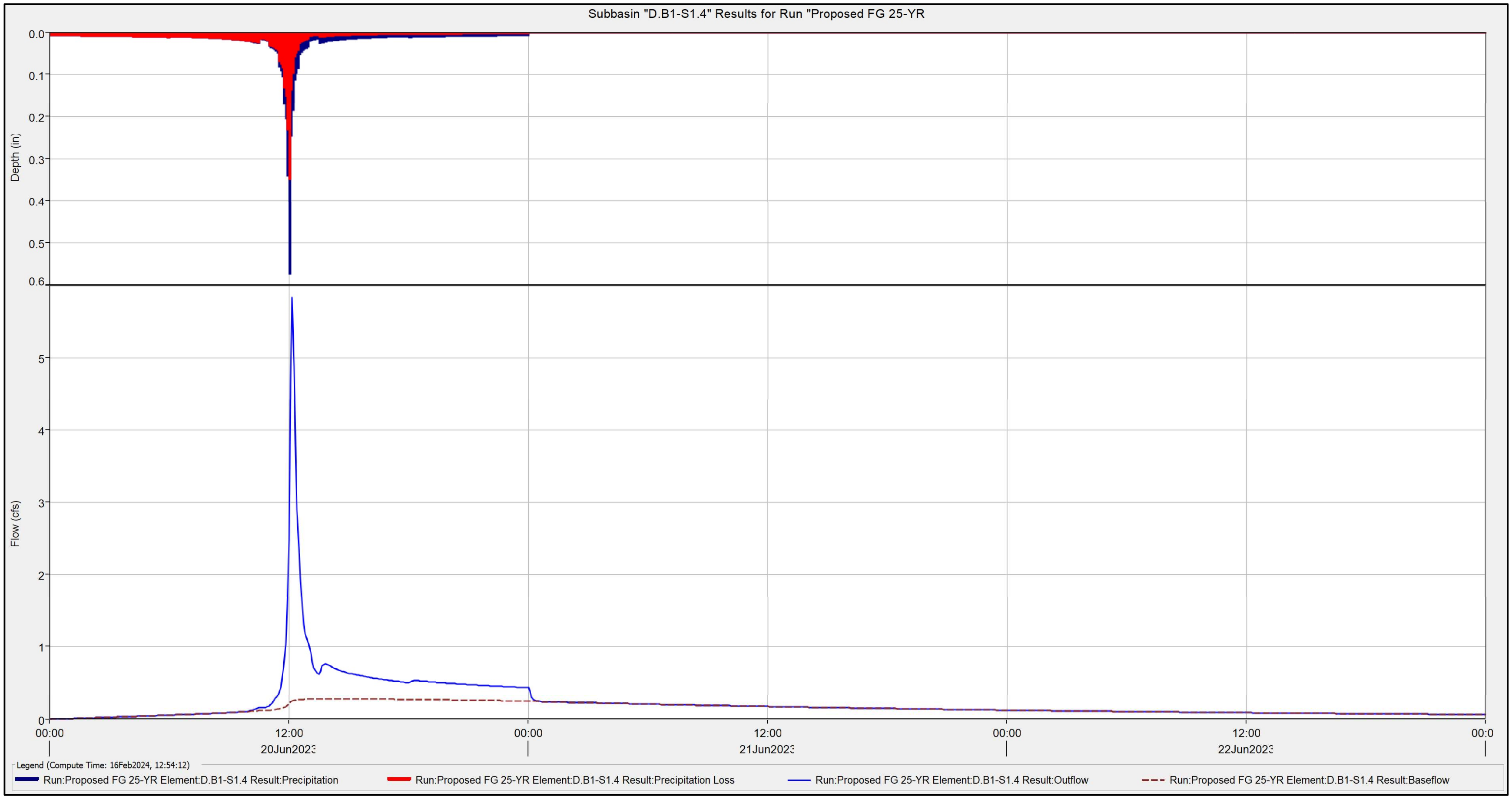
Subbasin "D.B1-C.W1" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
12
10
8
6
4
2
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-C.W1 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-C.W1 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-C.W1 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-C.W1 Result:Baseflow


Subbasin "D.B1-S1.1" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
2.5
2.0
1.5
1.0
0.5
0.0
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-S1.1 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-S1.1 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-S1.1 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-S1.1 Result:Baseflow

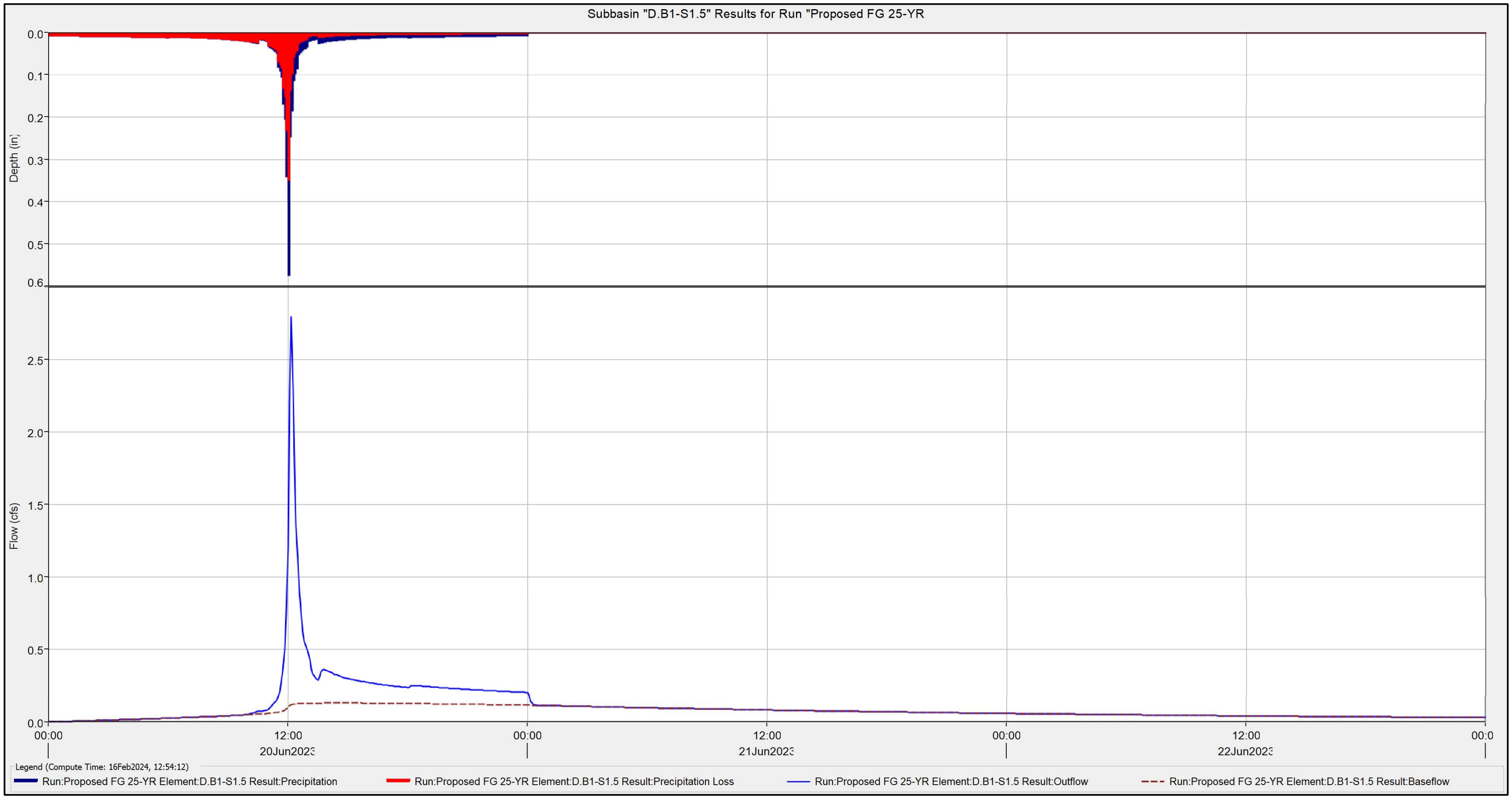

Subbasin "D.B1-S1.2" Results for Run "Proposed FG 25-YR
Depth (in)
Flow (cfs)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-S1.2 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-S1.2 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-S1.2 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-S1.2 Result:Baseflow

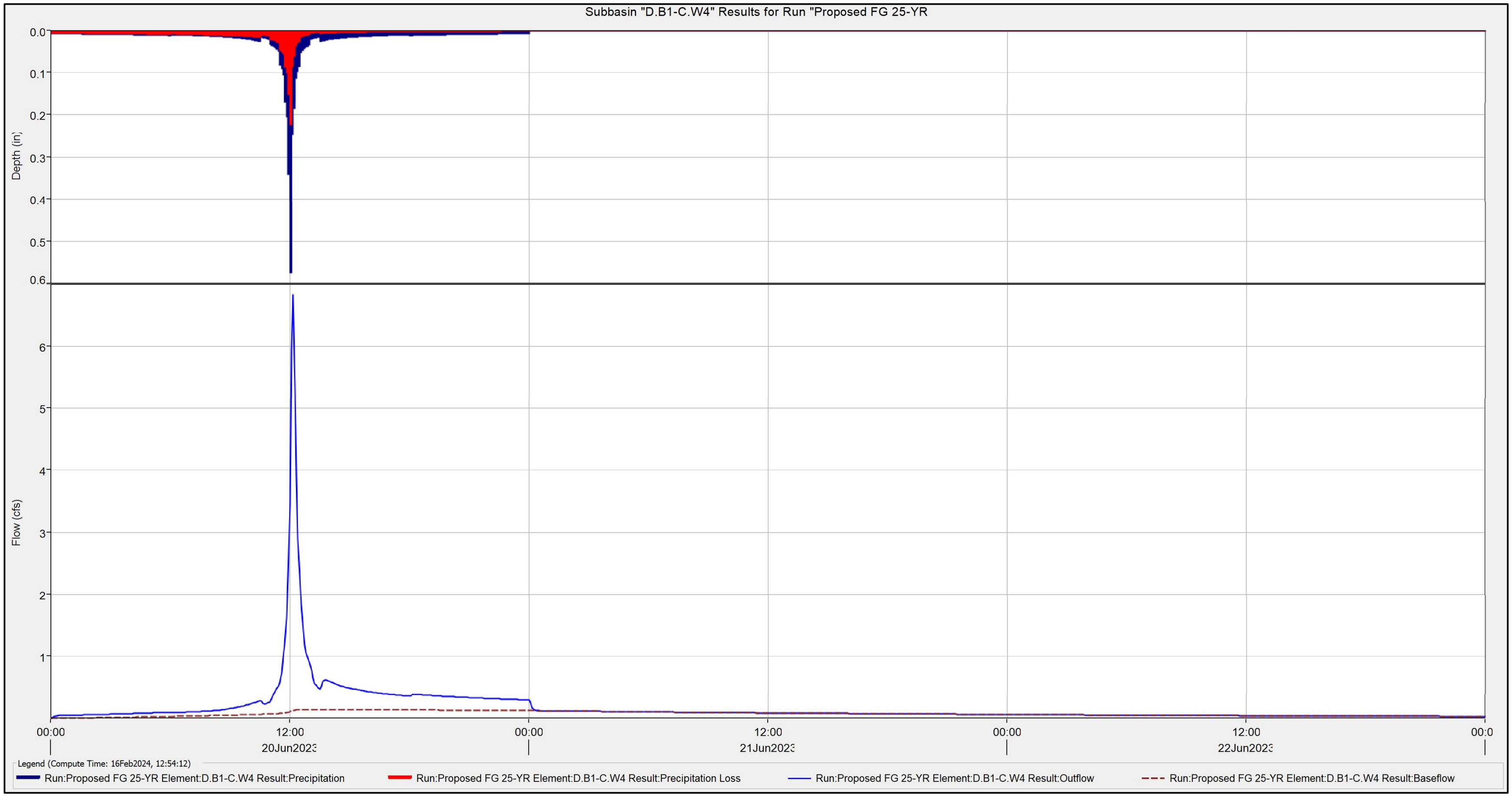


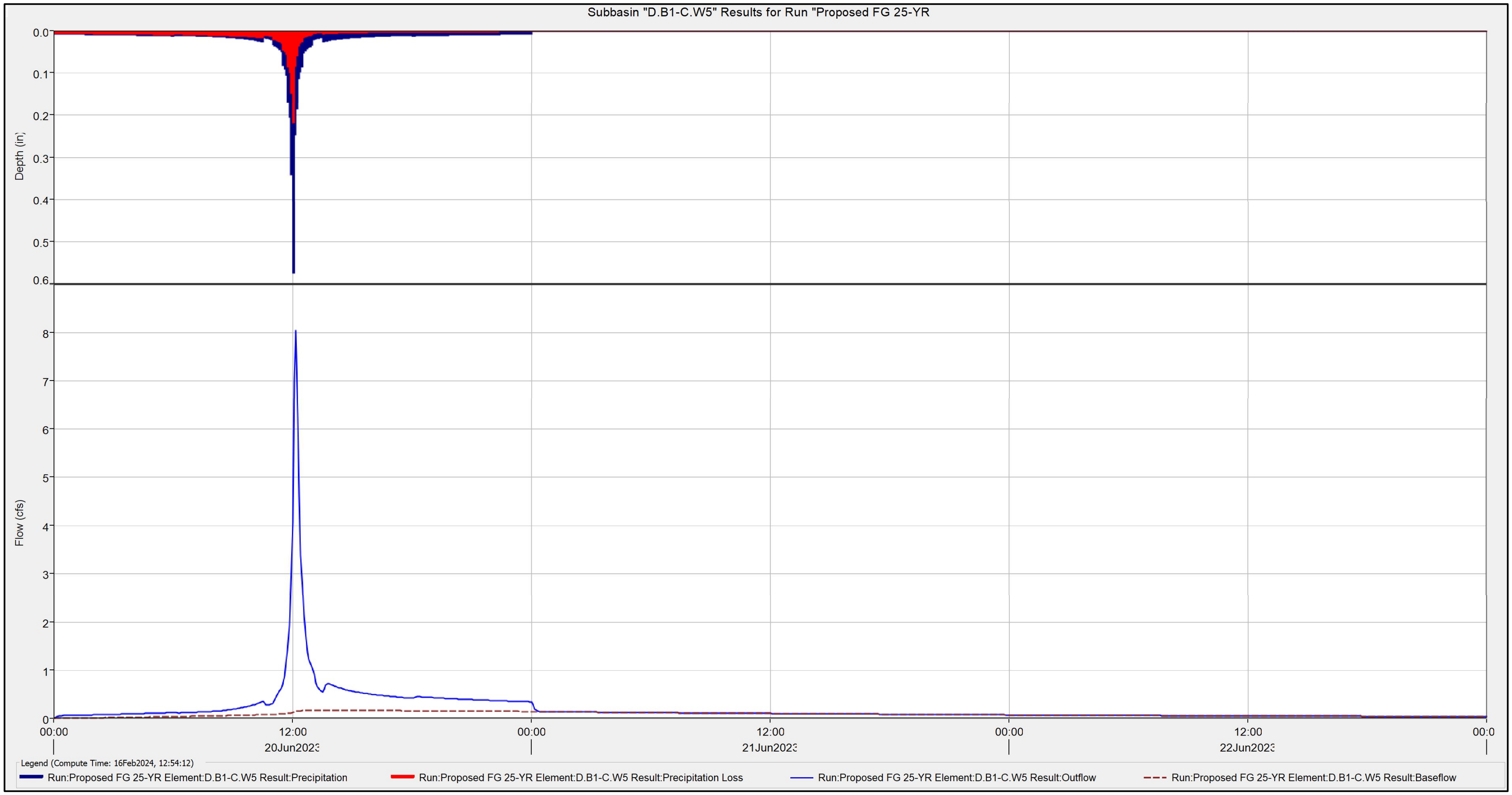
Subbasin "D.B1-S1.3" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
6
5
4
3
2
1
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-S1.3 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-S1.3 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-S1.3 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-S1.3 Result:Baseflow



Subbasin "D.B1-S1.4" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
0
1
2
3
4
5
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-S1.4 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-S1.4 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-S1.4 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-S1.4 Result:Baseflow


Subbasin "D.B1-S1.5" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
0.0
0.5
1.0
1.5
2.0
2.5
00:00
12:00
00:00
12:00
00:00
12:00
00:0
20Jun2023
21Jun2023
22Jun2023
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-S1.5 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-S1.5 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-S1.5 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-S1.5 Result:Baseflow


Subbasin "D.B1-C.W4" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
6
5
4
3
2
1
00:00
12:00
20Jun2023
00:00
12:00
21Jun2023
00:00
12:00
22Jun2023
00:0
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-C.W4 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-C.W4 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-C.W4 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-C.W4 Result:Baseflow


Subbasin "D.B1-C.W5" Results for Run "Proposed FG 25-YR
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
8
7
6
5
4
3
2
1
0
00:00
12:00
00:00
12:00
00:00
12:00
00:0
20Jun2023
21Jun2023
22Jun2023
Legend (Compute Time: 16Feb2024, 12:54:12)
Run:Proposed FG 25-YR Element:D.B1-C.W5 Result:Precipitation
Run:Proposed FG 25-YR Element:D.B1-C.W5 Result:Precipitation Loss
Run:Proposed FG 25-YR Element:D.B1-C.W5 Result:Outflow
Run:Proposed FG 25-YR Element:D.B1-C.W5 Result:Baseflow

ATTACHMENT 5

CLOSURE COST ESTIMATE

Solid Waste Disposal Facility Cost Estimate Form, DEQ Form CE SWDF

Facility Name: Bremo Bluff FFCP Management Facility **Permit No. SWP** 627
Location Address: 2134 Bremo Road
City, State, Zip: Bremo Bluff, VA, 23022

FA Holder: VEPCO d/b/a Dominion Energy
Estimate Prepared by: Schnabel Engineering

Indicate the plan versions for which this cost estimate was prepared, identifying the following information for each plan:

Closure Plan

Title: Closure Plan
Plan Date: November 2024 **Approved:** Pending
Consultant: Schnabel Engineering

Post-Closure Plan

Title: Post-Closure Plan
Plan Date: November 2024 **Approved:** Pending
Consultant: Schnabel Engineering

Corrective Action Plan

Title: N/A
Plan Date: N/A **Approved:** N/A
Consultant: N/A

Corrective Action Monitoring Plan

Title: N/A
Plan Date: N/A **Approved:** N/A
Consultant: N/A

Cost Estimate Summary

Closure Cost Element	Total Cost	Notes
Total Closure Cost:	$14,475,934	
Total Post-Closure Cost:	$25,442,500	
Total Corrective Action Cost:	$0	
Total:	**$39,918,434**	

References: Please indicate references used to develop this cost estimate: Schnabel Engineering and private sector lab rates and current similar contractor bids from the private power and waste sectors.

CERTIFICATION BY PREPARER

This is to certify that the cost estimates pertaining to the engineering features and monitoring requirements of this solid waste management facility have been prepared by me and are representative of the design specified in the facility's Closure Plan. The estimate is based on the cost of hiring a third party and does not incorporate any salvage value that may be realized by the sale of wastes, facility structures, or equipment, land or other facility assets at the time of closure. In my professional judgment, the cost estimates are a true, correct, and complete representation of the financial liabilities for closure and postclosure care of the facility and comply with the requirements of 9 VAC 20-70 and all other DEQ rules and statutes of the Commonwealth of Virginia.

SIGNATURE: [signature] DATE: 11/15/2024

NAME: Ron DiFrancesco, P.E.
TITLE: Principal / Practice Leader

Acknowledgement by Owner / Operator:

SIGNATURE: Robert W Sauer DATE: Dec 13, 2024

NAME: Robert W. Sauer
TITLE: Vice President, System Operations

Worksheet CEW-01: FORMAT FOR THE ESTIMATION OF CLOSURE COSTS

Facility Name:	Bremo Bluff FFCP Management Facility
Permit Number:	627
Facility Address:	2134 Bremo Road
	Bremo Bluff, VA 23022
Facility Owner:	Virginia Electric and Power Company d/b/a Dominion Energy Virginia
Representative Completing Format:	Schnabel Engineering, Ron DiFrancesco, P.E.
Date Completed:	February 8, 2024

Total Permitted Footprint	47 ac.	
Constructed Landfill Area	47	
Existing Capped Area (closed)	0 ac.	
Non-Capped Landfill Area	**47 ac.**	**Requires full permitted cap section**
Remaining Undeveloped MSW Area	0 ac.	

Soil Cap Components

		Input	Unit	Calculation or Conversion	Result
I.	**Slope & Fill (Intermediate cover)**				
a.	Area to be capped	47	acres	x 4,840yd2/ac	227,480 yd2
b.	Depth of soil needed	0	inches	x 1yd/36in	0.00 yd
c.	Quantity of soil needed			a x b	0 yd3
d.	Percentage of soil from off-site	0%			
e.	Purchase unit cost for off-site material	$0.00	/yd3		
f.	Percentage of soil from on-site	100		(1 - d)	100%
g.	Excavation unit cost (on-site material)	$3.00	/yd3		4700
h.	Total soil unit cost			(d x e) + (f x g)	$3.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$5.00	/yd3		4700
j.	Compaction unit cost	$1.50	/yd3		
k.	Total soil unit cost			h + i + j	$9.50 /yd3
	Total Slope & Fill Cost			k x c	***$0***

		Input	Unit	Calculation or Conversion	Result
II.	**Infiltration Layer Soil (Additional subgrade material)**				
	Infiltration Soil Cost				
a.	Area to be capped	47	acres	x 4,840yd2/ac	227,480 yd2
b.	Depth of soil needed	8	inches	x 1yd/36in	0.22 yd
c.	Quantity of soil needed			a x b	50,551 yd3
d.	Percentage of soil from off-site	0%			
e.	Purchase unit cost for off-site material	$0.00	/yd3		
f.	Percentage of soil from on-site			(1 - d)	100%
g.	Excavation unit cost (on-site material)	$3.00	/yd3		
h.	Total soil unit cost			(d x e) + (f x g)	$3.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$5.00	/yd3		
j.	Compaction unit cost	$1.50	/yd3		
k.	Total soil unit cost			h + i + j	$9.50 /yd3
n.	*Subtotal Infiltration Soil Cost*			k x c	*$480,236*
	Soil Admixture Cost				
o.	Area to be capped	0	acres	x 4,840yd2/ac	0 yd2
p.	Soil admixture unit cost	$0.00	/yd2		
q.	*Subtotal admixture cost*			a x b	*$0*
	Soil Testing				
r.	Area to be capped	47	acres		
s.	Testing unit cost	$500.00	/acre		
t.	*Subtotal soil testing cost*			r x s	*$23,500*
	Total Infiltration Soil Cost (soil, admixtures, and testing)			n + q + t	***$503,736***

III. Erosion Control / Protective Cover Soil

a.	Area to be capped	47	acres	x 4,840yd2/ac	227,480 yd2
b.	Depth of soil needed	18	inches	x 1yd/36in	0.50 yd
c.	Quantity of soil needed			a x b	113,740 yd3
d.	Percentage of soil from off-site	0%			
e.	Purchase unit cost for off-site material	$0.00	/yd3		
f.	Percentage of soil from on-site			(1 - d)	100%
g.	Excavation unit cost (on-site material)	$3.00	/yd3		
h.	Total erosion/protective soil unit cost			(d x e) + (f x g)	$3.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$5.00	/yd3		
j.	Compaction unit cost	$1.50	/yd3		
k.	Total soil unit cost			h + i + j	$9.50 /yd3
	Total Erosion Control/Protective Cover Soil Cost			k x c	***$1,080,530***

IV. Vegetative support soil (Topsoil)

a.	Area to be capped	47	acres	x 4,840yd2/ac	227,480 yd2
b.	Depth of topsoil needed	6	inches	x 1yd/36in	0.17 yd
c.	Quantity of topsoil needed			a x b	37,913 yd3
d.	Percentage of topsoil from off-site	0%			
e.	Purchase unit cost for off-site material	$0.00	/yd3		
f.	Percentage of topsoil from on-site			(1 - d)	100%
g.	Excavation unit cost (on-site material)	$3.00	/yd3		
h.	Total topsoil unit cost			(d x e) + (f x g)	$3.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$5.00	/yd3		
j.	Total soil unit cost			h + i	$8.00 /yd3
	Total Topsoil Cost			j x c	***$303,307***

V. Vegetative Cover

a.	Area to be vegetated	47	acres		
b.	Vegetative cover (seeding) unit cost	$6,500	/acre		
c.	Erosion control matting unit cost	$0	/acre		
	Total Vegetative Cover Cost			a x (b + c)	***$305,500***

Soil Cap Component Subtotal (I + II + III + IV + V): $2,193,072

Geosynthetic Barrier & Infiltration Layers

VI. Flexible Membrane Liner

				Calculation or Conversion	
a.	Quantity of FML needed	47	acres	x 43,560ft2/ac + 5%	2,149,686 ft2
b.	Purchase unit cost	$1.05	/ft2		
c.	Installation unit cost	$0.35	/ft2		
d.	Total FML unit cost			b + c	$1.40 /ft2
	Total FML cost			a x d	***$3,009,560***

VII. Geosynthetic Clay Liner

a.	Quantity of GCL needed (top deck only)	4	acres	x 43,560ft2/ac + 5%	182,952 ft2
b.	Purchase unit cost	$0.75	/ft2		
c.	Installation unit cost	$0.25	/ft2		
d.	Total GCL unit cost			b + c	$1.00 /ft2
	Total GCL Cost			a x d	***$182,952***

Geosynthetic Layers Subtotal (VI + VII): $3,192,512

Drainage Components

VIII. Sand or Gravel Drainage

		Input	Units	Calculation or Conversion	Result	Units
a.	Area to be capped	0	acres	x 4,840yd2/ac	0	yd2
b.	Depth of sand or gravel needed	0	inches	x 1yd/36in	0.00	yd
c.	Quantity of drainage material needed			a x b	0	yd3
d.	Percentage of media from off-site	0%				
e.	Purchace unit cost for off-site material	$0.00	/yd3			
f.	Percentage of material from on-site			(1 - d)	100%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total drainage material unit cost			(d x e) + (f x g)	$0.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3			
j.	Compaction unit cost	$0.00	/yd3			
k.	Total drainage material unit cost			h + i + j	$0.00	/yd3
l.	Drainage material subtotal			k x b	$0.00	
m.	Percent compaction	0%				
	Total drainage material cost			l x (1 + m)	***$0***	

IX. Geotextile

a.	Quantity of geotextile needed	0	acres	x 43,560ft2/ac + 5%	0	ft2
b.	Purchase unit cost	$0.20	/ft2			
c.	Installation unit cost	$0.15	/ft2			
d.	Total geotextile unit cost			b + c	$0.35	/ft2
	Total Geotextile Cost			a x d	***$0***	

X. Geonet Composite

a.	Quantity of geonet composite needed	47	acres	x 43,560ft2/ac + 5%	2,149,686	ft2
b.	Purchase unit cost	$1.25	/ft2			
c.	Installation unit cost	$0.30	/ft2			
d.	Total geonet composite unit cost			b + c	$1.55	/ft2
	Total Geonet Composite Cost			a x d	***$3,332,013***	

XI. Underdrain Pipes

a.	Length of drainage tile needed	15,320	LF			
b.	Purchase unit cost	$55.00	/LF	6" perf pipe + stone wrap		
c.	Trenching and backfilling cost	$2.50	/LF			
d.	Total drainage tile unit cost			b + c	$57.50	/ft2
	Total Drainage Tile Cost			a x d	***$880,900***	

XII. Drainage Channels (Stormwater Control)

Drainage benches and berms					
a.	Size of drainage bench needed	525	LF	Tack-on berms only	
b.	Drainage bench unit cost	$150	/LF		
c.	*Subtotal drainage bench cost*			a x b	*$78,750*
d.	Size of drainage swale/berm needed	0	LF		
e.	Drainage swale/berm unit cost	$0	/LF		
f.	*Subtotal drainage swale/berm cost*			d x e	*$0*
Rip Rap		Class I			
g.	Quantity of Rip Rap needed	48	tons		
h.	Rip rap unit cost	$85.00	/ton		
i.	*Total rip rap cost*			g x h	*$4,080*
Downslope Pipes (or alternate)		Downslope Pipes			
j.	Quantity of downslope pipes needed	2,010	LF		
k.	Downslope pipe unit cost	$450.00	LF		
l.	Subtotal downslope pipe cost			j x k	*$904,500*
	Total Stormwater Control			c + f + i + l	***$987,330***

Drainage Component Subtotal (VIII + IX + X + XI+ XII): $5,200,243

Landfill Gas and Groundwater Features

XIII. Landfill Gas Monitoring & Control Components

				Calculation	
Landfill Perimeter System					
a.	Number of probes to be installed	0	probes		
b.	LFG probe unit cost	$4,500	/probe		
c.	*Subtotal LFG probe cost*			a x b	*$0*
Landfill Control Systems					
d.	Area to be closed	47.00	acres[1]		
e.	Average number of vents per acre	0	vents / acre		
f.	LFG vent unit cost	$7,500	/vent		
g.	*Subtotal LFG vent cost*			d x e x f	*$0*
h.	Length of header pipe needed	-	LF		
i.	Header pipe unit cost	$0.00	/LF		
j.	Header pipe installation cost	$0.00	/LF		
k.	*Subtotal LFG active vent hook-up*			h x (i + j)	*$0*
	Total Landfill Gas Management Cost			c + g + k	***$0***

XIV. Groundwater Monitoring Components

a.	Hydrogeologic study cost	$0			
b.	Number of wells to be installed	0	wells		
c.	GW Monitoring Well unit cost	$22,500	/well		
d.	Number of wells > 50 ft length	0	wells		
e.	Additional well length over 50 ft	0	LF/well		
f.	Unit cost for additional well length	$0	/LF		
	Total Groundwater Monitoring Well Cost			a + (b x c) + (d x e x f)	***$0***

Landfill Gas & Groundwater Features Subtotal (XIII + XIV): $0

Miscellaneous

		Input	Unit	Calculation	Amount
XV.	**Conversion of the CSWP to a Stormwater Pond**			Calculation	
a.	Quantity of materials for disposal	5,000	yd3		
b.	Loading and Hauling unit cost	$80.00	/yd3		
c.	Disposal unit cost	$65.00	/yd3		
d.	Total Removal/Disposal Cost			a x (b + c)	$725,000
e.	Cleaning of pond liner	$25,000	LS		$25,000
	Total Conversion Cost			d + e	***$750,000***
XVI.	**Erosion/Sediment Control**				
a.	Quantity of silt fence needed	3,500	LF		
b.	Silt Fence unit cost	$5.00	/LF		
	Total Silt Fence Cost			a x b	***$17,500***
c.	Quantity of clearing and grubbing needed	14	AC		
d.	Clearing and grubbing unit cost	$5,500	/AC		
	Total Erosion/Sediment Control Cost			c x d	***$77,000***
XVII.	**Landfill Access Road**				
a.	Size of LF access road	8,655	yd2		
b.	Depth of gravel needed	12	inches	x 1yd/36in	0.3 yd
c.	Depth of asphalt needed	0	inches	x 1yd/36in	0.0 yd
d.	Total material needed			a x (b + c)	2,885 yd3
e.	Road material unit cost	$85.00	/yd3		
f.	Placement/Spreading unit cost	$5.50	/yd3		
	Total access road cost			c x (d + e)	***$261,093***
XVIII.	**Site Security**				
Fencing		Existing			
a.	Length of fencing needed	-	ft		
b.	Fence unit cost	$0.00	/ft		
c.	*Subtotal fencing cost*			a x b	*$0*
Gate or Barrier		Existing			
d.	Number of gates required	-			
e.	Gate unit cost	$0.00	/gate		
f.	*Subtotal gate cost*			d x e	*$0*
Closed Sign					
g.	Number of signs required	1			
h.	Sign unit cost	$1,500	/gate		
i.	*Subtotal sign cost*			g x h	*$1,500*
	Total site security cost			c + f + i	***$1,500***
XIX.	**Mobilization / Demobilization**				
a.	Cost for mobilization/demobilization	$250,000			
	Total mobilization/demobilization cost				***$250,000***

Miscellaneous Subtotal (XV + ... + XIX): $1,357,093

	Calculation	Amount
Closure Cost Subtotal (CCS):	(I + ... + XIX)	$11,942,920
Contingency (10%):	CCS x 0.10	$1,194,292
Engineering & Documentation:		
Construction QA/QC (8%)	CCS x 0.1	$955,434
Closure Certification and CQA Report (1%)	CCS x 0.01	$119,429
Survey and as-builts (2%)	CCS x 0.02	$238,858
Cost for survey and deed notation		$25,000
Total Engineering & Documentation Costs		***$1,338,721***
Total Closure Cost:	CCS + Contingency + Engineering	**$14,475,934**